★ **Roll Call Number**

Agenda Item Number

32

Date January 11, 2021

ESTABLISHING NEW GREENHOUSE GAS EMISSIONS REDUCTION GOALS AND A COMMUNITY 24X7 CARBON-FREE ELECTRICITY GOAL FOR THE CITY OF DES MOINES

WHEREAS, the City of Des Moines is responsible for securing the economic, physical, and social well-being of current and future residents; and

WHEREAS, the transition to a 24x7 zero-carbon community, reliant on the efficient use of a mix of carbon-free electric energy resources, will provide a range of benefits including but not limited to reduced greenhouse gas emissions, improved air quality, enhanced public health, business attraction, local job growth, increased resilience, and energy security; and

WHEREAS, there is scientific consensus regarding the reality of climate change and the connection between human activity, especially the combustion of fossil fuels that create greenhouse gases, and warming of the planet; and

WHEREAS, the 2018 report of the United Nations Intergovernmental Panel on Climate Change (IPCC) found that to limit global warming to 1.5 degrees Celsius, there would need to be a 45% reduction of greenhouse from 2010 levels by 2030 and a need to reach net-zero by 2050; and

WHEREAS, the City of Des Moines is already experiencing the effects of climate change locally through increased temperatures, changes in water systems, extreme weather events such as the record rainfalls and flooding of June 30, 2018, the Derecho of August 10, 2020, and other disruptions that threaten our economy, residents, and overall quality of life; and

WHEREAS, inaction perpetuates inequity and ensures the burdens of climate hazards will be borne by the City's most marginalized and vulnerable residents; and

WHEREAS, carbon-free energy resources paired with energy storage, and microgrids, where feasible, are important strategies to build disaster resilience into our communities and will assist with disaster recovery; and ensuring equitable distribution of the benefits of these resources is imperative to adequately prepare for disasters, particularly those exacerbated by climate change; and

WHEREAS, the Mayor has pledged to uphold the Paris Climate Agreement, is the Interim President of Local Governments for Sustainability (ICLEI International), and has established the Taskforce on Sustainability, which seeks to commission a comprehensive climate action plan to attain greenhouse gas reduction goals; and

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WHEREAS, Guide DSM and Plan DSM commit the City to foster sustainable communities, and the City has pledged to reduce greenhouse gas emissions 28% by 2025, further demonstrating this commitment by enacting the Energy and Water Use Benchmarking Ordinance and initiating a Climate Action and Adaptation Planning Process (CAAP); and

WHEREAS, a host of solutions exist to provide reliable, affordable, and sustainable energy while reducing demand and emissions, including but not limited to solar, wind, energy storage, geothermal, biomass, energy efficiency, demand control technologies, carbon sequestration, waste reduction, water systems technologies, and tree planting; and

WHEREAS, new and existing buildings must play a key role in reducing energy demand through smart building technologies, grid interaction, electrification, and efficiency, with residential, commercial, and industrial energy usage accounting for 73% of Des Moines greenhouse gas emissions in 2017; and

WHEREAS, transportation advancements, including electric vehicles, intermodal transit, and pedestrian and bicycle-oriented streets offer solutions to limit harmful vehicle emissions, reduce congestion, and support vibrant neighborhoods; and

WHEREAS, the City of Des Moines and the greater Des Moines community rely on MidAmerican Energy Company (MidAmerican) for electricity, who is committed to a 100% carbon-free energy vision for its Iowa customers, and who under GreenAdvantage® delivered approximately 83% of its customers' energy needs from renewable sources in 2020; and

WHEREAS, many corporations value reliable, low-cost, carbon-free energy when considering sites for business retention and expansion, such as data centers, distribution, and manufacturing facilities, making clean energy a valuable tool for economic development; and

WHEREAS, the City can accelerate the local clean energy transition by partnering with stakeholders to support carbon-free energy resources and the City will continue to pursue options for renewable energy systems on government buildings and properties through ownership and Power Purchase Agreements, develop public electric vehicle charging infrastructure, and phase in electric fleet vehicles, non-road equipment, and public transportation; and

NOW, THEREFORE, BE IT RESOLVED by the City Council of the City of Des Moines, Iowa, that the City hereby updates its greenhouse-gas emission goals to align with IPCC recommendations and commits to developing partnerships that advance a 45% reduction of greenhouse gas emissions from 2010 levels by 2030 and to reach net-zero greenhouse gas emissions by 2050.

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BE IT FURTHER RESOLVED that the City hereby commits to a community-wide goal of achieving 100% 24x7 electricity from carbon-free sources by 2035.

BE IT FURTHER RESOLVED that the City Manager and his designees are directed to work with utility partners, businesses, residents, and community stakeholders to identify a collaborative approach to achieve the emissions targets and energy goals with meaningful benchmarks and milestones between now and the target years referenced in this resolution.

APPROVED AS TO FORM:

Moved by ______________________ to adopt.

/s/ *Lawrence R. McDowell*
Lawrence R. McDowell
Deputy City Attorney

COUNCIL ACTION	YEAS	NAYS	PASS	ABSENT
COWNIE				
BOESEN				
GATTO				
GRAY				
MANDELBAUM				
VOSS				
WESTERGAARD				
TOTAL				

MOTION CARRIED APPROVED

______________________________ Mayor

CERTIFICATE

I, P. Kay Cmelik, City Clerk of said City hereby certify that at a meeting of the City Council of said City of Des Moines, held on the above date, among other proceedings the above was adopted.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my seal the day and year first above written.

______________________________ City Clerk

Accelerating Iowa City's Climate Actions

April 2020

IOWA CITY
CLIMATE
ACTION
TODAY

Achieving 45% Reduction in Carbon Emmissions by 2030 and Reaching Net-Zero by 2050

CITY OF IOWA CITY
UNESCO CITY OF LITERATURE

Introduction

In December 2016, the Iowa City City Council established goals aligning with the Paris Climate Agreement, to reduce citywide carbon emissions by approximately 25% by 2025 and 80% by 2050. In partnership with the community and with the guidance of an appointed Climate Action Steering Committee, the City of Iowa City developed its first comprehensive Climate Action and Adaptation Plan. The Plan's development allowed for significant community and stakeholder input that was solicited in ten public meetings. In addition to those public meetings, hundreds of individuals responded to a survey to aid in the Plan's development. The Plan was finalized by the Climate Action Steering Committee and adopted by the City Council on September 18, 2018.

As additional climate science research and reports were since issued by agencies such as the Intergovernmental Panel on Climate Change (IPCC), the City Council committed on August 6, 2019, to update carbon emissions targets. As the resolution on the following pages declares, Iowa City's latest goals are to reduce citywide carbon emissions 40% by 2030 and reach net-zero emissions by the year 2050.

The City Council also called for this report, issued within 100 days of the resolution, to provide specific methods by which the City can accelerate progress on the initiatives described in the 2018 Climate Action Plan. This report was presented on November 14, 2019, to the City Council and the Iowa City community for review and comment. The Iowa City Climate Action Commission and their working groups reviewed the document and provided comment on the contents of this report and presented their recommendations to City Council on April 7, 2020. City Council accepted the review and staff brought the report to Council on April 21, 2020 for final adoption.

Iowa City's Climate Action and Adaptation Plan along with other climate action resources can be accessed at www.icgov.org/climateaction.

August 6, 2019 Climate Crisis Resolution

19

Prepared by: Ashley Monroe, Assistant City Manager, 410 E Washington St., Iowa City, IA 52240 (319) 356-5010

Resolution 19-218

Resolution declaring a climate crisis and requesting immediate and accelerated action to address the climate crisis and limit global warming to 1.5 degrees Celsius.

Whereas, Climate change is an urgent unfolding crisis that presents a serious threat to global stability and human existence; and

Whereas, The City of Iowa City developed a Climate Action and Adaptation Plan, approved in September 2018, to achieve the Council-set targets matching the Paris Agreement for a citywide carbon emissions reduction of 25-28% from 2005 levels by 2025 and 80% by 2050; and

Whereas, The Climate Action and Adaptation Plan notes that the majority of Iowa City's carbon emissions are sourced from fossil-fueled energy production by utilities and the University of Iowa; and

Whereas, In October 2018, the Intergovernmental Panel on Climate Change (IPCC) issued a special report on the impacts of global warming and the need to reduce global greenhouse gas emissions well before 2030 to hold warming to 1.5 degrees Celsius; and

Whereas, To stay within 1.5 degrees Celsius, the IPCC report indicates that global net human-caused emissions would need to fall 45% from 2010 levels by 2030 and reach "net zero", offsetting carbon emissions with carbon removal, by 2050; and

Whereas, In 2018, the United States' Fourth National Climate Assessment made clear that climate change will wreak havoc across the United States, and the current pace and scale of national climate action is not sufficient to avert substantial damage to the economy, environment, and human health over the coming decades; and

Whereas, According to the Urban Sustainability Directors Network *Climate in the Heartland Report*, Iowa City, like the Iowa City metropolitan area and the state of Iowa, is already suffering impacts of climate change and the expectation that damaging weather events, including average annual temperatures exceeding the hottest years of historical temperature ranges, increased spring and summer rainfall, excessive daily rainfall frequency, growing season length, and temperature of heat waves, cold waves, and summertime nights will continue and grow more severe if global greenhouse gas emissions are not significantly reduced; and

Whereas, Climate change will continue to impact the affordability of basic human necessities such as food, housing, healthcare, transportation, and energy, adding additional pressure on persons and families of low-income and challenging Iowa City's goal of fostering an inclusive, just, and sustainable community for all; now, therefore be it

Resolved, That the City Council hereby declares a state of climate crisis, given that the crisis poses a serious and urgent threat to the well-being of Iowa City, its inhabitants, and its environment; and, be it

Further Resolved, Iowa City adopts the IPCC targets of a 45% reduction in carbon emissions by 2030 and reaching "net-zero" by 2050; and, be it

Further Resolved, Iowa City will continue to coordinate its efforts with local municipalities, energy utilities, education institutions, as well as other local, regional, and state governments to accelerate actions to rapidly reduce greenhouse gas emissions from fossil fuels, such as gasoline, diesel and natural gas, refrigerants, and other sources; and, be it

Further Resolved, That the City Council directs the City Manager's Office to develop and deliver a report within 100 days, recommending ways to accelerate Iowa City's climate actions consistent with new reduction targets; and, be it

Further Resolved, That City Council intends to schedule a presentation of and opportunity for public comment on these strategies to achieve goals for emission reductions; and, be it

Further Resolved, That Iowa City's climate mitigation and adaptation planning, policy, and program delivery shall ensure a just transition for all its people; and, be it

Further Resolved, That as Iowa City works on climate mitigation it shall continue to advance climate adaptation efforts to address unavoidable current and future climate change impacts; and, be it

Finally Resolved, That City Council will work with the City Manager's Office to develop a budget that enables urgent climate action in the near term, while ensuring a climate resilient future for Iowa City in the long term.

Passed and approved this 6th day of August, 2019.

Mayor

Attest: Kellie K Fruehling
City Clerk

Approved by
8-1-19
City Attorney's Office

It was moved by Cole and seconded by Salih the Resolution be adopted, and upon roll call there were:

AYES:	NAYS:	ABSENT:	
X			Cole
X			Mims
X			Salih
X			Taylor
X			Teague
X			Thomas
X			Throgmorton

Iowa City Community-wide Greenhouse Gas Emissions 2018

Iowa City has conducted annual greenhouse gas (GHG) inventories since 2008. As of 2018, eleven consecutive years of data have been analyzed. Initially, the software (CACP 2009) and methodology was provided by ICLEI (International Council for Local Environmental Initiatives), the national standard for that time. After the City joined the Compact of Mayors (now the Global Covenant of Mayors for Climate & Energy), the *Global Protocol for Community-Scale Greenhouse Gas* was used to report community-wide emissions. All previous years were re-calculated using this new standard. The protocol now used is the most up-to-date global protocol and Iowa City's annual emissions have been reported using this method platform since 2015.

With the August 2019 adoption of the Climate Crisis Resolution, emissions reduction targets in Iowa City's Climate Action and Adaption Plan have been raised and the baseline year changed from 2005 to 2010. The new targets include 45% reduction in emissions by 2030 and approaching net-zero emissions by 2050. Both the new targets and change in the baseline year align with the October 2018 Intergovernmental Panel on Climate Change (IPCC) report and recommended targets.

The City factors in community growth when completing annual GHG inventories. From 2010 to 2018, Iowa City has experienced a steady decline in emissions per capita from 20.3 to 13.4 metric tonnes. Iowa City expects to continue to grow over the next several decades and will need to be mindful of growth strategies in order to achieve our goals.

The chart on the following page shows Iowa City carbon emissions trends, baseline level (red dash), and 2030 and 2050 targets (gold and silver dashes). Since 2010, Iowa City has seen a downward trend in community carbon emissions, in part by a two-thirds reduction in coal usage at the University of Iowa's power plant since that date. The large drop between 2014 and 2015 is primarily a result of MidAmerican Energy's decision to invest heavily in wind energy. This action retained renewable energy credits in the MidAmerican service territory instead of selling it to users outside the state. Despite the reduction of community-wide emissions, much work lies ahead to meet both the 2030 and 2050 emission targets. An average annual emissions reduction between 2-2.5% annually should enable us to reach our 2030 target and stay on track to become carbon neutral in 2050. It is staff's hope and expectation that Iowa City will not simply meet, but exceed, the 2030 target and put ourselves in position to be a national leader in the effort to achieve net-zero status.

The majority of metric tonnes of CO_2e are generated by industrial (27%), residential (22%), and commercial (20%) users. In order to reach our 2030 goals, the City will need to partner extensively with these sectors over the next ten years. The balance of emissions are generated by the University of Iowa Power Plant (14%), all community transportation (15%) and waste (2%). While these sectors account for a smaller portion of the carbon emissions, all sectors must be engaged to achieve long-term emission reduction targets.

Closing Summary and Acknowledgements

Through its August 6, 2019 declaration of a climate crisis and simultaneous establishment of goals to reduce citywide carbon emissions 45% by 2030 and approach net-zero by 2050, the City Council indicated a clear desire for Iowa City to be a nationwide leader in local climate action. This report briefly summarizes the City's climate action planning in recent years and sets forth 65 actions that accelerate our path to meet the City's carbon emissions reduction targets. Of these 65 actions, approximately half will be dedicated actions beginning in 2020. The table below summarizes the number and type of proposed actions:

Initiative Type	**Buildings**			**Transportation**			**Waste**			**Adaptation**			**Sustainable Lifestyle**			**Total Initiatives**
Phase	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
Education	3		1	1	1		2			2	3		2	1		16
Incentives	5	4	1		1	1			1	1			1		1	16
Regulations	2	3			1	1		2		1	1					11
City Policy	2			2		1	1				1			2		9
Projects	1	1	1	1	2		1			4			2			13
Key: *Phase 1 - 2020 / Phase 2 - 2021 - 2023 / Phase 3 – 2024-2025*																**65**
Number Proposed in Each Start Year: 2020 – 34 / 2021 – 23 / 2024 - 8																

In order to carryout these actions, the City will need strong political leadership, an engaged Climate Action Commission and dedicated staff that can work across all departments and create strong relationships with external stakeholders and the general public. In order to jump-start this effort, this report recommends the creation of an Office of Climate Action and Outreach that will reside in the City Manager's Office. A core team of three staff members will be assembled to help focus on the implementation of the 65 actions in this report.

Prior to moving to implementation, it is important that the residents and businesses of Iowa City, the Climate Action Commission and the City Council all have ample opportunity to weigh in with their thoughts and ideas on how best to move forward. This report is intended to serve as a starting place for accelerated action, but community engagement is critical to our success. The public must feel that they have ownership in these actions if we expect to reach our long-term targets. It is recommended that the Climate Action Commission consider this report and that they initiate opportunities for public comment before sending their recommendations related to the report to the City Council.

In closing, staff would like to acknowledge the efforts of many in the community, including those on the Climate Action Commission, that have shared their ideas throughout the Climate Action and Adaptation Plan process, and in recent months as the City Council considered revised emission targets and accelerated actions. Your involvement has provided a strong foundation for our future work and will be critical in sustaining that effort in the years ahead.

Press Releases

- **Honoring Honoring...**
  Friday, January 07
- **Public Health Officials...**
  Friday, January 07
- **Illinois EPA Notifies...**
  Friday, January 07

VIEW MORE>

Gov. Pritzker Signs Transformative Legislation Establishing Illinois as a National Leader on Climate Action

Press Release - Wednesday, September 15, 2021

Legislation Charts a Path To 100% Clean Energy Future by 2050

Ensures Equity is Prioritized in Just Transition to Green Economy

CHICAGO - Delivering on principles previously laid out, Governor JB Pritzker signed landmark legislation into law that puts the state on a path toward 100% clean energy, invests in training a diverse workforce for the jobs of the future, institutes key ratepayer and residential customer protections, and prioritizes meaningful ethics and transparency reforms. Illinois is the first state in the Midwest to enact legislation to combat the climate crisis and build an economy for the future.

"We can't outrun or hide from climate change - not to the north, where the Boundary Waters burn; not to the south, where Ida swallows lives and livelihoods in the blink of an eye," **said Governor JB Pritzker.** "There is no time to lose. Thanks to the Climate and Equitable Jobs Act, Illinois is taking action in the fight to stop and even reverse the damage that's been done to our climate. As of today, Illinois is a force for good, for an environmental future we can be proud of. With economic growth and jobs woven into its fabric, this new law is the most significant step Illinois has taken in a generation toward a reliable, renewable, affordable and clean energy future in a generation."

"Preserving our existing fleet of nuclear reactors, adopting more clean and renewable energy, and incentivizing sales of electric vehicles are all key components of President Biden's Build Back Better agenda and essential to reaching our nation's bold climate goals," **said United States Secretary of Energy Jennifer M. Granholm.** "Thanks to the leadership of Governor Pritzker and legislators, Illinois will keep a number of nuclear power plants online - preserving thousands of good paying jobs - all while showing just what bold state-level action can do to usher in the clean energy future."

"The magnitude of this legislation cannot be overstated," **said House Speaker Emanuel "Chris" Welch.** "We have a clear path to a carbon-free future with a more diversified energy sector that includes some of the strictest utility ethics reforms in the country. We did all of this in a bipartisan way with the support of labor and environmental advocacy groups, as well as thousands of others. I want to thank everyone who had a hand in these negotiations that resulted in a final product all of Illinois can be proud of."

"Our goal all along was to enact reliable, renewable and affordable energy policies that create thousands of jobs in a burgeoning green energy economy and put Illinois at the forefront of addressing the undeniable threats of climate change," **said Senate President Don Harmon (D-Oak Park).** "With the governor's signature today, that shared goal becomes our new reality. I want to thank my Senate colleagues, the House and Governor Pritzker for all their hard work in bringing this to fruition."

"This landmark legislation prioritizes the hardworking people of Illinois' energy industry and addresses the economic impacts the coal plant closures have on both workers and the economy," **said State Senator Christopher Belt (D-Swansea).** "I'm proud to have negotiated a deal that makes Illinois a national leader in the ongoing energy crisis, while prioritizing jobs."

state is supporting a transportation revolution while creating a cleaner, greener state for generations to come," **said Pasquale Romano, President and CEO of ChargePoint, the nation's leading electric vehicle charging network.** "We thank Governor Pritzker and his

colleagues in the legislature for their commitment to making Illinois one of the best states in the nation to drive an EV, and we look forward to working with them to implement these new programs, electrify communities across the state, and ensure Illinoisans can charge electric vehicles wherever they live, shop and work."

After more than a year of energy working group meetings, Senate Bill 2408, brings together the best ideas from a diverse range of stakeholders.

SB 2408 accomplishes the following.

Combats Climate Change and Invests in Renewable Energy

• Provides that it is the policy of the State of Illinois to move toward 100% clean energy by 2050.
• Makes changes to the Illinois Power Agency (IPA) Act to double the state's investment in renewable energy.
• Puts the state on a path to 40% renewable energy by 2030 and 50% by 2040.
• Ensuring that all utility-scale wind and solar projects are built with project labor agreements and that prevailing wages are paid on all non-residential wind and solar projects.
• Requires renewable industry reporting on diversity and inclusion efforts.
• Requires all private coal-fired and oil-fired electric generating units to reach zero emissions by January 1, 2030.
• Requires municipal coal, including Prairie State and CWLP Dallman, to be 100% carbon-free by December 31, 2045, with an interim emissions reductions goal of 45% from existing emissions by no later than January 1, 2035. If that emissions reduction requirement is not achieved by December 31, 2035, they must retire one or more units or reduce emissions by 45% from existing emissions by June 30, 2038.
• Requires all private natural gas-fired units to reach zero emissions by 2045, prioritizing reductions by those with higher rates of emissions and those in and near environmental justice communities.
• Requires municipal natural gas-fired units to reach zero emissions by 2045, unless companies convert units to green hydrogen or similar technology that can achieve zero carbon emissions.
• Requires all units that utilize combined heat and power or cogeneration technology to reach zero emissions by 2045, unless companies convert units to green hydrogen or similar technology that can achieve zero carbon emissions.
• Creates a coal to solar program to support the transition of coal plants to renewable energy facilities.
• Authorizes the Governor to create a commission on market-based carbon pricing solutions.
• Creates a Nonprofit Electric Generation Task Force to investigate carbon capture and sequestration and debt financing options for Prairie State.
• Requires the Illinois Environmental Protection Agency, IPA, and Illinois Commerce Commission (ICC) to jointly conduct a study, every 5 years starting in 2025, on the State's progress toward its renewable energy resources development goals and the current and projected status of electric resource adequacy and reliability throughout the state.
• Requires the ICC to open an investigation to develop and adopt a renewable energy access plan to improve transmission capacity to support renewable energy expansion.
• Permits Ameren to establish up to 2 utility-scale solar pilot projects.
• Permits schools to lease property in excess of 25 years to support renewable energy projects.

Invests in Workforce Development

• Creates the Energy Transition Assistance Fund to allocate funding from ratepayers to support $180 million in state clean energy programs.
• Allows local governments to engage in community energy and climate planning.
• Creates a displaced energy workers bill of rights to provide state support to transitioning energy sector workers, administered by the Department of Commerce and Economic Opportunity (DCEO) and the Illinois Department of Employment Security (IDES)

Opportunity (DCEO) and the Illinois Department of Employment Security (IDES).
• Creates a Clean Jobs Workforce Network Hubs Program, establishing 13 program delivery hub sites that leverage community-based organizations to ensure members of equity-focused populations have dedicated and sustained support to enter and complete the career pipeline for clean energy and related sector jobs.
• Establishes Energy Transition Navigators to provide education, outreach, and recruitment to equity-focused populations to ensure they are aware of workforce development programs.
• Establishes three Climate Works Hubs throughout the state which will be administered by DCEO and will recruit, prescreen, and provide pre-apprenticeship training to equity focused populations.
• Creates a clean energy contractor incubator program to provide access to low-cost capital and financial support for small clean energy businesses and contractors.
• Creates a returning residents clean jobs training program to provide training for careers in the clean energy sector to individuals who are currently incarcerated.
• Creates a clean energy primes contractor accelerator program to mentor and support businesses and contractors through business coaching and operational support.
• Creates a jobs and environmental justice grant program to provide upfront and seed capital to support community ownership and development of renewable energy projects.
• Establishes the Energy Workforce Advisory Council within DCEO to make recommendations to the state on clean energy workforce programs.

Establishes Transition Programs and Assistance

• Creates an Energy Transition Workforce Commission to report on anticipated impacts of transitioning to a clean energy economy and recommend changes to the workforce through 2050.
• Requires DCEO to establish an energy transition barrier reduction program.
• Requires DCEO to establish a grant program to award grants to promote economic development in eligible, transitioning communities.
• Requires DCEO, in collaboration with IDES, to implement a displaced worker bill of rights that provides benefits to displaced energy workers.
• Requires DCEO to administer a transition scholarship program to support youth who are deterred from attending or completing an educational program at an Illinois institution of higher education because of his or her parent's layoff from a retiring power plant.
• Requires DCEO to create or commission a report on the energy worker and transition programs.
• Allows units of local government to establish Community Energy and Climate Plans, which are intended to aid local governments in developing a comprehensive approach to combining different energy and climate programs and funding resources.
• Requires plant owners to notify employees and public officials of a plant closure two years in advance.

Ensures Consumer Protections Are at the Forefront

• Eliminates the customer deposit requirement and late fees for low-income utility residential customers.
• Eliminates the online payment fee for all customers' utility bills.
• Requires utility companies to accurately report to the ICC on the number of shutoffs and reconnections on a monthly basis.
• Provides utility-funded compensation to non-profit representatives of consumer interests that intervene in ICC proceedings in order to increase public engagement and transparency, expand information available to the ICC, and improve decision-making.
• Requires the ICC to conduct a comprehensive study to assess whether low-income discount rates for residential customers are appropriate and consider the design and implementation of such rates.
• Requires the ICC to initiate a docket to provide for the refunding of excess deferred income taxes by the end of 2025.
• Prevents municipal and cooperative electric providers from imposing discriminatory financial repercussions on customers who self-generate electricity.

Establishes Illinois as a Clean Transportation Leader

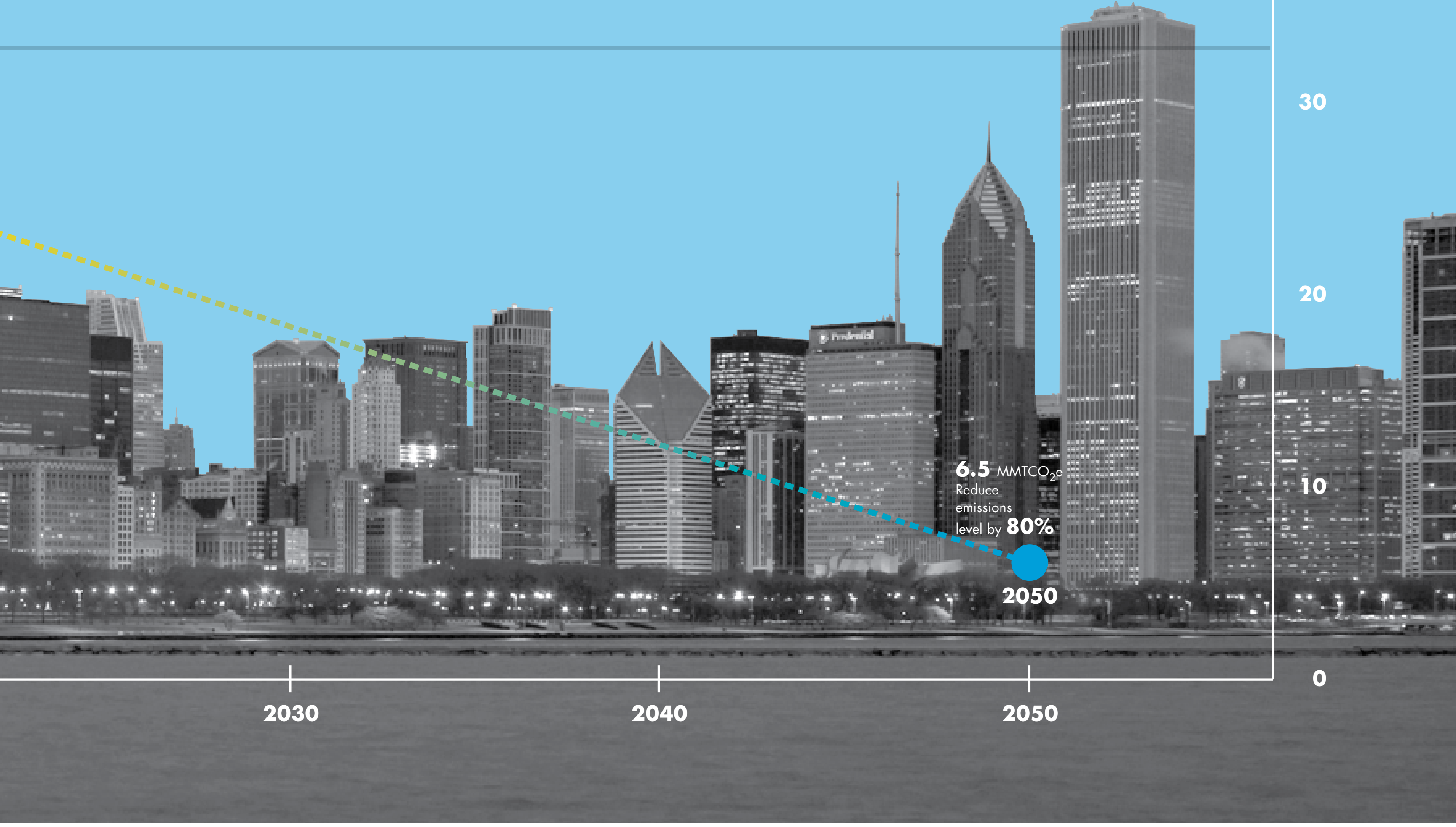
CHICAGO CLIMATE ACTION PLAN

OUR CITY. OUR FUTURE.

CHICAGO GREENHOUSE GAS EMISSIONS AND REDUCTION GOALS

Amounts are in million metric tons carbon dioxide equivalent (MMTCO_2e)

Chicago's goal is to reach an 80 percent reduction in greenhouse gas emissions from 1990 levels by 2050, with the sharpest reductions occurring over the next 12 years, by 2020 (the use of 1990 levels follows the Kyoto Protocol). Achieving this goal will also help reduce other forms of harmful gases, such as nitrous oxide, which will improve overall air quality. Achieving this goal will require the commitment and collective action of individuals, businesses, government and other institutions.



KEY FACTS:
A SNAPSHOT IN TIME

While based on extensive research and analysis, the Chicago Climate Action Plan represents a snapshot in time, using the best information available today. But technology and markets change almost daily, which is why we expect the Plan to evolve over time. A strategy identified today may become obsolete, just as new technologies may emerge that weren't even considered possible when this plan was written. As a result, like Chicago itself, the Plan is dynamic and nimble.

has a role to play in implementing the Plan, which will not only ensure a more livable climate for the world, but also for the city. The economy and quality of life could improve. Jobs could be created. New technologies will emerge.

The Strategies section of this Plan outlines 26 actions for mitigating greenhouse gas emissions and nine actions to prepare for climate change. These actions call upon a range of government bodies—local, regional and national—to improve policies. Companies whose actions are already making a difference need to do more; other businesses must begin. Environmental, community and faith-based organizations have a key role to play. All Chicagoans bear a new responsibility. The Plan details steps for organizations of all kinds and suggests actions for every individual.

The Plan is a snapshot in time—the actions detailed in the Strategies section draw on current technology and options now available in the market. As new technologies and options emerge, actions may change. The goal, however, remains the same: to reduce our emissions and prepare for change.

This report can be thought of as an overview document to help everyone learn about Chicago's Climate Action Plan—how it was created, why it is necessary, what are its goals. Reports on the scientific research are available at www.chicagoclimateaction.org. This website also provides more detailed steps that City government, individuals and organizations are taking to implement change.

We will share our progress citywide. We also must communicate it to cities nationwide and worldwide if we are to have a true global impact. Chicago can make a difference by reducing our own emissions—and by standing as a model for how cities worldwide can tackle this urgent issue.

For more information on Chicago's Climate Action Plan, visit **www.chicagoclimateaction.org**.

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Record #:	R2019-157		
Type:	Resolution	Status:	Adopted
Intro date:	3/13/2019	Current Controlling Legislative Body:	Committee on Health and Environmental Protection
		Final action:	4/10/2019
Title:	Support for implementation of clean energy transition plan		
Sponsors:	Emanuel, Rahm		
Topic:	ENERGY/ENVIRONMENTAL ISSUES - Miscellaneous		
Attachments:	1. R2019-157.pdf		

History (3) | Text

OFFICE OF THE MAYOR

CITY OF CHICAGO

RAHM EMANUEL MAYOR

March 13, 2019

TO THE HONORABLE, THE CITY COUNCIL OF THE CITY OF CHICAGO

Ladies and Gentlemen:

I transmit herewith a resolution regarding Chicago's implementation of a clean energy transition plan.

Your favorable consideration of this resolution will be appreciated.

Mayor

Very truly yours,

RESOLUTION

WHEREAS, The City of Chicago is committed to promoting and encouraging clean renewable energy generation in order to invest in local economies and provide local jobs and workforce development opportunities; and

WHEREAS, Renewable Chicago Project released a renewable energy deployment initiative in September 2018 which outlines how the City and Sister Agencies can power municipal buildings with clean renewable energy by 2025, in accordance with Mayor Emanuel's April 2017 commitment to a renewable energy future for Chicago; and

WHEREAS, The City of Chicago is a member of the C40 Cities Climate Leadership Group, which connects more than 90 global megacities focused on addressing climate change through bold urban action that reduces greenhouse gas emissions and climate risks, while increasing the health, well-being, and economic opportunities for these cities' residents; and

WHEREAS, The Future Energy Jobs Act mandates that Illinois source 25% of the state's electricity from renewable sources by 2025, and addresses the need to create more accessible methods of engagement and decision-making by low-income, frontline, and environmental justice communities through the Illinois Solar For All program and similar programs; and

WHEREAS, Climate change will bring unprecedented environmental changes including extreme heat, heavy precipitation, and flooding to our region, which will stress our finite resources; and

WHEREAS, The use of clean, renewable energy such as wind, solar, and geothermal has significant public health and environmental co-benefits; and

WHEREAS, Community residents led efforts to close the Crawford and Fisk coal-fired power plants in 2012, which helped to avoid more than 40 premature deaths, 550 emergency room visits, and 2800 asthma attacks annually, supported by over 12 years of work by a diverse coalition of community leaders, parents, environmental advocates, and health care professionals; and

WHEREAS, Hazel Johnson's trailblazing environmental justice work on Chicago's Southeast Side illuminated the linkage between socioeconomic, public health, and environmental inequities experienced in low-income and communities of color across the US, led to the passage of the first federal legislation to address environmental justice, and empowered strong environmental justice leadership and organizing in communities beyond Chicago, earning her recognition as the Mother of Environmental Justice; and

WHEREAS, Residents of communities experiencing disproportionate cumulative impacts of environmental exposures and population vulnerability, as well as other communities across Chicago, desire a just transition away from all fossil fuels that prioritizes environmental justice, public health, community self-determination, high-quality jobs, and ownership opportunities for local residents; and

WHEREAS, Chicago's workforce, capital, and private investments will continue to grow as the City takes bold, progressive action towards carbon neutrality and climate justice; and

WHEREAS, This energy transition is an opportunity to build equity for communities that have been traditionally underrepresented in the energy field and marketplace as the City of Chicago is committed to maximizing opportunities to right inequity, particularly in impacted communities; and

WHEREAS, The City's commitment to develop local clean energy infrastructure will significantly stimulate the local economy through the manufacturing, construction, operations, service, and procurement sectors by the creation of new prevailing wage careers and the development of the local clean energy industry workforce, particularly in impacted communities; and

WHEREAS, The City can continue to implement inclusive procurement policies, such as the U.S. Employment Plan implemented by the Chicago Transit Authority, to ensure high economic development standards in clean energy infrastructure; and.

WHEREAS, The cost of wind and solar energy is rapidly falling and opportunities such as community solar, distributed renewable energy generation, and microgrids are making renewable electricity easier to access; and

WHEREAS, The City of Chicago will be the largest city in the country to commit to a robust, community-wide renewable energy commitment through the Ready for 100 campaign; now, therefore,

BE IT RESOLVED, That we, the Mayor and Members of the City Council of the City of Chicago, assembled this thirteenth day of March 2019, commit to transition to 100% clean renewable energy community-wide beginning with 100% renewable electricity in buildings by 2035 and complete electrification of CTA's bus fleet by 2040; and

BE IT FURTHER RESOLVED, That we commit to ensuring that community-wide power will come from the generation and storage of clean, renewable energy from solar, wind, and geothermal sources with an emphasis on new and local resources; and

BE IT FURTHER RESOLVED, That the City of Chicago will develop a transition plan by December 2020, which will outline key strategies, set progression milestones, develop a timeline for reaching an equitable clean energy transition, and further opportunities to create a 100% clean, renewable energy future community-wide, as well as addressing issues including but not limited to:

Prioritizing energy efficiency investment for municipal, residential, industrial, and commercial buildings, structures, ancillary power, and auxiliary services; and building upon the Future Energy Jobs Act's energy efficiency targets that require ComEd to reduce electricity use for its customers by 21.5 percent by 2030

Seeking to provide benefits for all residents by weighing cost effectiveness, equity, displacement,-and economic development

Promoting and investing in clean, accessible, and renewable transit and transportation solutions throughout the city to maximize emission reductions

Leveraging the City's purchasing power to invest in companies committed to recruiting, hiring, and retaining historically disadvantaged workers and displaced fossil fuel workers to manufacture clean energy infrastructure and equipment at a prevailing wage with comprehensive benefits

Ensuring accessibility and shared benefits of renewable energy and energy efficiency through processes such as community solar and inclusive financing

Engaging communities to determine principles of a just transition, identify key equity metrics, and develop a meaningful community feedback process that includes listening to members of impacted communities and centering their needs, goals, and concerns

Stimulating local economies by creating and maintaining prevailing-wage career pathways for workers in local distributed renewable energy generation, infrastructure modernization, energy efficiency improvement, and beneficial vehicle and building electrification projects

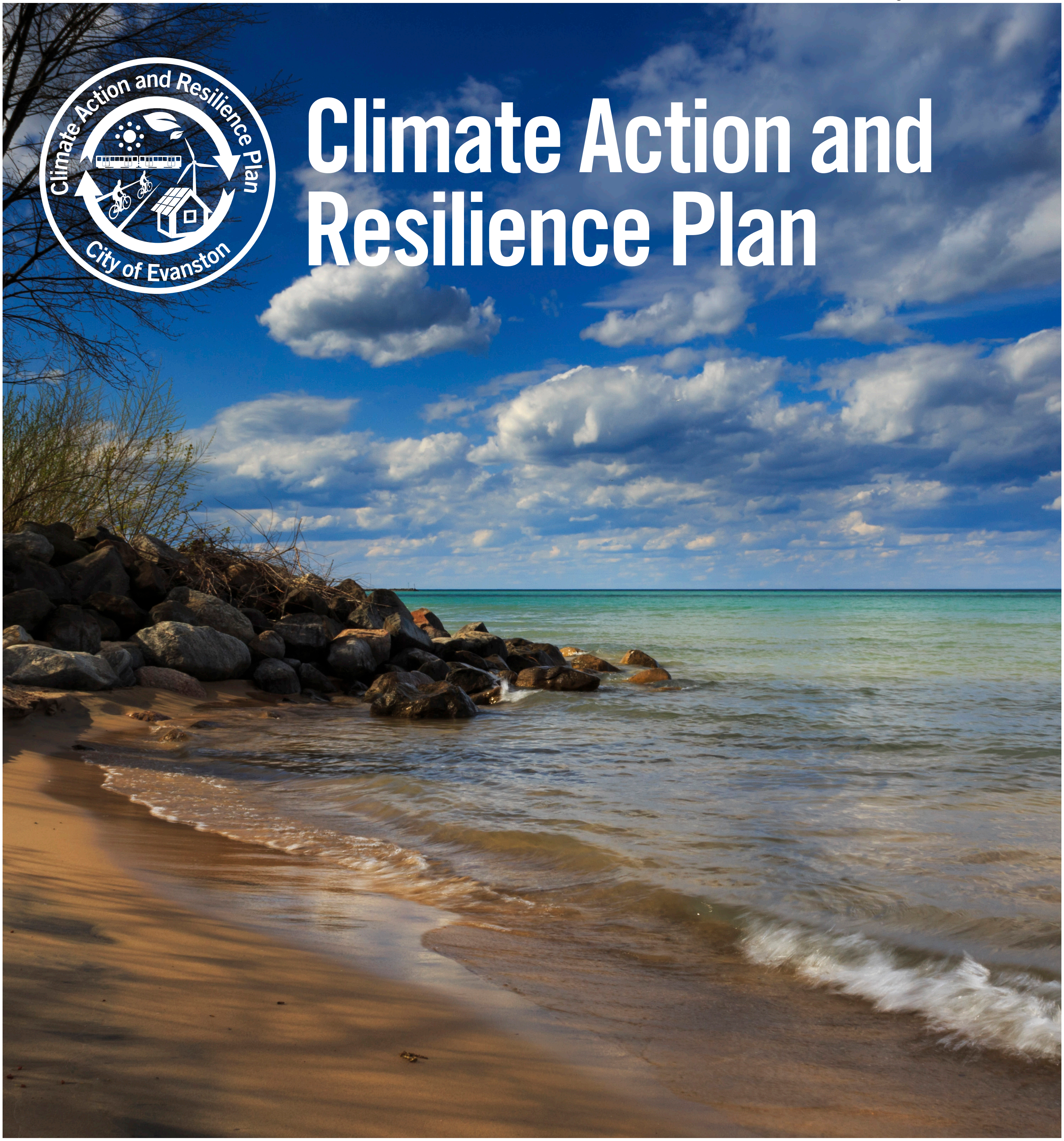
Ensuring that environmental and public health policies fully recognize and respond to the disparate impacts of public health and environmental inequities experienced in low-income and communities of color

Reevaluating and improving the transition plan based on real, community-wide trends, successes, and challenges; and

BE IT FURTHER RESOLVED, That the City of Chicago will work with community-based organizations and leaders to develop the transition plan through an inclusive stakeholder engagement process, with a particular focus on the needs of low-to-moderate income residents and communities that have been most impacted by environmental injustices.

i

Climate Action and Resilience Plan



Carbon Neutral by 2050

City of Evanston™

cityofevanston.org/climate

November 2018

Letter from the Mayor

Evanston has a long track record of success when it comes to climate action. Since the City Council's unanimous decision to support participation in the U.S. Conference of Mayors Climate Protection Agreement in 2006, our City has successfully implemented two climate action plans under the leadership of Mayor Lorraine H. Morton and Mayor Elizabeth Tisdahl, received certification and recertification as a 4-STAR sustainable community, been named the U.S. Earth Hour City Capital, and achieved a 24 percent reduction in greenhouse gas emissions relative to 2005 baseline levels. Still, there's more work to be done.

That's why, in 2017, I formed a resident-led working group to chart a path forward. The group, comprised of 17 community members with a wide array of backgrounds and expertise, has been hard at work over the last year developing a plan to not only continue reducing Evanston's impact on climate change, but to also prepare the city and its residents for its effects.

I am pleased to announce the culmination of their efforts with the release of **Evanston's Climate Action and Resilience Plan (CARP)**. Detailed on the following pages, the plan lays out a bold vision that "by 2050, Evanston will be a climate ready and resilient city that has successfully prioritized the needs of its most vulnerable while combating climate change."

To achieve that vision, the Climate Action and Resilience Plan sets a goal of achieving carbon neutrality by 2050, while reaching ambitious greenhouse gas reduction targets along the way. Other goals include securing 100 percent renewable energy for all Evanston properties by 2030, achieving zero waste by 2050, shifting to low- or non-polluting transportation methods, enhancing Evanston stormwater systems, and, for the first time, ensuring that all residents, including our most vulnerable, are prepared for the impacts of a changing climate.

Achieving these goals will require a community-wide effort, and the City can't do it alone. That's why our plan includes commitments from some of Evanston's largest institutions, including the Evanston Community Foundation, NorthShore University HealthSystem, Northwestern University, Presbyterian Homes, Presence Saint Francis Hospital, Rotary International, Evanston/Skokie School District 65, and Evanston Township High School.

From our residents, to our businesses, to our schools and hospitals, Evanston is united in its efforts to mitigate the far-reaching effects of climate change through bold action. While our city will likely undergo many changes on the way to 2050, this plan ensures that our commitment to climate action will remain.

Stephen H Hagerty

Evanston Mayor
Stephen H. Hagerty

Executive Summary

Dire warnings and new reports continue to fill news headlines that demand immediate and decisive action at all levels of government and throughout society, including local government. On October 8, 2018, the Intergovernmental Panel on Climate Change (IPCC), the leading scientific body responsible for climate research, issued a dire warning indicating that in order to limit global warming to 1.5 C, "net human-caused emissions from carbon dioxide (CO2) would need to fall by about 45 percent from 2010 levels by 2030, reaching 'net-zero' around 2050."* With nine of the 10 hottest years on record having occurred since 2005, precipitation continues to occur in more intense and less frequent storms, and wildfires and hurricanes have ravaged large swaths of the United States. This warning reflects the need for action.

In Evanston, the question is not whether or not climate change exits. The question remains, how do the City and community take actions that reflect the immediacy of the situation while centering the needs of those who will be most severely impacted locally? Although Evanston, as a Great Lakes city, is relatively insulated from threats such as hurricanes, sea level rise and wildfires, it is not insulated from increasingly intense storms, the influx of invasive species, hotter temperatures, drought-like conditions, human migration, threats to water quality and the relative instability of energy prices. Vulnerable communities and individuals will experience disproportionately negative impacts from climate change in the coming years and decades.

Evanston has a long-standing history of bold climate action and a track record of making consistent reductions in carbon emissions. This strong history, begun by Mayor Lorraine H. Morton and elevated by Mayor Elizabeth Tisdahl, is being taken to the next level under Mayor Stephen H. Hagerty. The Climate Action and Resilience Plan (CARP) calls for ambitious reductions in carbon emissions and, for the first time, establishes goals to ensure Evanston is prepared for the daunting impacts of climate change.

The Climate Action and Resilience Plan calls for carbon neutrality by 2050, 100% clean and renewable electricity by 2030, zero waste by 2050, and much more. These ambitious goals were developed by a community working group established by Mayor Hagerty in late 2017. The working group had 17 members and convened dozens of times in smaller task forces and as a whole from November 2017 to November 2018.

The plan is divided into five sections, with two major sections: Climate Mitigation and Climate Resilience. Climate Mitigation explores the far-reaching ways in which many daily routines are tied to larger systems that account for much of the City's emissions, namely buildings, which account for 80% of Evanston's emissions. Climate Resilience focuses on preparing social, ecosystem and built environments for the impacts of climate change. Many recommended actions improve climate resilience as well as reduce carbon emissions; the plan seeks to amplify those actions as especially critical.

Thirteen years after Mayor Morton signed the U.S. Mayors Climate Protection Agreement, Evanston has reduced its overall emissions by 24% and leads the region in climate-related planning and progress. The Climate Action and Resilience Plan builds on the foundation of community-driven planning and calls for another round of ambitious action.

* *Global Warming of 1.5°C, an IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty.*

Climate Mitigation

Climate Mitigation describes actions that reduce the release of greenhouse gas emissions in order to limit climate change. Climate mitigating actions at the local level is imperative if Evanston is to play its part in holding average global temperature increases to below 2 degrees Celsius (3.6 degrees Fahrenheit) and preferably below 1.5 degrees Celsius (2.7 degrees Fahrenheit).

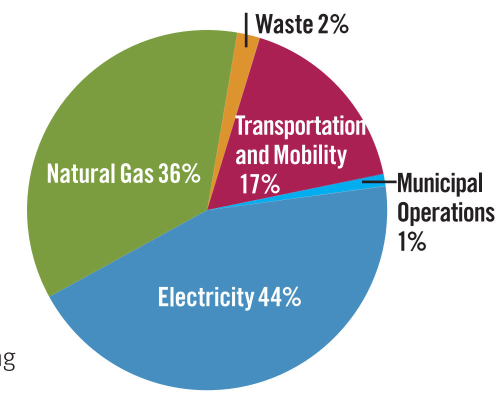
Research compiled by the Intergovernmental Panel on Climate Change (IPCC) indicates that if global temperatures are allowed to increase by 2 degrees Celsius, the consequences will be much more catastrophic than if we can limit warming to 1.5 degrees Celsius or below. The average global temperature has already increased by 1 degree Celsius (1.8 degree Fahrenheit) since pre-industrial levels. Warming greater than the global average is already occurring in many land regions, such as the Arctic, where it is occurring two to three times faster. Global warming is likely to reach 1.5 degrees Celsius by mid-century if trends continue at the current rate. Limiting the increase to 1.5 degrees Celsius as opposed to 2 degrees would mean the difference between a world with Arctic summer sea ice and coral reefs and one without them. More information on the IPCC and climate data can be found at **www.ipcc.ch**.

Greenhouse Gas Reduction Targets

This plan calls for ambitious and immediate reductions in greenhouse gas emissions, building upon the success of the 2008 Evanston Climate Action Plan (ECAP) and the 2014 Livability Plan. The 2017 community greenhouse gas emissions inventory (Emissions Inventory) showed a 24% reduction in emissions from the 2005 baseline, which demonstrates significant progress towards carbon neutrality. To build off of this progress, the City has established the following community reduction targets:

2025 – 50% reduction
2035 – 80% reduction
2050 – Carbon Neutrality

2017 GHG Emissions by Source



To evaluate and measure the community's progress towards these targets, the City has developed an Emissions Inventory that is compliant with the internationally accepted best practices put forth in the global protocol for community-scale greenhouse gas emissions (GPC). The Emission Inventory identifies emissions by sector and illustrates changes in emissions over time. An inventory makes it possible to evaluate the City's progress in reducing emissions and the impact of emission reduction policies.

The Emissions Inventory accounts for emissions attributed to activities taking place within the City's municipal boundaries. The Emissions Inventory is measured in metric tons of carbon dioxide equivalent ($MTCO_2e$), which is the standard measurement of greenhouse gas (GHG) emissions. The 2005 baseline of emissions attributed to the community totaled 1,056,169 $MTCO_2e$. The 2017 Emissions Inventory revealed total net emissions of 793,266 $MTCO_2e$ from the following sectors:

1. Electricity (44%)
2. Natural Gas (36%)
3. Waste (2%)
4. Transportation (17%)
5. Municipal Operations (1%)

A detailed Emission Inventory is available in *Appendix A: Emissions Inventory*.

Greensburg
Sustainable **Comprehensive Plan**

05.19.08

"Energy and persistence alter all things."

- BENJAMIN FRANKLIN

ENERGY

Carbon emissions and energy independence are arguably the most important issues facing our society. Our modern lifestyle requires a constant supply of energy. Unfortunately, our means of power production threatens the stability of the economy and the natural balance of the ecosystem. As a country, we are moving toward a lean carbon economy, and from this it will be possible for our rural communities to tap their immense wind, solar, and biomass resources to become the nation's largest energy producers. Not only do these resources provide new jobs and stabilize the cost of energy, but they also provide cleaner air and cleaner water. There is little doubt that renewable energy is a potential boon for many small towns. The current energy landscape is rapidly changing and Greensburg is well suited to capitalize on the shift.

Working in conjunction with the National Renewable Energy Laboratory (NREL), community stakeholders, and City staff, the planning team has seen a growing appetite for renewable energy generation and a genuine interest in improving the energy efficiency of new structures. This is in no small part due to the hard work of the City leadership, NREL's on-the-ground presence, and Greensburg GreenTown's ongoing efforts. It should also be noted that much of the technical reporting included in this section comes directly from the National Renewable Energy Laboratory's diligent work and their final reports, "Near-Term Energy Strategy Recommendations Volumes I and II," available in the appendix of this Plan.

A COMPREHENSIVE STRATEGY

A comprehensive energy strategy for Greensburg requires a two-pronged approach focusing first on energy efficiency to reduce demand as much as possible and then on energy generation. Only when the town is operating at optimal efficiency and is being powered by a sustainable energy source will Greensburg's energy future be secure.

Much work has been done on both sides of this equation and many successes should be noted.

- NREL assisted dozens of home owners and builders, businesses and public projects to improve the energy efficiency of new buildings.
- The City is currently working with NREL and Maxon on many policy initiatives including a strategy by which the town will be powered by 100 percent renewable sources.
- The City Council resolved that public projects will be built to the U.S. Green Building Council's LEED Platinum standards and achieve 42 percent energy efficiency above code, a level not yet committed by any other city in the country.
- Greensburg GreenTown continues to offer education to the community regarding the benefits of sustainable living and support the City's progressive goals.

A wind farm in the rural town of Conception, Missouri

POST-TORNADO POWER SUPPLY

Immediately following the tornado, FEMA provided emergency generators and other support. Mid-Kansas Electric assisted in providing limited power very quickly. As of December 1st, 2007, the City replaced the distribution lines, a $10 million project, with assistance from FEMA and the State of Kansas.

As of March 2008, the City decided to work toward a 100 percent renewable energy strategy in both its primary and back-up generation. It is likely that in the coming months the City will enter into a short term agreement to receive power from a local provider until the renewable plan can be implemented.

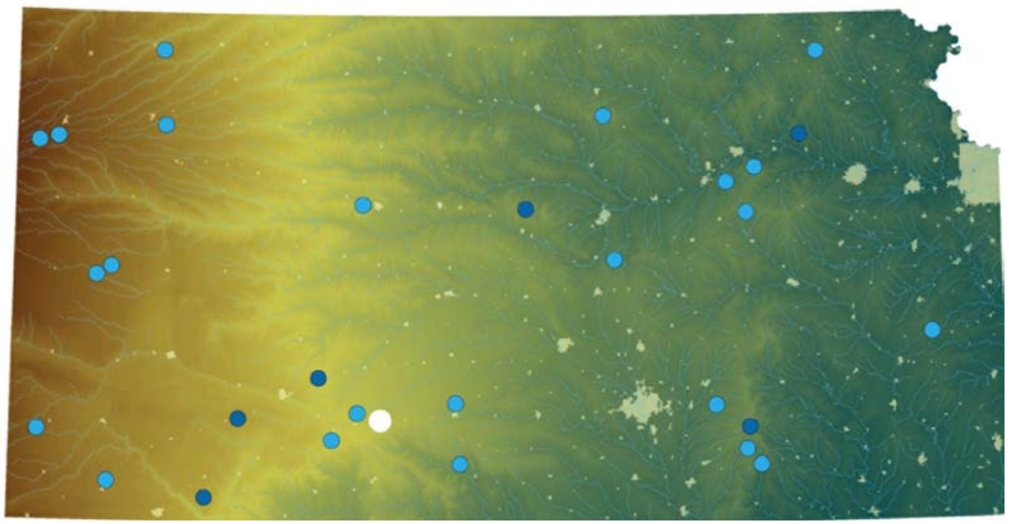
Research shows that if the business as usual model is followed in Greensburg, energy prices will continue to increase over the coming decades. A renewable electricity strategy will protect Greensburg from cost increases and fully realize the community's goal to become a sustainable model town. The City leadership, with the help of a high caliber team of experts, is currently working on a strategy and subsequent agreements whereby Greensburg will be fueled by 100 percent renewable sources. Currently, the renewable electricity strategy for Greenburg includes between 3MW and 4MW of wind power installed near town and owned by the City, and 1.5 MW of back up bio-diesel power. They will likely enter into a Power Purchase Agreement (PPA) with a local power pool to provide additional baseload from renewable sources.

The following framework for the Comprehensive Energy Strategy has been developed and agreed upon:

- Offer 100% renewable source energy to Greensburg area customers.
- Maintain the consumer rates at or near the current rate despite nationwide increases in fuel and energy costs.
- Implement a system that can be maintained by current City staff.
- Include back up power in case of grid failure.
- Allow Greensburg the flexibility to control future electricity supplies.
- Define a system and strategy that is replicable in other Kansas communities.

CAPITALIZING ON ENERGY GOALS

When Greensburg's plan for citywide renewable generation is fully implemented and as the town develops into a truly sustainable community, a new value proposition will be available to attract businesses and industries to Greensburg. By achieving the goals for energy, the community will be able to offer stable energy rates, an attractive proposition in a volatile market. It is also recommended that Greensburg encourage the development of industries and businesses that are based on renewable energy such as energy service companies, wind turbine maintenance shops, and manufacturers of bio-based fuels. More information about leveraging the green vision for economic development can be found in the economic development section of the Plan.



The six existing wind farms, and 24 engineered wind sites in Kansas. Three are in close proximity to Greensburg.

Engineered Wind Sites
Existing Wind Farms
Greensburg

5 Ways We Put the "Green" in Greensburg

- Greensburg is home to the most LEED (Leadership in Energy and Environmental Design) buildings per capita in the U.S.
- We are the first city in the U.S. to use all LED streetlights.
- Greensburg is 100% renewable, 100% of the time. All of the electricity used in the City of Greensburg is wind energy.
- Water is a very precious resource and we conserve every drop with low flow fixtures and native plantings in our landscaping. We also collect rainwater for use in irrigation and in some facilities, as grey water in toilets.
- Greensburg has single stream curbside recycling with Nisly Brothers.
- And more!

Expand
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SUSTAIN Louisville

PROGRESS REPORT 2017–2018

> **We are facing a climate emergency, and we must take greater action now!**
>
> — MAYOR FISCHER

Louisville is rated as a LEED City for its sustainability achievements. The rating was awarded in November 2018 by U.S. Green Building Council when the STAR Community Rating System was fully integrated into the LEED for Cities and Communities certification program.

SUSTAINABILITY 2017–2018

Dear Friends,

It has been five years since we released Sustain Louisville, our citywide sustainability plan. The 2017-18 Progress Report highlights many of our key successes toward these goals, but also identifies areas that need more rigorous action and community-wide effort.

In 2017, Louisville updated its greenhouse gas inventory to understand the source of our city's emissions and the activities that drive them. Louisville also began taking significant strides to manage urban heat by launching the most robust Cool Roof Rebate Program in the nation, as well as enacting a comprehensive tree ordinance to help combat the city's declining tree canopy.

In 2018, Louisville updated its comprehensive plan, emphasizing sustainability as one of its five guiding principles. The city also set a target to reduce its greenhouse gas emissions 80% by 2050.

As apparent by the increased rainfall and extreme heat, Louisville is already starting to feel the impacts of climate change. To build a sustainable future and avoid irreversible tipping points, the city must take urgent and accelerated action toward climate mitigation and adaptation. The decisions we make today about energy, transportation, and the environment will lock in emissions for decades. We need community leaders, businesses, schools, agencies, and residents to come together to tackle the climate crisis and ensure a healthy and prosperous future for generations to come.

Sincerely,
Greg Fischer

EXECUTIVE SUMMARY

Louisville Metro Government is pleased to release the Sustain Louisville 2017-18 Progress Report, which summarizes the progress toward meeting the goals and initiatives set forth in the city's sustainability plan. Published in 2013, Sustain Louisville charts a path toward making Louisville a more sustainable city. The plan's 17 goals are categorized under six focus areas: **Energy, Environment, Transportation, Economy, Community** and **Engagement**. The goals and initiatives outlined in Sustain Louisville promote and prioritize social, economic and environmental sustainability objectives – all through the lens of human health.

SUSTAIN LOUISVILLE OBJECTIVES

1. Protect the environment and reduce Louisville's carbon footprint
2. Ensure the health, wellness and prosperity of all residents
3. Create a culture of sustainability

The success of Sustain Louisville is recounted in regular progress reports that document achievements within each year. Since Sustain Louisville was published, a framework of programs and projects has been developed to help reduce energy consumption, improve air and water quality, increase landfill diversion rates and increase access to local food and nature. Goals and initiatives are expected to evolve over time as priorities change, progress is met and new targets are identified.

KEY SUCCESSES 2017

- Louisville completed the 2016 Community Greenhouse Gas Inventory, which reported a 10.1% decrease in core emissions from the 2010 baseline.
- Mayor Greg Fischer signed the Chicago Climate Charter, joining the pledge to reduce greenhouse gas emissions by an aggregate of at least 26 to 28% below 2005 levels by 2025.
- The city was awarded a gold designation by SolSmart for its leadership in advancing solar energy.
- The Office of Sustainability launched a Cool Roof Rebate Program to help manage urban heat.
- A comprehensive tree ordinance was enacted to help combat the city's declining tree canopy.
- The city launched its first bike share program, LouVelo, consisting of 28 stations and 305 bikes.
- The Solid Waste Management Division released a 10-Year Solid Waste Study to improve recycling and maximize landfill diversion.

KEY SUCCESSES 2018

- Louisville completed Phase 1 and Phase 2 of the 100 Resilient Cities Strategy Development Process.
- The Air Pollution Control District formed the Drive Clean Louisville Team to implement its vision of increasing alternative fuel and clean engine vehicle usage throughout Louisville and Jefferson County.
- Louisville Forward and the Department of Public Health and Wellness launched the Louisville Farmers Market Association to increase the capacity of farmers markets and create access to a just, healthy and sustainable food system.
- Public Works established a policy for permitting and regulating dockless vehicles.
- The city implemented its first Energy Project Assessment District project.
- Louisville set a target to reduce greenhouse gas emissions 80% below the 2050 projected emissions.
- Over 14,000 trees were planted and over a million square feet of cool roofs were installed city-wide.

PROGRESS SUMMARY

Sustain Louisville lists 82 initiatives, and 37 have been completed since the plan was released. A status of each initiative can be found in Appendix A.

2.0 ENVIRONMENT

Clean air, clean water, climate change and waste management are important elements that contribute to Louisville's overall sustainability performance. To ensure the health and wellness of all its citizens, Louisville Metro and its many partners have taken steps to update the city's greenhouse gas inventory, reduce its emissions, mitigate the urban heat island and divert waste from the landfill.

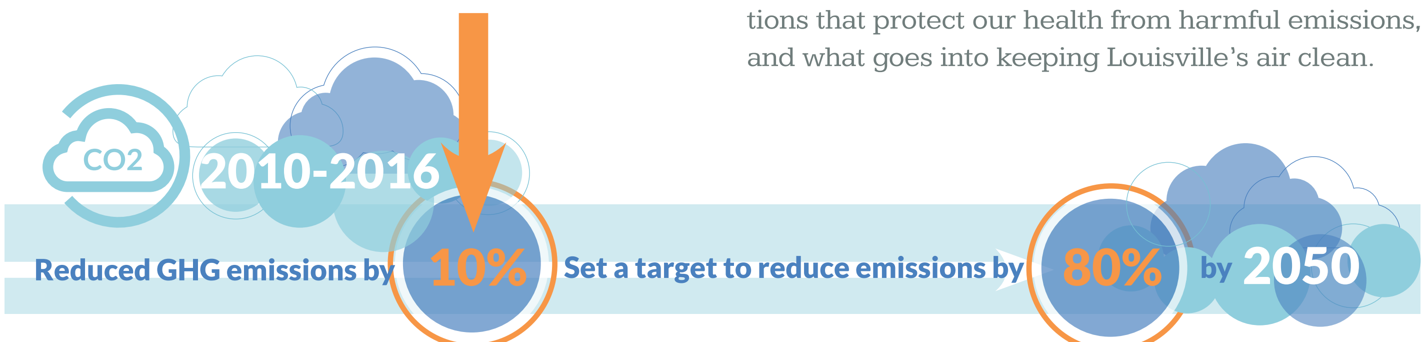
OUR PROGRESS

Goal 3: Mitigate the risk of climate change impacts by 2018

- Mayor Fischer signed the Chicago Climate Charter, pledging our city to reduce greenhouse gas (GHG) emissions by 26 to 28% below 2005 levels by 2025.
- The Office of Sustainability partnered with the Central Presbyterian Church to perform a cool coating pilot project, a heat management strategy recommended in the 2016 Urban Heat Management Study. Biweekly temperature measurements were taken to assess how applying a light color, reflective paint on an asphalt parking lot would affect its surface and near-surface ambient air temperatures.
- The city completed a Community Greenhouse Gas Inventory as a commitment to the Global Covenant of Mayors for Climate & Energy. Total Core emissions for 2016 were 16,000,537 tonnes of carbon dioxide equivalent (tCO2e) and decreased 10.1% from the 2010 baseline reporting year.
- In response to the GHG Inventory, Louisville set a target to reduce city-wide emissions by 80% below the 2050 business-as-usual projected emissions. The next step for the city will be to develop a strategy on how we as a community will achieve the target.
- Louisville completed Phase 1 of the 100 Resilient Cities Strategy Development process, which included an Agenda Setting Workshop and preparing a Preliminary Resilience Assessment. The city also completed Phase 2 of the process, which focused on identifying actions and strategies that will build community resilience through an equity lens.

Goal 4: Achieve and maintain National Ambient Air Quality Standards (Ongoing)

- Louisville's air quality continues to improve, but more improvements will be needed to meet all of the National Ambient Air Quality Standards (NAAQS). To determine an area's status in meeting these national, health-based standards, a "design value" is calculated for each pollutant. While each is calculated differently, they all consider three-years of air monitoring data to derive a design value. As levels of fine particulates (PM2.5) continue to decrease, Louisville has been reclassified from "Unclassifiable" for the current (2012) Annual standard of 12.0 µg/m3 to "Attainment." The area's current 2016-2018 design value for Annual PM2.5 is 9.4 µg/m3. Although a portion of Louisville was still officially designated as "Nonattainment" for the 1-hour sulfur dioxide (SO2) standard in 2018, the current 2016-2018 design value of 18 ppb (compared to the current standard of 75 ppb) shows the significant improvements made of the past few years. In 2015, the Environmental Protection Agency (EPA) set a new, more stringent NAAQS of 0.070 ppm for 8-hour ozone levels (down from the previous standard of 0.075 ppm). With a 2016-2018 design value of 0.075 ppm, the Louisville area has been designated as "Nonattainment" for this standard. The Louisville Metro Air Pollution Control District (APCD) has begun planning efforts with EPA to find strategies to help the area meet this challenge.
- APCD began offering the Clearing the Air community workshops series to educate the public on the science of air pollution, the laws and regulations that protect our health from harmful emissions, and what goes into keeping Louisville's air clean.



LOUISVILLE

GREENHOUSE GAS EMISSIONS REDUCTION PLAN

APRIL 2020

SUSTAIN Louisville

Executive Summary

Louisville's Greenhouse Gas (GHG) Emissions Reduction Plan (ERP) establishes a framework for achieving the climate action goals that Louisville Metro Government (Louisville Metro) committed to under the Global Covenant of Mayors for Climate & Energy on Earth Day 2016. As the first part of this commitment, Louisville Metro updated its community-wide GHG inventory in 2016 to describe the current sources of GHG emissions generated within its political boundaries. As the second part of the commitment, Louisville Metro joined cities across the globe in setting a target to reduce its community-wide GHG emissions by 80% by 2050. This target was chosen in December 2018 because it aligned with the Paris Agreement and the scientific consensus of what was required to avoid the most damaging effects of climate change at that time.

The ERP builds on a history of past work completed by Louisville Metro to understand the level of GHG emissions generated in our community. In 2005, Louisville Metro joined the U.S. Mayors Climate Protection Agreement. In 2008, Louisville Metro completed Louisville's first GHG inventory based on the 2006 calendar year. In 2018, Louisville Metro released an updated inventory based on the 2016 calendar year. This updated inventory estimates that Louisville generates 16,000,537 tonnes of carbon dioxide equivalent (tCO_2e) per year. Without making any changes, we can expect to see emissions rise to 18,766,066 by the year 2050. If Louisville is successful in reducing emissions by 80% by 2050, remaining GHG emissions will be 3,383,063 tCO_2e (Table E1).

Table E1. Summary of Louisville Metro's GHG Emissions and GHG Reduction Targets

2016 Baseline	2050 Business as Usual	2035 Interim Target	2050 80% Reduction Target
16,000,537 tCO_2e	18,766,066 tCO_2e	12,612,255 tCO_2e	3,383,063 tCO_2e

In addition to setting the target, the ERP communicates strategies that will set Louisville on a path to achieve it. New or improved technologies, continued population growth, regulatory changes, and our connection and relationship with the global economy will drive change in our community. The selected strategies include actions that are already successful in peer cities and reflect our best understanding of where current trends will take us in the years ahead. Although these strategies require significant effort, they align with best practice and are shared with many other communities.

Achieving our reduction goal will require coordinated action from government, businesses, industry, and residents. We identified strategies across six key areas that outline areas of focus for reducing our carbon footprint. These include Residential Buildings, Commercial and Institutional Buildings, Manufacturing Industries and Construction, the Energy Industry, Transportation, and Waste. Strategies include actions that range from administrative policies, incentives, and collaborative partnerships to operational changes and targeted investment in new infrastructure and building technology.

The selection of strategies was informed by input received from key stakeholders, Louisville Metro leaders and internal stakeholders, and from residents through a community survey. Through survey responses, we heard clear messages on which actions were widely supported by the community. The ERP focuses on actions that are broadly supported and actions the community sees as beneficial to improving the quality of life in Louisville. As a forward-looking document, the ERP is intended to be flexible and will be reviewed and updated regularly as a living document.

State of Louisiana

UNION JUSTICE AND CONFIDENCE

EXECUTIVE DEPARTMENT

EXECUTIVE ORDER NUMBER JBE 2020 – 18

CLIMATE INITIATIVES TASK FORCE

WHEREAS, Louisiana's working coast is a national treasure, exporting over $120 billion in annual goods, servicing 90% of the oil and gas activity in the Gulf of Mexico, producing 21% of all commercial fisheries landings by weight in the Lower 48 states, and providing winter habitat for five million migratory waterfowl;

WHEREAS, coastal Louisiana is also a vital regional asset which serves as residence to 2.5 million people and as a historical foundation to our unique cultural heritage;

WHEREAS, Louisiana's coast continues to experience one of the fastest rates of land loss in the world, and parts of our State remain unprotected from or vulnerable to future hurricane and flood event impacts;

WHEREAS, Louisiana and its citizens have suffered catastrophic losses and human, economic, and social harm as a result of increased flood risk due to coastal land loss, and the continued threat of further land loss to Louisiana's coast endangers its residents, economy, and native fish and wildlife species;

WHEREAS, beginning in 2007, Louisiana has adopted, carried out, and updated a comprehensive plan for a sustainable coast (the "master plan");

WHEREAS, the master plan integrates coastal protection strategies and coastal restoration strategies to provide increased flood protection for communities and to maximize the amount of land maintained or restored in coastal Louisiana;

WHEREAS, according to the 2017 Coastal Master Plan, without significant action, continued subsidence and sea level rise over the next fifty years could result in the additional loss of between 2,250 and 4,120 square miles of Coastal Louisiana;

WHEREAS, rising sea levels will reduce the effectiveness of built and planned investments in coastal protection and restoration, threatening the longevity of coastal protection and restoration projects;

WHEREAS as is the case today with natural disasters, impacts from climate change will be disproportionately felt by the residents of our state with the fewest resources;

WHEREAS, in the 2018 Special Report Global Warming of 1.5 Degrees Celsius, the Intergovernmental Panel on Climate Change (the "IPCC") concluded that overall "climate-related risks to health, livelihoods, food security, water supply, human security, and economic growth are projected to increase with global warming of 1.5 degrees and increase further with 2 degrees" above pre-industrial temperatures;

WHEREAS, in the same 2018 Special Report, the IPCC further concluded that reducing greenhouse gas emissions can slow global warming and reduce the magnitude and speed of future sea level rise, enabling greater opportunities for adaptation for human and ecological systems in low-lying coastal and deltaic areas;

WHEREAS, limiting global warming to 1.5 degrees Celsius would require global net human-caused emissions of greenhouse gases to fall by about 45% from 2010 levels by 2030, reaching "net zero emissions" around 2050;

WHEREAS, to improve our resilience, sustain our coast, and help avoid the worst impacts of climate change, Louisiana must proactively work to reduce the greenhouse gas emissions that are driving up global temperatures, raising sea levels, and increasing risks that threaten our health and safety, quality of life, economic growth, and vital habitats and ecosystems;

WHEREAS, a significant reduction in greenhouse gas emissions will require a coordinated, intentional, and collaborative state effort;

WHEREAS, Louisiana Revised Statute 49:214.3.1 directs the Governor, through his Executive Assistant for Coastal Activities, to "coordinate the powers, duties, functions, and responsibilities of any state agency relative to integrated coastal protection";

WHEREAS, Louisiana is committed to working with Louisiana businesses, industries, local communities, and civil society to reduce emissions through a suite of balanced policy solutions;

WHEREAS, by following the science and welcoming all stakeholders, Louisiana can and will reduce greenhouse gas emissions to limit the impacts of climate change that harm the state's natural and cultural heritage, while adapting to maintain its position as a world leader in energy, industry, agriculture, and transportation;

NOW THEREFORE, I, JOHN BEL EDWARDS, Governor of the State of Louisiana, by virtue of the authority vested in the Constitution and laws of the State of Louisiana do hereby order and direct as follows:

SECTION 1: The Climate Initiatives Task Force (hereafter the "Task Force") is hereby established within the executive branch, Office of the Governor – Coastal Activities.

SECTION 2: The duties of the Task Force shall include, but are not limited to, the following:

A. Review and comment on ongoing efforts to update the state's greenhouse gas emissions inventory;
B. Investigate and make recommendations for the reduction of greenhouse gas emissions originating in Louisiana to achieve the following greenhouse gas emissions reduction goals:

   1. By 2025, reduce net greenhouse gas emissions by 26-28% of 2005 levels;
   2. By 2030, reduce net greenhouse emissions by 40-50% of 2005 levels; and
   3. By 2050, reduce greenhouse gas emissions to net zero;

C. Develop policies, strategies, and incentives designed to achieve the net emissions reduction targets established in this Order, while improving the health and welfare of the people of Louisiana and advancing Louisiana's economic and energy profile.

SECTION 3: By February 1, 2021, the Task Force shall submit to the Governor and Coastal Protection & Restoration Board an interim report recommending strategies, policies, and incentives for meeting the goals provided in Section 2 of this Order. The report, in whole or in part, shall also be submitted to the relevant legislative committees.

SECTION 4: By February 1, 2022, the Task Force shall submit to the Governor and Coastal Protection & Restoration Board a detailed plan for meeting the goals provided in Section 2 of this Order. The plan, in whole or in part, shall also be submitted to the relevant legislative committees.

SECTION 5: After February 1, 2022, the Task Force shall meet at least annually and shall submit to the Governor and Coastal Protection & Restoration Board an annual status report on the implementation of greenhouse gas emission reduction strategies, policies, and incentives.

SECTION 6: The Coastal Protection and Restoration Authority Board shall consider the recommendations of the Task Force for inclusion in the comprehensive plan for a sustainable coast.

SECTION 7: The Task Force shall be composed of a maximum of twenty-three (23) voting members who, unless otherwise specified, shall be appointed by and serve at the pleasure of the Governor and shall include:

1. The Executive Assistant to the Governor for Coastal Activities, or his designee,
2. The Commissioner of Administration, or his designee;
3. The Commissioner of the Louisiana Department of Agriculture and Forestry, or his designee;
4. The Executive Director of the Coastal Protection and Restoration Authority, or his designee;
5. The Secretary of Louisiana Economic Development, or his designee;
6. The Secretary of the Department of Natural Resources, or his designee;
7. The Secretary of the Department of Environmental Quality, or his designee;
8. The Secretary of the Department of Transportation and Development, or his designee;
9. A member of the Louisiana Public Service Commission, or his designee;
10. The Speaker of the Louisiana State House of Representatives, or his designee;
11. The President of the Louisiana State Senate, or his designee;
12. A person appointed by the Governor from at least three nominations submitted by the Louisiana Mid-Continent Oil and Gas Association;
13. A person appointed by the Governor from at least three nominations submitted by the Louisiana Chemical Association;
14. A representative of an electricity utility;
15. A nonvoting representative of a federal scientific agency;
16. A member of the environmental nonprofit community;
17. A person with experience in community development and engagement;
18. A member of Louisiana's academic community;
19. A member of the environmental justice community;
20. A member of an indigenous tribe, nation, or community;
21. A representative of local government perspectives;
22. A person with qualifications deemed appropriate by the Governor, which shall include experience in climate change policy; and
23. A person appointed at-large.

SECTION 8: The Executive Assistant to the Governor for Coastal Activities, or his designee, shall serve as the Chair of the Task Force.

SECTION 9: The Task Force shall meet at regularly scheduled meetings and at the call of the Governor or the Chair. All meetings of the Task Force shall be subject to the Open Meetings Law as contained in La. R.S. 42:11 et seq. A majority of the serving members of the Task Force shall constitute a quorum. The Task Force shall act by a majority vote of its serving members. The nonvoting representative of a federal scientific agency shall not count as a member for quorum or voting purposes.

SECTION 10: The Task Force shall be supported by committees, including but not limited to the following:

A. power production, distribution, and use;
B. land use, buildings, and housing;
C. transportation;
D. agriculture, forestry, conservation, and waste management;
E. manufacturing and industry; and
F. mining and oil and gas production.

The membership of the committees and their co-chairs shall be determined by the Task Force Chair and may include individuals who do not serve on the Task Force. Each committee shall be co-chaired by at least one member of the Task Force.

SECTION 11: The Task Force and its committees shall be assisted and advised by a scientific advisory group, a finance advisory group, an equity advisory group, and a legal advisory group.

SECTION 12: The Task Force shall be staffed by employees of the Office of the Governor, Office of Coastal Activities. In addition, all executive branch agencies shall cooperate fully with the Task Force and provide any assistance necessary, upon request of the Task Force or its staff.

SECTION 13: All departments, commissions, boards, offices, entities, agencies, and officers of the State of Louisiana, or any political subdivision thereof, are authorized and directed to cooperate with the Task Force in implementing the provisions of this Order and the recommendations of the Task Force.

SECTION 14: The Task Force may collaborate with or seek input from additional local, state, and federal agencies or other stakeholders, including university or not-for-profit research institutions, to develop, implement, and evaluate the necessary components or actions of the Task Force.

SECTION 15: Task Force members shall not receive additional compensation or a per diem from the Office of the Governor for serving on the Task Force.

SECTION 16: This Order is effective upon signature and shall continue in effect until, amended, modified, terminated, or rescinded by the Governor, or terminated by operation of law.

IN WITNESS WHEREOF, I have set my hand officially and caused to be affixed the Great Seal of Louisiana in the City of Baton Rouge, on this 19th day of August, 2020.

GOVERNOR OF LOUISIANA

ATTEST BY THE SECRETARY OF STATE

SECRETARY OF STATE

Two cities become first in their states to commit to 100% renewable energy

By Kelsey Misbrener | March 22, 2017

The Madison Common Council formally approved the city's commitment to transition to 100% clean, renewable energy across all sectors including electricity, heating and transportation. Madison represents the first city in Wisconsin and the biggest city in the Midwest to make a community-wide 100 percent clean energy commitment.

"I look forward to working with residents, schools, churches, businesses and our local utility as we begin transitioning to clean energy, community-wide," said councilman Zach Wood. "The benefits of a transition to 100% clean energy are many. These goals will drive a clean energy economy that creates local jobs, provides affordable and sustainable electricity, and results in cleaner air and water. I am proud to be a part of this council that has made the historic commitment that will lead our community to a more sustainable future."

In an important first step toward achieving the community-wide 100% clean energy goal, the Madison Common Council vote allocated $250,000 to develop a plan by January 18, 2018 for city operations to achieve goals of 100% renewable energy and net-zero greenhouse gas emissions. This plan will include target dates for reaching these goals, interim milestones and budget estimates for the transition.

Sierra Club senior campaign representative Elizabeth Katt Reinders said, "Madison can help lead the Midwest with this bold commitment to 100% renewable energy, but we cannot do it alone. Our community has shown incredible

& Electric will heed the calls of community leaders and residents throughout our city by committing to move beyond dirty fuels and working with us to achieve our community's goals of 100% clean and renewable energy."

Madison Gas & Electric currently gets, on average, 88% of its power generation from fossil fuel sources, including 68% coming from coal-fired generation. Only 12% is from renewables.

"Tonight's vote for 100% clean energy shows a commitment to the future," said councilwoman Denise DeMarb. "This vote is for our children and grandchildren. The work ahead will take many willing hands, decisions and some sacrifice, but the result is so worth it. The future became brighter tonight because of the vote for clean energy. Madison residents can look forward to a stronger, cleaner and healthier place for all to live."

Abita Springs' commitment

Meanwhile, in Louisiana, the Abita Springs Town Council approved a resolution establishing a community-wide goal of transitioning to 100% clean and renewable energy by 2030. Abita Springs represents the first city or town in Louisiana to commit to 100% renewable energy and the 24th city across the United States to make such a commitment.

In January, Abita Springs Mayor Greg Lemons, a Republican, signed a proclamation endorsing a goal of 100% renewable energy in Abita Springs. The resolution, which builds off of the mayor's proclamation, affirms the goal of "deriving 100% of the town's electricity from renewable energy sources by December 31, 2030."

In response to Tuesday's vote, Abita Springs Mayor Greg Lemons issued the following statement:

"As the mayor of a small town, I take seriously my responsibility to set the direction for our community.

"Transitioning to 100 percent renewable energy is a practical decision we're making for our environment, our economy, and for what our constituents want in Abita Springs. Politics has nothing to do with it for me. Clean energy just makes good economic sense.

"By establishing a 100 percent renewable energy goal, we have an opportunity to use solar power that we can control in our community, for our community. Clean energy is a way that we can save money for Abita Springs both today and in the future."

LeAnn Pinniger Magee, chair of Abita Committee for Energy Sustainability, also issued the following statement:

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Exhibit No. ANR-0023
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Solar Power World

money on our utility bills, and protect our legendary water and clean air in the process."

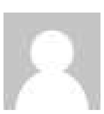
News item from Sierra Club

ABOUT THE AUTHOR

Kelsey Misbrener

Kelsey is senior editor of Solar Power World.

Comments



John Alvarez

April 20, 2017 at 8:22 pm

We need more cities in New York committing to 100% renewable energy. Great renewable energy policy incentives in New York. Learn more here — https://www.hellosolar.info/blog/solarinnyc

Reply

Trackbacks

1. **Cities are increasingly taking the lead in making bold clean energy pledges - Lizuan Technologies** says:
   May 5, 2017 at 4:20 pm

Reply

2. **Cities all over the U.S. are pledging to go 100 percent renewable. - Eco Save Earth** says:
   May 4, 2017 at 10:04 pm
   […] not just the coasts: In March, Madison, Wisconsin became the biggest city in the Midwest to pledge to a community-wide switch to 100 percent renewable energy (though it hasn't set a […]

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3. **Cities all over the U.S. are pledging to go 100 percent renewable.** says:
   May 4, 2017 at 8:50 pm
   […] entirely volunteer-driven. It's not just the coasts: In March, Madison, Wisconsin became the biggest city in the Midwest to pledge to a community-wide switch to 100 percent renewable energy (though it hasn't set a […]

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Maxeon releases line of flexible silicon-based solar panels

Silfab solar modules now distributed through BayWa r.e.

Power Factors acquires 3megawatt in asset management software consolidation

UL acquires solar software platform from Clear Sky Analytics

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City of Petoskey

Agenda

CITY COUNCIL

June 17, 2019

1. Call to Order - 7:00 P.M. - City Hall Council Chambers

2. Recitation - Pledge of Allegiance to the Flag of the United States of America

3. Roll Call

4. Consent Agenda – Adoption of a proposed resolution that would confirm approval of the following:

   (a) June 3, 2019 regular session City Council meeting minutes

   (b) Acknowledge receipt of a report concerning certain administrative transactions since June 3, 2019

5. Miscellaneous Public Comments

6. City Manager Updates

7. New Business

   (a) Adoption of a proposed resolution that would approve 100% renewable energy powering the City's electric needs by 2040

   (b) Authorization to approve the Municipal Curbside Recycling Service Agreement with Emmet County

   (c) Adoption of two proposed resolutions that would adopt and implement a Local Agency Pavement Warranty Program as required by the State

8. City Council Comments

9. Adjournment

City of Petoskey

Resolution

A RESOLUTION ADOPTING A VISION OF 100% RENEWABLE ENERGY POWERING THE CITY OF PETOSKEY'S ELECTRIC NEEDS BY 2040

WHEREAS, a recent study published by scientists and experts titled *"An Assessment of the Impacts of Climate Change on the Great Lakes,"* concluded that the effects of climate change on the Great Lakes is occurring at a much faster pace than other parts of the country and that if not properly mitigated, climate change has the potential to degrade economic, aesthetic, recreational and ecological factors in Midwestern communities; and

WHEREAS, research has demonstrated that in addition to climate benefits, shifting to 100% renewable energy creates jobs, boosts economic growth, has marginal impact on energy rates, and if done pragmatically over time, keeps energy rates lower over time as well as reducing pollution-which improves public health, saves lives and reduces health care costs; and

WHEREAS, the City of Petoskey has adopted the 2014 Petoskey Master Plan that addresses environmental, economic and social goals pertaining to long-term sustainability and resiliency within the community; and

WHEREAS, the Petoskey Master Plan states that the community should encourage sustainability and resiliency measures through the reduction of dependence upon fossil fuels and activities that harm life-sustaining ecosystems while meeting the hierarchy of present and future human needs fairly and efficiently; and

WHEREAS, the Petoskey Master Plan also encourages the City to "*Work with the Michigan Public Power Agency (MPPA) and other jurisdictions to develop and utilize alternative, renewable energy resources";* and

WHEREAS, the City Council adopted the 2018 Action Plan with Goal Five to Develop and Promote Community Sustainability Measures by conserving energy and promoting energy efficiencies and the use of clean and renewable energy; and

WHEREAS, addressing energy use and climate change with renewable energy goals provides an opportunity for the City to move towards greater community sustainability and resiliency; and

WHEREAS, in March of 2019, MPPA representatives made a presentation to the Petoskey City Council stating that wind and solar power are currently competitive sources of new energy generation now and into the foreseeable future; and

WHEREAS, the City of Petoskey owns and operates its own electric utility and desires to maintain affordable electric rates for residential and commercial properties; and

WHEREAS, renewable energy resources have been shown by a wide range of studies to be the most cost-effective and stable future sources of energy power generation; and

WHEREAS, rooftop solar, low-income community solar, and demand control technologies can be integrated through rate studies and analysis that offer the opportunity to redistribute resources, address poverty, and stimulate new economic activity in the City; and

WHEREAS, the City is currently undertaking energy audits that will provide valuable information on how to increase energy efficiency on City buildings further complementing the efforts to transition to more renewable energy production:

NOW, THEREFORE, BE IT RESOLVED that the City of Petoskey City Council does and hereby authorizes the following:

The City of Petoskey resolves to partner with MPPA and its other member jurisdictions to derive 100% of the community's electric energy through renewable energy resources and associated technologies by 2040. To that end, the City of Petoskey establishes the following goals:

- **Transition to Renewable Energy Sources:** Work with MPPA and other member jurisdictions to increase the percentage of electric power generated by renewables according to the following schedule.

December 31, 2020	15%
2025	25%
2030	40%
2035	70%
2040	100%

- **Maximizing opportunities for citizen participation and the development of new business models:** At the heart of a successful 100% renewable energy strategy, it will be fundamental to allow open participation in the development and financing of energy infrastructure.

- **Structured mechanisms to include low-income citizens in the benefits to be derived:** Access to the financial and environmental benefits of renewable energy must be shared equally across all economic classes.

- **Educating and informing citizens and businesses:** Implementing a 100% renewable energy strategy will require the participation of a variety of stakeholders, which makes both the breadth and the depth of awareness crucial to long term success. Educating and informing the public as well as businesses about Petoskey's renewable energy goals and its long-term benefits will facilitate public support and acceptance.

- **Adopting an integrated approach to fiscal, economic and energy policy:** A successful 100% renewable energy strategy will require an integrated approach across policy areas such as fiscal, energy, economic and infrastructure policy.

- **Review of Renewable Energy Goals:** At least every two years, City Council and Staff will review progress on the aforementioned goals.

State of Michigan)
County of Emmet) ss.
City of Petoskey)

I, Alan Terry, Clerk of the City of Petoskey, do hereby certify that the foregoing is a true copy of a resolution adopted by the City of Petoskey City Council in regular session assembled on the ____ day of _____ 2019, and of the whole thereof.

In witness whereof, I have here unto set my hand and affirmed the corporate seal of said City this ____ day of _____, 2019.

____
Alan Terry, City Clerk

Traverse City Commits to 100% Clean Energy by 2020

by Katy McBenge
Wednesday, December 21, 2016

Subject: **Traverse City Commits to 100 Percent Clean Energy by 2020**

Contact

Primary: **Kate Madigan,** 231-633-5353

Secondary: **Jim Carruthers, Mayor** 231-922-7768 jcarruthers@traversecitymi.gov (mailto:jcarruthers@traversecitymi.gov)

Tim Werner, Commissioner 231-313-6903 twerner@traversecitymi.gov (mailto:twerner@traversecitymi.gov)

Benjamin Marentette, City Clerk
tcclerk@traversecitymi.gov (mailto:tcclerk@traversecitymi.gov)

Issued: December 21, 2016

Traverse City, on Monday, pledged to power itself entirely with renewable power in just four years, adding significant momentum to a growing list of cities leading the transition to clean energy with 100 percent goals.

The resolution unanimously adopted by the Traverse City Commission sets a goal to meet all electricity needs for city operations with renewable sources by 2020. City operations include things like city buildings, streetlights, traffic signals and water treatment facilities and make up 3 to 4 percent of total electricity use in the Traverse City area. The resolution defines renewable energy as wind, solar, geothermal and landfill gas.

"Renewable energy is the right direction for our city. It creates jobs, reduces pollution, and will help keep energy prices low," said Traverse City Mayor **Jim Carruthers**. "Traverse City is nationally known for being a great place to live and visit because of our thriving downtown and our amazing natural resources. Setting forward-looking renewable energy goals matches with our reputation as a leading green city in Michigan and in the nation."

Traverse City joins two other Michigan communities with similar targets: Grand Rapids has a goal to use 100 percent renewable energy by 2025, and the Village of Northport finalized a plan this year to go fully renewable. If it accomplishes its goal by 2020, Traverse City will be the first city in the state to reach 100 percent renewable electricity for city operations. Nationally, about 20 communities have set all-renewable goals, and three have already hit the mark.

"This is a huge step forward for our city, and one that I hope will inspire other communities across Michigan to embrace 100 percent clean energy goals as a positive response to climate change and as a way to bring local benefits to their community," said **Kate Madigan**, a Traverse City resident, energy specialist for the Michigan Environmental Council (http://environmentalcouncil.org/) and director of the Michigan Climate Action Network (http://www.miclimateaction.org/) (MICAN). "I'm proud to be part of this community, and I can't thank Mayor Carruthers, and the rest of the City Commission enough for providing such strong leadership."

The Traverse City announcement is also a big win for MICAN's new 100% Renewable Cities campaign to swell the ranks of Michigan communities officially committed to—and actively pursuing—a target of 100 percent clean energy by midcentury. MICAN's broader vision is for all of Michigan to be powered entirely by renewables by 2050. A growing body of research shows (https://cleantechnica.com/70-80-99-9-100-renewables-study-central/) that shifting to 100 percent renewable energy is feasible and will produce many benefits, including stabilizing the climate, creating jobs, boosting economic growth, keeping energy rates lower over time, and reducing pollution—which would save lives, improve health, and reduce health care costs.

Traverse City and its municipal utility, Traverse City Light and Power (TCLP), have a history of leading on renewable energy. TCLP installed the state's first utility-scale wind turbine in 1996 and first community solar garden in 2013. Renewable energy has broad community support, and surveys show that most area residents support more renewable energy and would be willing to pay more for it if necessary.

The idea for a 100 percent renewable energy goal was brought to the city by a group of community members and organizations, including Citizens Climate Lobby, Groundwork Center for Resilient Communities, Michigan Environmental Council, MICAN, Michigan League of Conservation Voters, NMEAC, SEEDS, and TC350.

"Transitioning to 100 percent clean energy is going to create jobs and make for a more durable local economy that's protected from future spikes in energy prices," said **Dan Worth,** clean energy policy specialist for the Traverse City-based Groundwork Center for Resilient Communities (https://www.groundworkcenter.org/) . "With a president-elect who claimed climate change is a hoax and a Congress that has been slow to embrace a clean energy economy, real change is going to have to start at the local level. It's wonderful to see Traverse City stepping up and setting a great example for other communities."

This resolution also sets a goal of launching two clean energy or other greenhouse gas-reduction projects annually, and calls for the creation of a "Green Team" to advise city officials on sustainability efforts and craft a plan for Traverse City to become carbon neutral by midcentury. Several states, cities, and universities are now beginning to develop plans and set goals to become fully carbon neutral by midcentury, which is what scientists agree is necessary to avoid the worst consequences of climate change and sustain a livable planet.

"Traverse City is leading by example by passing this resolution," said City Commissioner **Tim Werner**, who also is a board member of TCLP. "We are focusing first on getting enough renewable energy to provide the electricity we are responsible for. By doing so, we hope to inspire the community as a whole to embrace more renewable energy."

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The City of Traverse City

Office of the City Clerk

GOVERNMENTAL CENTER
400 Boardman Avenue
Traverse City, MI 49684
(231) 922-4480
tcclerk@traversecitymi.gov

**CITY OF TRAVERSE CITY RESOLUTION
TO INCREASE RENEWABLE ENERGY AND
SUSTAINABLILTY FOR THE CITY OF TRAVERSE CITY**

Because, addressing energy use and climate change with renewable energy goals provides an opportunity for the City of Traverse City to move toward energy self-reliance and greater community resiliency; provide environmentally healthy and cheaper-to-operate buildings; encourage new economic development and local jobs; and support local renewable energy production; and

Because, the City of Traverse City and its municipal utility, Traverse City Light & Power, have a history of leading on renewable energy, installing the first utility-scale wind turbine in the state in 1996, and developing the first community solar garden in the state in 2013; and

Because, the City of Traverse City passed a 2011 Climate Action Plan with a goal to reduce greenhouse gas emissions by 25% by 2012 with suggested measures including: green electricity purchase for Government Center and many energy efficiency measures within the City of Traverse City; and created a Green Team to implement this Plan but is no longer active; and

Because, the City of Traverse City's Master Plan includes objectives to "Recognize our responsibility for Climate Change and take rectifying action" and "create an energy plan that balances our demand for electricity with a supply of energy sources that have the lowest possible net-use of fossil-based carbon fuels.

Because, at least 17 cities in the United States have set 100% renewable energy goals to date for the electricity use for municipal operations, including Grand Rapids, Michigan, and some of these cities have already met their 100% target; and

Because, research by Stanford University and other sources demonstrate that in addition to climate benefits, shifting to 100% renewable energy creates jobs, boosts economic growth, keeps energy rates lower over time, and reduces pollution – which improves public health, saves lives, and reduces health care costs; and

Because, surveys of Traverse City residents and businesses, including those completed by the Grand Vision Energy Network and Traverse City Light & Power (TCLP), have consistently found that the majority of respondents support more clean, renewable energy and more locally-generated energy, even if it means it would increase electric rates; and

Because, Michigan Public Service Commission's 2016 annual renewable energy report found that the combined cost of renewable energy and energy efficiency is less than any new generation, including new natural gas combined cycle plants, and

City of Traverse City Resolution to Increase Renewable Energy and Sustainability for the City of Traverse City

that the cost of renewable energy contracts continues to show a downward pricing trend; and

Because, the Michigan Public Power Agency presented to Traverse City Light & Power Board in June 2016 and said that wind and solar power are the best sources of new energy generation now and into the foreseeable future, recommended that the City and TCLP purchase more renewable energy; and

Resolved, that the City of Traverse City does hereby commit to meet 100% of the electricity demand for City operations as reflected by the yearly total of all municipal electric meters, with clean, renewable energy sources (defined as wind, solar, geothermal, and/or landfill gas) by 2020; and be it further

Resolved, that the City of Traverse City set a goal to reduce its greenhouse gas emissions by pursuing renewable energy and energy efficiency and/or other sustainability projects annually, with the goal of initiating at least two such projects per year from now until 2027; and be it further

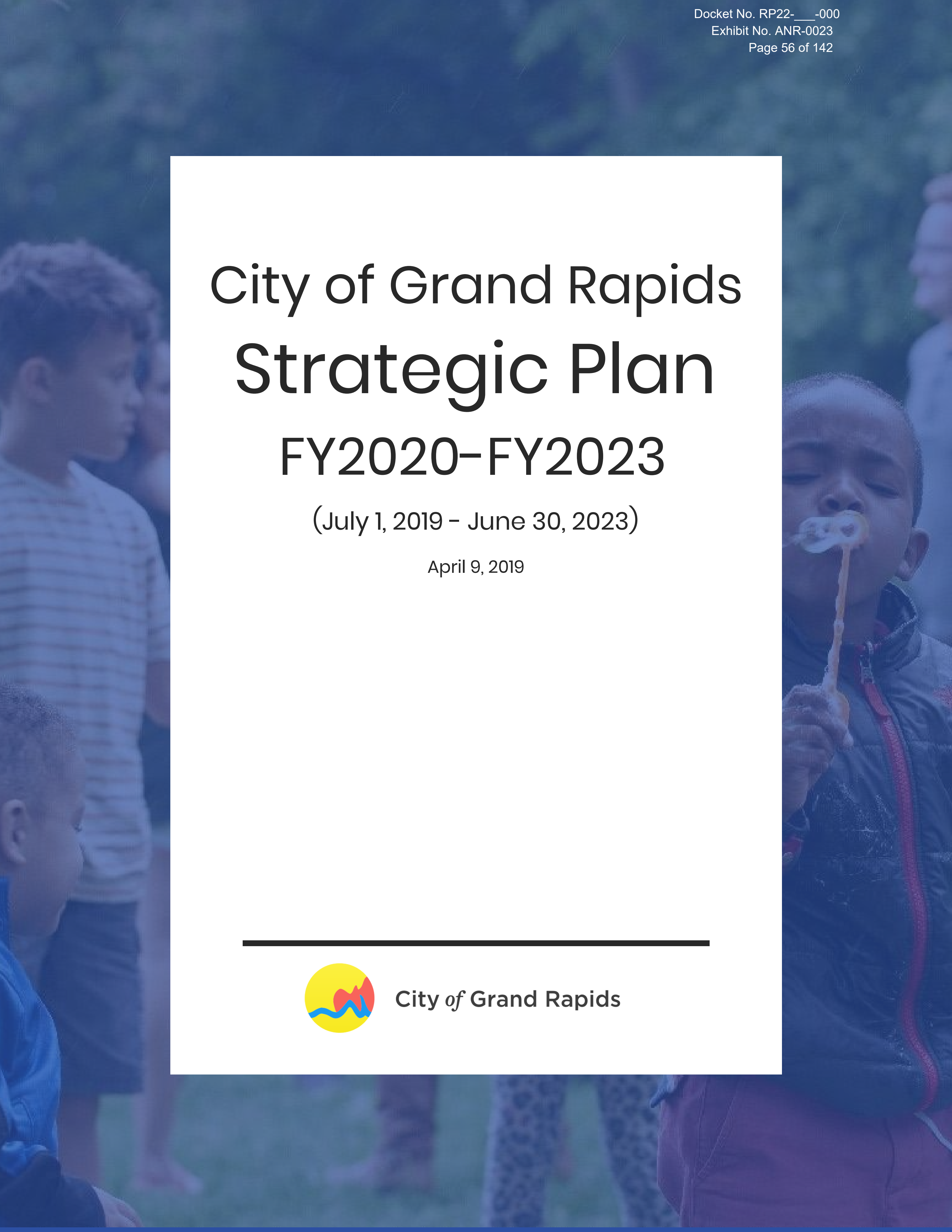
Resolved, that the City of Traverse City will create an advisory "Green Team" within 60 days comprised of 6 to 10 people designated by the City Manager including a representative from the City Planning Commission, a representative from Traverse City Light & Power, a representative from Grand Traverse County, and community members, and charged with: 1) updating the 2011 Traverse City Climate Action Plan to include a 100% renewable energy goal, new GHG reduction goals, and recommended measures to achieve these goals; 2) recommending to the City Commission two renewable energy, energy efficiency and/or other sustainability projects to be implemented each year; 3) meeting regularly to implement these objectives and reporting progress annually to the City Commission; and 4) developing a plan for Traverse City to become carbon neutral before midcentury; and be it further

Resolved, that with the creation of the Traverse City "Green Team" the City of Traverse City Commission directs the City Manager to assign City staff to promote and further develop clean and renewable energy opportunities in conjunction with the "Green Team."

I hereby certify that the above Resolution was adopted by the Traverse City, City Commission at its Regular Meeting held on December 19, 2016, in the Commission Chambers of the Governmental Center, 400 Boardman Avenue, Traverse City, Michigan.

____

Benjamin C. Marentette, MMC, City Clerk



City of Grand Rapids Strategic Plan

FY2020–FY2023

(July 1, 2019 - June 30, 2023)

April 9, 2019

City *of* Grand Rapids

Health and Environment

The health of all people and the environment are advocated for, protected and enhanced.

Objective 1: Reduce carbon emissions and increase climate resiliency.

Strategies

1. Create carbon reduction goals and integrate goals into appropriate City plans, including the Comprehensive Master Plan
2. Reduce the carbon footprint of City operations (buildings, utilities and fleet)
3. Assess the feasibility and cost of offsetting 100% of City electricity with renewable sources by FY2025
4. Create and support programs and policies to reduce carbon emissions from the building and transportation sectors throughout the community
5. Create a Climate Action and Adaptation Plan in partnership with the community
6. Work with community partners and businesses to achieve a 40% tree canopy

Draft Metrics

- Carbon footprint of city buildings, utilities and fleet (metric tons of carbon dioxide equivalents)
  2018: 59,088* Goal: To be created
  *Fleet not included
- % of City electricity supplied by renewable sources
  2018: 34% Goal for June 30, 2025: 100%
- % of tree canopy
  2018: 34% Goal: 40%

Objective 2: Ensure equitable access to and use of green spaces and increase recreational activities.

Strategies

1. Expand parks and active open spaces to reduce disparities in park deficient neighborhoods
2. Increase grade level of park maintenance as prescribed in Parks and Recreation Master Plan
3. Increase accessible, diverse and inclusive recreational programs and facilities to encourage utilization by all races, ages and abilities
4. Close gaps in the City's segments of the regional multi-use trail system
5. Increase the number of children connected to nature through expanded recreational and youth employment opportunities and through increased access to natural areas

KC GREEN
CITY OF KANSAS CITY, MISSOURI

OFFICE OF ENVIRONMENTAL QUALITY

2017 GREENHOUSE GAS INVENTORY UPDATE

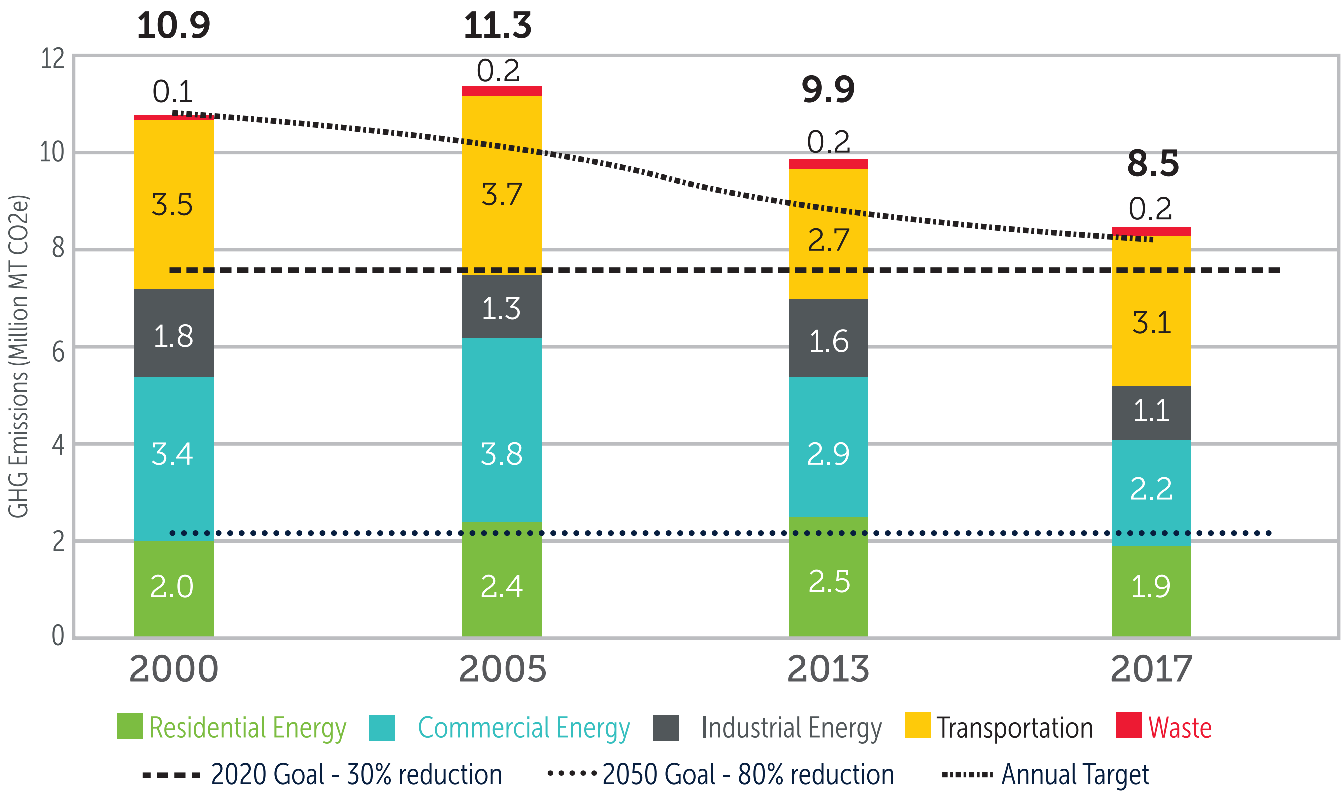


Figure 1 – Kansas City City-wide GHG Emissions by Fuel Source – 2005, 2013 Comparison

Kansas City has been working for over 18 years to address energy, water, waste, and land use city-wide and within the City's internal municipal operations. An important component of these efforts is addressing climate change by reducing the City's greenhouse gas (GHG) emissions. The City's efforts are guided by its Climate Protection Plan, which includes the following goals:

- Reduce city government GHG emissions by 30 percent below 2000 levels by 2020.
- Reduce city-wide GHG emissions 30 percent below 2000 levels by 2020 and 80 percent by 2050.

This report provides results of the 2017 GHG emissions inventory to illustrate progress made in the last 4 years toward the City's GHG goals.

The emissions generated city-wide in Kansas City in 2000 totaled 10.9 million metric tons carbon dioxide equivalent (MTCO2e) as shown in Figure 1. Since the 2000 inventory, total emissions have decreased despite a growing population, resulting in an **overall decrease in emissions of 21 percent below the 2000 baseline**. The reductions are primarily attributable to reductions in building energy use with more modest progress in the transportation sector. To meet the 2020 city-wide goal, the City must maintain the same reduction trend that was seen from 2013 to 2017 and reduce emissions at least 948,000 MTCO2e.

Taking the lead in Kansas City's community-wide emissions reduction efforts, the City conducts a separate GHG inventory of all municipal operations. In 2000, municipal operations generated 384,000 MTCO2e, or approximately 3 percent of city-wide emissions. Municipal emissions have decreased each year and in 2017 were 230,000 MTCO2e, a **decrease of 40 percent below the 2000 baseline**.

This 2017 GHG inventory update is an important step in tracking Kansas City's progress toward its emissions reduction goals. Continued tracking helps confirm the successful activities that have been undertaken to reduce emissions as well as identify areas that still need improvement. This update will help the City stay on track with its Climate Action Road Map.

STLOUIS-MO GOV

100% Clean Energy Advisory Board

The Board of Aldermen of the City of St. Louis authorizes the City's Sustainability Plan and calls for the City to commit to transition to 100 percent clean energy in the form of wind and solar and energy efficiency measures within the electricity sector by 2035.

Clean Energy Advisory Board Overview

The City of St. Louis Sustainability Office recently released a Climate Adaptation Plan for the City that details the strategies to achieve an 80 percent reduction in citywide greenhouse gas emissions by 2050.

The Board of Aldermen of the City of St. Louis authorizes the City's Sustainability Plan and calls for the City to commit to transition to 100 percent clean energy in the form of wind and solar and energy efficiency measures within the electricity sector by 2035.

The Board of Aldermen requests that the City develops a plan by December 2018 to meet the clean energy goal through a transparent and inclusive stakeholder process which includes community members as well as representatives from organizations representing labor, faith, social justice, environmental justice, frontline communities and those most impacted by our current energy systems, public health and the environment, economic development, utility sector, clean energy sector, universities and academic institutions, business, housing, employment services, low income advocates, government, and any other relevant groups.

100% Clean Energy Advisory Board Goals

Cost Effective

Meet electricity needs of consumers in the most cost-effective manner possible or should lead to cost-savings for consumers over the life of the project

Health

Improve local health outcomes and health impacts associated with the generation of electricity

Equity

Ensure equitable access for low-income communities, communities of color, and other traditionally marginalized groups

Jobs

Create additional employment opportunities for residents that meets or exceeds the City's required M/WBE requirements

Emissions

Reducing carbon emissions and harmful pollution from power plants

Pathways 2019 Executive Summary

Read the pathway strategies and goals to 100% Clean Energy in St. Louis.

Learn More, Email Us

Email us at cleanenergy@stlouis-mo.gov

Docket No. RP22-___-000
Exhibit No. ANR-0023
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Board Members

- Emily Andrews
- Rev. Rodrick Burton
- Jenn DeRose
- Andy Knott
- Bruce Morrison
- Reagan Nelson
- Rajiv Ravulapati
- Dan Siegel
- Phil Valko

View all Board Members

Agendas

May 22, 2019 100% Clean Energy Advisory Board Meeting Minutes

March 20, 2019 100% Clean Energy Advisory Board Meeting

April 24 2019 100% Clean Energy Advisory Board Meeting

January 29, 2019 100% Clean Energy Advisory Board Meeting

January 16, 2019 100% Clean Energy Advisory Board Meeting

November 28, 2018 100% Clean Energy Advisory Board Meeting

September 26, 2018 100% Clean Energy Advisory Board Meeting

July 25, 2018 100% Clean Energy Advisory Board Meeting

June 26, 2018 100% Clean Energy Advisory Board Meeting

June 12, 2018 100% Clean Energy Advisory Board Meeting

View all agendas, minutes, and meeting materials.

News and Announcements

100 Percent Clean Energy Pathways Report

| Board of Aldermen,President of the Board of Aldermen | 11/27/2019

Pathways Report 2019 Executive Summary

| Board of Aldermen,President of the Board of Aldermen | 11/18/2019

President Lewis Reed announces release of 100 percent Clean Energy Plan for St. Louis

The 100% clean energy goal was established by the unanimous passage of Resolution 124 by the Board of Aldermen.

Press release | Board of Aldermen,President of the Board of Aldermen | 11/15/2019

[St. Louis is Ready for 100 Percent Clean Energy]

Shape the future of our City's energy goals, take the online survey by May 31st

News/Announcement | President of the Board of Aldermen | 04/25/2019

[Clean Energy Informational Sessions St. Louis]

President of the Board of Aldermen led initiative to move City operations to 100% Clean Energy by 2035

Press release | President of the Board of Aldermen | 04/11/2019

[St. Louis Showcased for Clean Energy Work]

New Sierra Club Report Showcases 10 U.S. Cities Moving To 100% Clean Energy Report highlights 100% clean, renewable energy pathways for St. Louis

Press release | Board of Aldermen | 09/11/2018

[Board of Aldermen is Ready for 100]

Board of Aldermen President Lewis Reed established the 100% Clean Energy Advisory Board to move forward with 100% clean energy efforts in the City.

News/Announcement | President of the Board of Aldermen,Board of Aldermen | 07/27/2018

[Board of Aldermen Passes Resolution for Clean Energy in St. Louis]

Resolution 124 calls for the City to pursue a transition to 100% clean energy by 2050.

News/Announcement | President of the Board of Aldermen,Board of Aldermen | 10/27/2017

Upcoming Events

No upcoming events available.

[View past events and meetings.]

Related Legislation

[Resolution No. 124 | Session 2017-2018]

Questions / Comments

2018

2018 Green Cincinnati Plan

Adopted May 2018

The Energy Team enthusiastically supports these bold new ideas and has outlined a series of other opportunities and investments to help achieve the City's larger energy and greenhouse gas goals. In doing so, we have sought solutions that will not only help solve our community's energy challenges, but to confront issues of equity as well. Our diverse group of energy professionals and community leaders believes that in creating solutions that benefit all, we are best able to achieve these ambitious goals.

Jeremy Faust
Energy Task Team Lead
Fifth Third Bank

Goals

1) 100% RENEWABLE ENERGY FOR CITY GOVERNMENT BY 2035.

Path to 100% Renewable Energy
In accordance with Mayor John Cranley's commitment to 100% renewable energy by 2035, the City of Cincinnati has outlined five key steps to accomplishing this goal as well as the interim goal of achieving Carbon Neutrality by 2030.

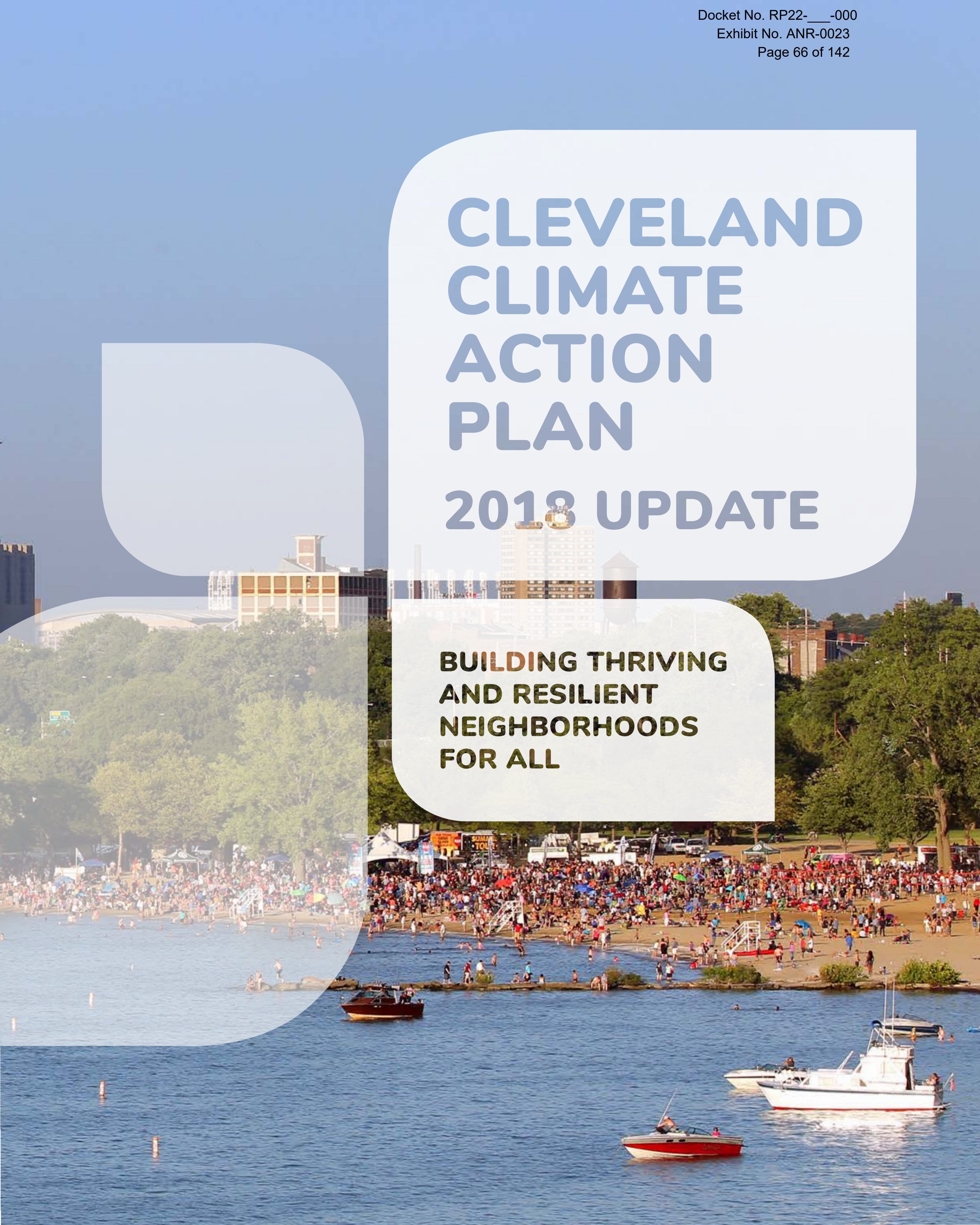
Key Steps to 100% by 2035:

1. **25 MW solar array:** Installation is scheduled to begin in 2019. The arrays will produce approximately 33 million KWH per year, eliminating 25,000 tons of greenhouse gas emissions annually. (See Energy Recommendation # 4 for more details.)
2. **RECs for City buildings:** The City has signed a contract with Dynegy to power 100% of the City's buildings with carbon-free energy. The City expects to save up to $100,000 annually and reduce greenhouse gas emissions up to 9.1% through this contract. (See Energy Recommendation # 3 for more details).
3. **Off-site power purchase agreement for the remaining electrical load:** Ohio regulations allows the City to select the generation supplier of its electricity. When the City's current electricity contract expires in December of 2020, the City will investigate contracting the remaining load not met by the solar array to an off-site renewable energy generation facility. To meet the remaining load, the array will need to produce over 260 million KWH of power, eliminating 193,000 metric tons of greenhouse gas emissions annually. (See Energy Recommendation #4 for more details.)
4. **LEED Silver for all City buildings:** All new City Facilities will be LEED Silver or better. An example of this is the District 3 Police headquarters, which is a LEED Platinum and Net Zero Energy facility. The building generates as much energy as it consumes. It is the first net zero police station in the country. Most importantly however, is that it is a functional police station enhancing the officers' ability to do their job. This facility met the LEED standards by incorporating solar panels to produce electricity, geothermal heating and cooling, LED lighting, super-insulating triple pane (and bullet proof) windows, bio-swales for stormwater retention,

CLEVELAND CLIMATE ACTION PLAN

2018 UPDATE

BUILDING THRIVING AND RESILIENT NEIGHBORHOODS FOR ALL



Introduction

When the U.S. pulled out of the Paris Climate Agreement in 2017, it became clear that leadership from cities, counties and states, businesses, and universities is needed now more than ever. So Mayor Jackson, along with climate mayors across the country, re-affirmed commitment to the Paris Agreement. A statement from the 400+ U.S. Climate Mayors aligns well with Cleveland's approach to climate action.

"We will continue to lead. We are increasing investments in renewable energy and energy efficiency. We will buy and create more demand for electric cars and trucks. We will increase our efforts to cut greenhouse gas emissions, create a clean energy economy, and stand for environmental justice. And if the President wants to break the promises made to our allies enshrined in the historic Paris Agreement, we'll build and strengthen relationships around the world to protect the planet from devastating climate risks."

80%: *Cleveland's Greenhouse Gas reduction goal by* **2050**

At the heart of climate action in Cleveland is building thriving and resilient neighborhoods throughout the city. **The 2013 Cleveland Climate Action Plan established an overarching greenhouse gas (GHG) reduction goal of 80% below 2010 emissions by 2050, with interim goals of 16% reduction by 2020 and 40% reduction by 2030.** These goals are designed to be bold yet achievable. This updated plan retains those goals, while elevating the actions neighborhoods and residents can take every day.

Goals

- 25% of electricity used in Cleveland is supplied by renewable sources by 2030 (15% by 2022)
- Ensure all residents and businesses have access to affordable clean energy programs.
- 100% of electricity demand from clean, renewable energy by 2050

Objectives

5 Generate More Solar Energy Locally

6 Improve Access to Affordable Clean Energy for Residents and Small Organizations

7 Reduce Commercial & Industrial Emissions with Advanced Technologies

8 Establish an Offshore Wind Industry in Northeast Ohio

9 Use Advanced Technology to Build a Cleaner, Safer, Smarter City

10 Support Clean Energy Policy

City of Cleveland to Launch Updated Climate Action Plan at Sustainable Cleveland Summit Sept. 20-21

Wednesday, September 19, 2018

Plan focuses on a community-wide vision to make equity, engagement, and emissions reductions central in City's response to climate change

CLEVELAND – Over the past year, the City of Cleveland's Office of Sustainability engaged more than 450 people to inform the updated Cleveland Climate Action Plan (CAP). The update maintains the goal of reducing greenhouse gas emissions 80 percent by 2050, with interim goals of 16 percent by 2020 and 40 percent by 2030. Implementing the CAP will be a major focus of Mayor Frank G. Jackson's 10th Annual Sustainability Summit, taking place Sept. 20-21, 2018 at Cleveland Public Auditorium.

"Given the U.S. withdrawal from the Paris Climate Agreement, it is even more important for Cleveland and other cities to lead on climate action," said Mayor Jackson. "This Cleveland Climate Action Plan is critical to ensuring we transition to a sustainable economy while cleaning the environment and protecting our most vulnerable residents."

The plan includes 28 key objectives in six focus areas:

- Energy Efficiency and Green Building
- Clean Energy
- Sustainable Transportation
- Clean Water & Vibrant Green Space
- More Local Food, Less Waste
- Cross-Cutting Priorities

"This plan is about much more than climate change," said Chief of Sustainability Matt Gray. "This CAP update builds off our progress by firmly establishing a series of cross-cutting priorities: (1) social and racial equity, (2) good jobs, green jobs, (3) resilience to the impacts of climate change, and (4) business leadership."

This CAP update prioritized engagement and involved the community, including 90 members of the Climate Action Advisory Committee, 300 resident leaders who participated in 12 neighborhood workshops, and those who contributed to the 200 comments received during the public comment period. The commitment to update the initial 2013 plan and report publicly on its progress has elevated Cleveland nationally and across the globe, including:

- In parallel with the Global Climate Action Summit, the City of Cleveland was selected in Sept. 2018 as the U.S. winner of the World Wildlife Fund's One Planet City Challenge. Cities were evaluated on their level of ambition and innovation for low carbon development.
- Cleveland was recognized in summer 2018 as a top five city globally in climate change reporting by the Carbon Disclosure Project, alongside Paris, Mexico City, Durban, and Sydney.
- Cleveland became compliant with the Global Covenant of Mayors for Climate and Energy, making it one of the first 10 U.S. cities to do so. The Global Covenant is an international alliance of cities and local governments with a shared long-term vision of promoting and supporting voluntary action to combat climate change and move to a low emission, resilient society.

The updated plan and the extensive engagement process behind it were supported in large part through a Partners for Places grant that looked to Cleveland as one of seven cities to incorporate equity into sustainability efforts. Each action under consideration for the plan was reviewed using a Racial Equity Tool developed by a subset of the Climate Action Advisory Committee. Additional support was provided by The Cleveland Foundation and The George Gund Foundation.

Cleveland City Hall
601 Lakeside Ave
Cleveland, Ohio 44114
Weekdays 8am-5pm

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Relay Service: 711
Send Email

City's Mission Statement

We are committed to improving the quality of life in the City of Cleveland by strengthening our neighborhoods, delivering superior services, embracing the diversity of our citizens, and making Cleveland a desirable, safe city in which to live, work, raise a family, shop, study, play and grow old.

– City of Cleveland

For more on the Cleveland Climate Action Plan and the City of Cleveland's commitment to sustainability, visit Sustainable Cleveland at www.sustainablecleveland.org/climate

About the City of Cleveland

The City of Cleveland is committed to improving the quality of life for its residents by strengthening neighborhoods, delivering superior services, embracing diversity and making Cleveland a desirable, safe city in which to live, work, play, and do business. For more information on the City of Cleveland, visit online at www.city.cleveland.oh.us, Twitter at @cityofcleveland or Facebook at www.facebook.com/cityofcleveland

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09.18.2018ClimateActionPlan.pdf

MINUTES
OF THE
REGULAR MEETING
OF
LAKEWOOD CITY COUNCIL
HELD IN COUNCIL CHAMBERS
12650 DETROIT AVENUE
OCTOBER 21, 2019
7:30 P.M.

Regular Meeting of the Lakewood City Council called to order at 7:32 PM by Council President O'Leary.

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Present: David Anderson, Thomas R. Bullock III, Meghan George, John Litten, Samuel T. O'Leary, Daniel O'Malley, Tristan Rader

Also Present: Mayor Summers, Law Director Butler, Planning and Development Director Sylvester, Human Resources Director Yousefi, Assistant Finance Director Schuster, LPD Captain Leslie Wilkins, Fire Chief Dunphy, Public Works Director Beno, Human Services Director Gelsomino, and many members of the public.

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Reading and disposal of the minutes of the Regular Meeting of Council held October 7, 2019. Motion by Mr. O'Leary, seconded by Mr. Anderson, to approve without the necessity of a reading. All members voted in favor. Motion passed.

Without objection, President O'Leary moved docket items #12 to the top of the agenda.

****OLD BUSINESS****

1. Housing Committee report regarding meeting held October 14, 2019. (to be provided)

Housing Committee Chairman Anderson delivered the following oral report:

> *Housing Committee met the evening of October 14th. All members of the Committee were present. Also present were Program Manager Mary Leigh, Assistant Law Director Jenn Swallow and Planning Director Sylvester. There were a number of items on the agenda of this meeting. The Committee voted to approve the minutes of the September 23rd meeting of the Housing Committee. Second up, was a quick update in regards to Ord 18-19 which would amend Chapter 1323 Registration of Contractors. I pledged to provide more complete feedback and next steps in regard to that ordinance in the near future. No action or deliberation was taken on Ord. 18-19.*

7. **ORDINANCE 50-18B -** AN ORDINANCE to take effect immediately provided it receives the affirmative vote of at least two thirds of the members of Council, or otherwise to take effect and be in force at the earliest period allowed by law, amending Ordinance 50-18A adopted May 20, 2019, authorizing the Mayor (Director of Public Safety), the Director of Public Works, the Director of Law, the Director of Finance, and/or the Purchasing Manager to enter into contracts for professional services, and to advertise for bids and enter into contracts for the purchase of repair maintenance and operating supplies, services and equipment as authorized by the 2019 Appropriation Ordinance and the Administrative Code of the City of Lakewood with the lowest and best bidder or bidders or as otherwise provided by law. *(1st reading 10/7/19)* (pg.009)

Motion by President O'Leary, seconded by Vice President Anderson to defer Ordinance 50-18B.

All members voting yea. Motion passed.

******NEW BUSINESS******

8. Communication from Councilmembers Bullock & Rader regarding resolution to adopt "Ready for 100" clean energy goals for Lakewood. (pg. 016)

Motion by Councilman Rader, seconded by President O'Leary to receive and file the communication.

Discussion: Councilman Bullock spoke about the practicality and affordability of adopting clean energy principles. He indicated that Fortune 500 companies and large institutions such as universities and the US Army have transformed electric markets through their purchase of renewable energy. By having a more sustainable energy grid, he believes Lakewood is better positioned to attract and retain residents. Costs have solar energy have trended down over the past 10 years, while its efficiency has trended upward. Councilman Anderson added that the issue of sustainability should now start to become part of Council's annual budget discussion with the administration and asked that the Resolution 9099-19 be referred to a committee of Council's choosing.

All members voting yea. Motion passed.

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9. **RESOLUTION 9099-19 -** A RESOLUTION to establish a goal of one hundred percent clean energy for the City of Lakewood facilities by 2025 and for the community at large by 2035. (pg. 018)

Motion by President O'Leary, seconded by Councilmember Bullock to adopt Resolution 9099-19.

Discussion: Councilmember Bullock stated that out of respect for the points voiced by Vice President Anderson, that he is open-minded to committee referral.

Motion by President O'Leary, seconded by Councilmember Rader to refer to Public Works Committee.

<u>Callum Holland – 2053 Arthur Ave.</u>
Callum spoke in support of Resolution 9099-19. He spoke about his research as a member of the Harding Green Team. He asked about the recent changes in plastics recycling in Lakewood.

President O'Leary & Mayor Summers explained the reason for the recent changes, noting that the economics of plastics recycling is dependent on the price of oil. Recently, markets overseas have stopped buying US plastics for recycling. In the past few years, the City would get paid for its recyclables and now, it must pay to dispose of them.

Vice President Anderson remarked on our society's continued dependence on crude oil.

<u>Richard Beck – Magadore</u>
Mr. Beck spoke in support of Resolution 9099-19, representing the Portage Trail Group of the Sierra Club. He urged politicians on all sides to come together around climate change. He thanked Council for bringing these topics to the forefront.

<u>Dave Simons – University Heights</u>
Mr. Simons spoke in support of Resolution 9099-19, as a co-chair of the Sierra Club's Energy Committee. He thanked Council for bringing this issue forward. He expressed optimism that 100% clean energy is possible and cost effective. He spoke about the need for action on climate issues.

<u>Cathy Cowan Becker – Grove City</u>
Ms. Becker spoke as Chair of the Ready for 100 Campaign. She thanked Council for supporting the initiative. Lakewood will be City 141 in Ohio. She spoke about the need to take action on climate change and what other cities are doing. She laid out the blue print for how to achieve the goals of the resolution and expressed optimism that the goal is achievable.

<u>Chad Stephens – Cleveland</u>
Mr. Stephens urged Council to adopt Resolution 9099-19 tonight and discussed the urgency of climate change. He urged all cities and communities to be accountable and do their parts. He spoke of the importance of Lakewood being a leader on this issue.

<u>Glenn Campbell – 15305 Lanning Ave.</u>
Mr. Campbell thanked Council for introducing and considering this. He noted that while some residents may need persuading on this issue, that many are very supportive. He spoke about the expertise, resources, and passion among citizens for this issue.

Councilmember Rader remarked about the role of citizens in bringing this item to the docket.

<u>Tom Collins – Garrettsville</u>

Mr. Collins spoke about his role with Drive Electric Ohio and the Sierra Club Energy Committee. He thanked Council for being a leader on this issue. He stated that small communities are taking note of Lakewood's action.

Discussion: Councilmember Litten expressed his willingness to act tonight, given that the resolution is aspirational in nature and that Council would have to be involved in any more concrete steps.

After further discussion, Council agreed that it would adopt the Resolution and also meet in Public Works to discuss the details.

Motion by President O'Leary, seconded by Vice President Anderson to adopt Resolution 9099-19.

All members voted in favor. Motion passed. Resolution 9099-19 adopted.

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10. Communication from Councilmembers Bullock, Rader, and Mayor Summers regarding a resolution to approve a power purchase agreement to enable the installation of solar panels on four City of Lakewood buildings. (pg. 019)

Motion by President O'Leary, seconded by Vice President Anderson to receive and file the communication.

All members voting yea. Motion passed.

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11. **RESOLUTION 2019-01** - A RESOLUTION to take effect immediately provided it receives the vote of at least two thirds of the members of Council, or otherwise to take effect at the earliest period allowed by law, authorizing the Mayor or his designee to enter into a solar power purchase agreement with Enerlogics Solar LLC for the installation of solar panels and purchase of the power generated from the solar panels at four City locations. (pg. 027)

Motion by President O'Leary, seconded by Vice President Anderson to refer to Public Works.

Discussion: Council discussed the preferred Committee to which the legislation should be referred.

On the motion: All members voting yea. Motion passed.

****

SUSTAINABLE COLUMBUS

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BACKGROUND

At Mayor Ginther's 2020 State of the City address, Mayor Ginther committed the City of Columbus to pursuing community choice aggregation with a goal to implement a program that provides 100% clean, renewable energy by 2022. In order to meet the goal, the City of Columbus has placed community choice aggregation on the November 3, 2020 ballot. Columbus residents voted 'yes' for a 100% clean energy community choice aggregation program.

Clean Energy Columbus is starting June of 2021! Visit ***http://www.cleanenergycolumbus.org*** to learn more.

WHAT IS COMMUNITY CHOICE AGGREGATION?

Community choice aggregation is an easy and effective way for local officials to contract for competitively priced electricity based on group buying power for its residents. Under community choice aggregation, the City of Columbus will contract to provide residents and small businesses competitively priced, clean electricity from a retail generation supplier certified by the Public Utilities Commission of Ohio.

To learn more, watch this 2-minute video: ***https://bit.ly/37gmCX8***

In addition, Columbus ***GreenSpot*** held a webinar on CCA to discuss how it works and how it's tied into Columbus' broader Sustainable Columbus work. To view a recording of this webinar, ***click here***.

BENEFITS OF COMMUNITY CHOICE AGGREGATION

- 100% clean energy sourced from wind, solar, and battery storage
- Clean energy jobs through an increased demand for local renewable energy
- Competitive pricing through bulk-purchase and community choice

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COMMUNITY CHOICE AGGREGATION ADVISORY GROUP

The City is convening an advisory group to collect stakeholder feedback and discuss the community choice aggregation program. The meeting schedule and related materials can be viewed below.

Advisory Group Meeting 1: September 10, 2020
-***Slide Deck***
-***Link to Recording***, *password 3FpS4G3**

Advisory Group Meeting 2: September 24, 2020
-***Slide Deck***
-***Link to Recording*** *(direct download)*

Advisory Group Meeting 3: October 8, 2020
-***Slide Deck***
-***Link to Recording***, *password fK*m5AaD*

Advisory Group Meeting 4: October 22, 2020
-***Slide Deck***
-***Link to Recording***, *password j?@WFc39*

Advisory Group Meeting 5: December 11, 2020
-***Slide Deck***
-***Link to Recording***, *password j3l7z*9s*

Advisory Group Meeting 6: February 18, 2021
-***Slide Deck***
-***Link to Recording***, *password H*Mo.93h*

Advisory Group Meeting 7: April 15, 2021
-***Slide Deck***
-***Link to Recording***, *password *v8QXshH*

TIMELINE

February 2020: Mayor Ginther announces City's commitment to pursue CCA.
February 2020: City releases competitive bid for an Aggregation Consultant.
May 2020: City Council approves Trebel Energy as Aggregation Consultant.

June 2020: City issues public, competitive bid for a preferred supplier.

July 2020: City holds virtual Public Hearing on community choice aggregation.

July 2020: City Council passes legislation to place community choice aggregation on the November ballot.

August 2020: City “kicks-off” aggregation and announces preferred supplier.

September 2020: City holds second virtual Public Hearing on community choice aggregation.

September & October 2020: City engaging with Community Choice Aggregation Advisory Group.

November 2020: Election.

To learn more about the process to date, visit ***https://cleanenergycolumbus.org/process***.

HAVE QUESTIONS?

Contact us at 866-856-5654 or ***cleanenergyCCA@columbus.gov***.

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File #:	1642-2020 Version: 1		
Type:	Ordinance	Status:	Passed
File created:	7/2/2020	In control:	Public Utilities Committee
On agenda:	7/20/2020	Final action:	7/23/2020
Title:	To authorize the City of Columbus to perform all necessary actions to effect a Governmental Electricity Aggregation program for the City with opt-out provisions pursuant to Section 4928.20 of the Ohio Revised Code; and to declare an emergency. ($0.00)		
Attachments:	1. Ord 1642-2020 Memorandum to City Clerk's Office.pdf		

History (4) | Text

Explanation

BACKGROUND: At the 2020 State of the City, Mayor Andrew J. Ginther announced the City's intention to pursue Community Choice Aggregation, and committed the City of Columbus to an aggregation program with a 100% renewable energy supply by 2022. The primary goals of the City's electric aggregation program will be to 1) provide competitive retail energy supply costs for Columbus citizens; 2) support renewable energy development, especially local renewable energy generation, to advance Columbus' sustainable economy; and 3) to ensure that supplier(s) provide quality, reliable service and first-rate customer service. The City is also committed to an aggregation program that supports sustainability efforts, energy efficiency, and other policy priorities of the City that benefit the Columbus community.

This Ordinance authorizes the City of Columbus to perform all necessary actions to effect a Governmental Electricity Aggregation program for the City with opt-out provisions pursuant to Section 4928.20 of the Ohio Revised Code for the residents and small businesses in the incorporated areas of the City of Columbus. The City will add this program to the ballot on November 3, 2020 to be approved by electors, as required by law (the "Aggregation Program").

Pursuant to Ordinance 1111-2020, the Finance and Management Director was authorized to enter into a contract with Trebel LLC to assist the City with developing a Sustainable Columbus Community Choice Aggregation program. The purpose of this project is to implement a program that provides City of Columbus residents and small commercial retail companies a means to pool their aggregate demand for electric, so that economies of scale can be used to purchase energy at a competitive cost and increase use of renewable energy sources.

The Ohio Legislature enacted electric deregulation legislation ("Am. Sub. S.B. No. 3"), which authorized the legislative authorities of municipal corporations, townships, and unincorporated areas of the county, to aggregate the retail electrical loads located within the respective jurisdictions and to enter into service agreements to facilitate for those loads the purchase and sale of electricity. Governmental aggregation provides an opportunity for residential and small business consumers to participate collectively in the potential benefits of electricity deregulation, which include, but are not limited to, competitive electricity rates, increased consumer choice, an increased demand for renewable energy to help grow the industry, and a 100% renewable energy supply. It would be in the best interest of the City of Columbus and its residents and businesses to have the opportunity to participate in this aggregation program.

Emergency action is requested so that energy efficiency initiatives can commence as soon as possible.

Fiscal Impact: No funding is required for this legislation.

Title

To authorize the City of Columbus to perform all necessary actions to effect a Governmental Electricity Aggregation program for the City with opt-out provisions pursuant to Section 4928.20 of the Ohio Revised Code; and to declare an emergency. ($0.00)

Body

WHEREAS, the Ohio Legislature enacted electric deregulation legislation ("Am. Sub. S.B. No. 3"), which authorized the legislative authorities of municipal corporations, townships, and unincorporated areas of the county, to aggregate the retail electrical loads located within their respective jurisdictions and to enter into service agreements to facilitate for those loads the purchase and sale of electricity; and

WHEREAS, such legislative authorities may exercise said authority individually or jointly with any other legislative authorities; and

WHEREAS, governmental aggregation provides an opportunity for residents and small businesses, defined by an annual energy use of 700,000 kWh or less and not part of a national account, to participate collectively in the potential benefits of electricity deregulation, which include, but are not limited to, competitive electricity rates, increased consumer choice, increased demand for renewable energy to help grow the industry and workforce, and a 100% renewable energy supply; and

WHEREAS, the City of Columbus is committed to pursuing governmental aggregation and providing a 100% renewable energy supply by 2022; and

WHEREAS, the City of Columbus has a community-wide goal to be carbon neutral by 2050, aligning with global efforts to combat climate change and limit global temperature rise by 1.5 degrees Celsius, and is committed to emissions reduction efforts, energy efficiency, and renewable energy development to help meet these goals; and

WHEREAS, the City of Columbus seeks to establish an electric governmental aggregation program with opt-out provisions pursuant to Section 4928.20, Ohio Revised Code, for the residents and small businesses in the incorporated areas of the City of Columbus (approved through a ballot measure by City of Columbus residents on November 3, 2020), and may be in conjunction with any other legislative authorities in the State of Ohio, as permitted by law (the "Aggregation Program"); and

WHEREAS, an emergency exists in the usual daily operation of the Department of Finance and Management in that it is immediately necessary to authorize the establishment of an Electric Aggregation Program and to authorize the Board of Elections to add a ballot measure to the November 3, 2020 ballot for the same, so that such aggregation program can be implemented as quickly as possible and residents and businesses can have the option of benefiting from the economies of scale of aggregated electricity purchasing**; NOW, THEREFORE,**

BE IT ORDAINED BY THE COUNCIL OF THE CITY OF COLUMBUS:

SECTION 1. That this Council finds and determines that it is in the best interest of the City, its residents, and small businesses located within the incorporated areas of the City to establish an Electric Aggregation Program within the incorporated areas of the City that promotes local clean energy generation, energy savings, and Columbus's sustainable economy. Provided that the Aggregation Program is approved by the electors of the City pursuant to Section 2 of this Ordinance, the City is hereby authorized to automatically aggregate, in accordance with Section 4928.20 of the Ohio Revised Code, the retail electric loads located within the incorporated areas of the City, and, for that purpose, to enter into service agreements to facilitate for those loads the purchase and sale of electricity. The City may exercise such authority jointly with any other political subdivision of the State of Ohio to the full extent permitted by law, which may include use of an energy broker/consultant/aggregator, so long as the broker/consultant/aggregator is certified by the Public Utilities Commission of Ohio.

The aggregation will occur automatically for each person owning, occupying, controlling, or using an electric load center proposed to be aggregated and will provide for the opt-out rights described in Section 3 of this Ordinance.

SECTION 2. That the Board of Elections of Franklin County is hereby directed to submit the following question to the electors of the City at the election on November 3, 2020:

Shall the City of Columbus have the authority to aggregate the retail electric loads located within the incorporated areas of the City, to support local clean energy generation, energy savings, and Columbus's sustainable economy and for that purpose, enter into services agreements to facilitate for those loads the sale and purchase of electricity, such aggregation to occur automatically except where any person elects to opt-out, in accordance with Section 4928.20 of the Ohio Revised Code and Ordinance No. 1642-2020 adopted by the Council?

The City Clerk is authorized and instructed to immediately file a certified copy of this Ordinance and the proposed form of the ballot question with the Franklin County Board of Elections not less than ninety (90) days prior to the election to be held November 3, 2020. The Aggregation Program shall not take effect unless approved by a majority of the electors voting upon the Aggregation Program provided for herein at the election held pursuant to this Section 2 and Section 4928.20 of the Ohio Revised Code.

SECTION 3. Upon approval of a majority of the electors voting at the election provided for in Section 2 of this Ordinance, this Council, individually or jointly with any other political subdivision, may develop a plan of operation and governance for the Aggregation Program. Before adopting such plan, this Council shall hold at least two public hearings on the plan. Before the first hearing, notice of the hearings shall be published once a week for two consecutive weeks in a newspaper of general circulation in the incorporated areas of the City. The notice shall summarize the plan and state the date, time, and place of each hearing. No plan adopted by this Council shall aggregate the electric load of any electric load center within the incorporated areas of the City unless it, in advance, clearly discloses to the person owning, occupying, controlling, or using the load center that the person will be enrolled automatically in the Aggregation Program and will remain so enrolled unless the person affirmatively elects by a stated procedure not to be so enrolled. The disclosure shall state prominently the rates, charges, and other terms and conditions of enrollment. The stated procedure shall allow any person enrolled in the Aggregation Program the opportunity to opt-out of the program at least every three years, without paying a switching fee. Any such person who opts out of the Aggregation Program pursuant to the stated procedure shall default to the standard service offer provided under Section 4928.141 of the Ohio Revised Code, until the person chooses an alternative supplier.

SECTION 4. It is hereby found and determined that all formal actions of this Council concerning and relating to the passage of this Ordinance were adopted in an open meeting of this Council and that the deliberations of this Council and any of its committees that resulted in such formal actions were in meetings open to the public, in compliance with all legal requirements, including Section 121.22 of the Ohio Revised Code

SECTION 5. That for reasons stated in the preamble hereto, which is hereby made a part hereof, this ordinance is hereby declared an emergency measure and shall take effect and be enforced from and after its passage and approval by the Mayor, or ten days after passage if the Mayor neither approves nor vetoes the same.

Resolution

R-1718-120

A RESOLUTION OF THE COUNCIL OF THE CITY OF NORMAN, OKLAHOMA, EXPRESSING A COMMITMENT TO ENDEAVER TO TRANSITION THE CITY TO 100 PERCENT (100%) RENEWABLE ENERGY AND COMMITTING TO APPOINT A SUB-COMMITTEE OF THE ENVIRONMENTAL CONTROL ADVISORY BOARD TO DEVELOP AN OUTLINE FOR THE TRANSITION PROCESS.

§ 1. WHEREAS, the City Council of the City of Norman has been given a responsibility in trust through the public vote to protect and promote the health, safety, and welfare of its citizens, including access to clean water and air, and the protection of their life, liberty, and property; and

§ 2. WHEREAS, the Environmental Control Advisory Board (ECAB) has recommended renewable energy as one factor of its overall plan for Norman's environmental sustainability, and the City Council has adopted this plan; and

§ 3. WHEREAS, clean energy sources such as wind and solar are now more affordable than fossil fuel sources; harvesting clean energy lacks the negative externalities associated with extraction, the risks of fossil fuel consumption now outweigh the benefits, and clean energy will reduce air and water pollution and associated public health risks, reduce the strain on public resources, and save citizens money; and

§ 4. WHEREAS, renewable energy strengthens national security through a reinforced power grid that utilizes both a macro and micro grid to create a system resilient to cyberattacks and weather disasters, and provides opportunity for the City to harvest its own power, and generate jobs, tax revenue, and energy security; and

§ 5. WHEREAS, renewable energy is one of the fastest growing employment sectors nationwide and presents tremendous economic opportunity for Norman to create local jobs in an emerging industry; and

§ 6. WHEREAS, the adoption of clean energy increases economic security and prosperity for Norman residents, and strengthens sustainability through community rooftop solar to benefit people of color, indigenous communities, immigrants, refugees, as well as rural and economically disadvantaged residents who experience the impacts of pollution and climate change disproportionately; and

§ 7. WHEREAS, technological innovation is progressing rapidly, and could affect the Ready for 100 timeline, and the City of Norman, through the auspices of the Mayors' Climate Agreement Subcommittee of ECAB, will review these objectives annually to review and update as needed to reflect changes in variables, new technologies, or extreme weather events that may alter the course or timeline of these objectives. A progress report will be published annually and provided to the public to measure transitions, progress and strategies going forward; and

§ 8. WHEREAS, twenty-five cities across the nation, including San Diego, Salt Lake City, and Chicago have made commitments to transition to 100 percent clean energy, and six U.S. Cities, including Aspen, CO, Burlington, VT, Greensburg, KS, Kodiak Island, AK, and Georgetown, TX have already hit their targets to generate 100% of the energy used community-wide from clean, non-polluting and renewable sources, and Norman strives to remain a leader among its peer cities.

NOW, THEREFORE, BE IT RESOLVED BY THE COUNCIL OF THE CITY OF NORMAN, OKLAHOMA:

§ 9. That the City of Norman is committed to strive to transition to 100 percent renewable energy in the form of wind, solar, energy efficiency measures and other renewable sources within the electricity sector by 2035, with an ultimate goal of all energy-use sectors including heating and transportation by 2050.

§10. That a Mayors' Climate Agreement Subcommittee of ECAB will be formed to develop an outline for the transition process with the hope of completing it by January 1st, 2020. The Mayors' Climate Agreement Subcommittee will determine the best way to meet the renewable energy goal through a transparent and inclusive process with stakeholders, which includes individuals representing areas such as: labor, faith, social justice, environmental justice, health, academic institutions, the utility sector, economic development, housing, low income advocates, and other relevant groups. The Subcommittee will create a system to track plausible policy measures to stay on target, distribute the burden, and meet our renewable energy goals as stated above in a timely manner.

PASSED AND ADOPTED this ____ day of _______________, 2018.

____
Mayor

ATTEST:

____
City Clerk

Sustainability Director

Brian Blackmon
bblackmon@knoxvilletn.gov
(865) 215-4430

400 Main St., Room 598
Knoxville, TN 37902

March 9, 2021:
The City of Knoxville invites all members of our community to fill out a survey to plan how we reduce our collective climate footprint.

The Mayor's Climate Council and its Working Groups evaluated dozens of strategies for their impact to our climate and community, and suggested possible actions to help fulfill those strategies.

Now, to make sure that we're working towards climate strategies that make sense for our community, we want to hear your priorities and ideas. Using the questionnaire link below, please share how you think we could best reduce our collective carbon footprint.

Public Survey on Community Climate Strategies

PROJECT AREAS:

- Community Engagement
- Energy
- Goods & Services
- Urban Agriculture
- Infrastructure
- Transportation
- Sustainable Growth

For over a decade, the City of Knoxville has worked to make Knoxville a greener, more sustainable city – one where the economy, environment, and community can thrive today and in the future. Thanks to our forward-looking, pragmatic, and effective approach, Knoxville is a regional and national sustainability leader. We've saved money through efficient City operations, improved infrastructure for folks who bike, walk, or use public transit, increased renewable energy capacity, and invested in energy efficiency for our homes and businesses. Jobs in energy and advanced technology sectors are strengthening our region's economy. We've shown that when we advance sustainability, we make Knoxville an even greater city.

Learn more about the history of the Energy & Sustainability Initiative here.

Our Progress

In 2008, the City of Knoxville set a goal to reduce greenhouse gas emissions **20% by 2020** relative to 2005 levels for both municipal operations and the Knoxville community. **We're on track to exceed our municipal goal**, and community emissions are lower in the midst of a growing economy and improving quality of life for our residents. You can read more about our progress of the Energy & Sustainability Initiative in the 2017 Work Plan & Emissions Inventory Update [PDF]

Knoxville is a leader, and leaders always move forward.

We are proud of our progress, but Knoxville shouldn't settle for "that's enough."

We've set two new climate goals for 2030 and 2050 that aspire to unlock bold, innovative action to ensure a sustainable future that protects our environment while also creating inclusive economic opportunities and improving quality of life for all our citizens.

Throughout 2020-2021, the City's Office of Sustainability will lead a variety of community conversations to inform the development of a plan for how Knoxville can meet these goals.

If you would like to learn more about and/or be involved in this planning process, please fill out a short survey here.

City Government Leads by Example: 50% by 2030

Emissions associated with City operations are down 15% relative to 2005, and we're on track to exceed 20% with the completion of our LED streetlight retrofit. We've reduced emissions while saving taxpayer dollars and maintaining the quality services our residents expect.

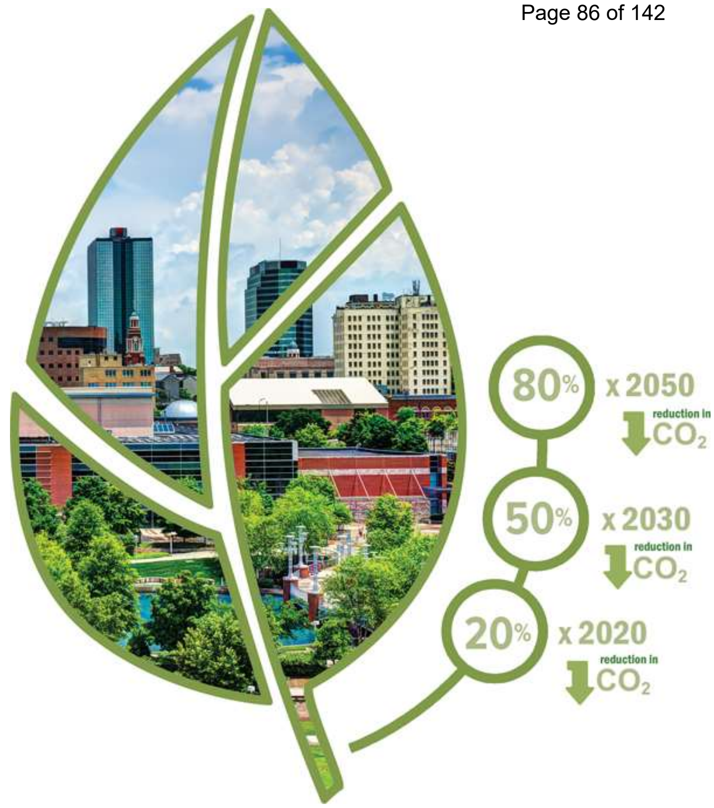
Our new goal is ambitious but realistic. With steady leadership,
the City can make smart, fiscally-responsible investments in new, cost-competitive technologies and operational innovations that achieve deep emission reductions while maintaining high quality services.

Aspiring for Deep Community Progress: 80% by 2050

The Knoxville community's greenhouse gas emissions are down 11% from 2005 levels, even while population, economic activity, and property values have increased over the last decade. We know that responsible environmental practices can go hand in-hand with economic development and an improved, more equitable quality of life.

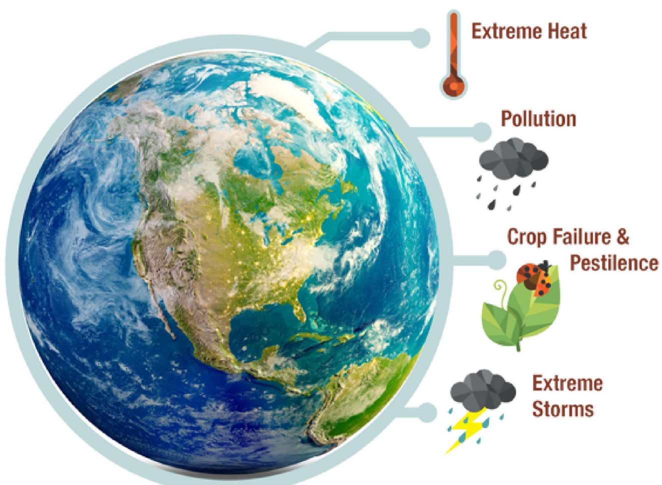
Reducing emissions 80% by 2050 is a bold aspirational goal that requires changes to technology markets and energy systems – most of which are outside City government control. But, the City is an agent of change, and by setting our compass toward a dramatically lower-carbon future, we aim to motivate cross-sector leadership from many partners to ensure Knoxville remains a great place for all residents to call home for generations to come.

Read more about the vision for Knoxville's new sustainability goals in the Sustainability Success Brochure [PDF].



Being a Sustainable Community Means Addressing Climate Change

Climate change is intensifying many challenges we already face in Knoxville, like extreme heat, extreme storms, localized flooding, air pollution, and pests to people and crops. It threatens our property, our wallets, our health, and places we love, like the Great Smoky Mountains National Park. Across the world, millions of lives are at risk. Experts agree: this big challenge calls for bold leadership to protect our children and grandchildren from the worst effects of climate change and prepare local communities to deal with impacts they already face.



Memphis City Council Adopts Climate Action Plan

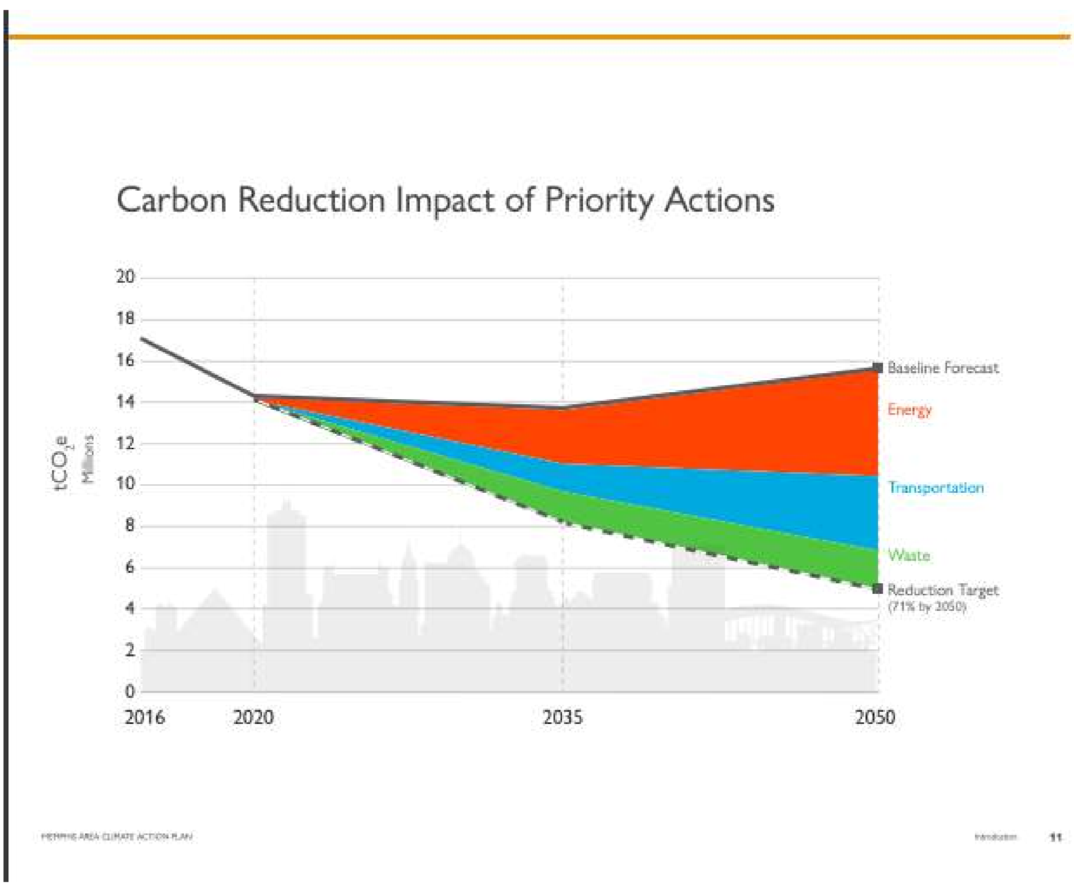
Memphis City Council adopted goals to reduce City and County climate pollution by 51% below 2016 levels by 2035, and 71% by 2050.

Brady Watson (https://cleanenergy.org/staff/brady-watson/) | April 22, 2021 | Climate Change (https://cleanenergy.org/category/climate-change/), Energy Policy (https://cleanenergy.org/category/energy-policy/), Tennessee (https://cleanenergy.org/category/tennessee/)

At their April 20 meeting, the Memphis City Council approved amendments to the Memphis 3.0 Comprehensive Plan, which includes the Memphis Area Climate Action Plan (https://shelbycountytn.gov/DocumentCenter/View/37431/Memphis-Area-Climate-Action-Plan-2019-FINAL_4_JANUARY-2020). The plan, released in January of 2020, is a joint venture between the City of Memphis and Shelby County. With support from City of Memphis Mayor Jim Strickland and Shelby County Mayor Lee Harris, the plan sets concrete carbon pollution reduction goals and lays out action steps based on input from community stakeholders.

With the benchmark of a 2016 inventory of greenhouse gas emission levels, the plan calls for reducing community-wide greenhouse gas emissions 51% by 2035, and 71% by 2050. To meet these goals, the plan includes sections on energy, transportation, and waste, with energy making up the largest share of emissions. Additionally, the plan calls on Memphis and Shelby County governments to reduce the emissions from their government-owned assets even more than the goal set for the community at large. It calls for both entities to reduce emissions in their buildings sector 55% by 2035, and 80% by 2050, and to reduce emissions in fleet vehicles 45% by 2035, and 80% by 2050.

The energy section includes actions to increase energy efficiency and renewable energy, as well as retrofit outdoor streetlights to LEDs. Specifically, the plan calls to increase the percentage of carbon-free energy in the electric grid 80% by 2035, and 100% by 2050, with a focus on solar and wind.



Source: The forecast reductions in carbon emissions from implementing strategies outlined in the [Memphis Area Climate Action Plan](https://shelbycountytn.gov/DocumentCenter/View/37431/Memphis-Area-Climate-Action-Plan-2019-FINAL_4_JANUARY-2020) (https://shelbycountytn.gov/DocumentCenter/View/37431/Memphis-Area-Climate-Action-Plan-2019-FINAL_4_JANUARY-2020).

The transportation section identifies an action to encourage the adoption of electric vehicles and the development of charging infrastructure. Goals include increasing passenger vehicle travel using electric vehicles (EVs) to 5% by 2025, 30% by 2035, and 50% by 2050. It also aims to increase freight vehicle travel by EVs to 3% by 2025, 20% by 2035, and 50% by 2050.

City of Memphis Mayor Jim Strickland said of the Memphis Area Climate Action Plan (https://shelbycountytn.gov/DocumentCenter/View/37431/Memphis-Area-Climate-Action-Plan-2019-FINAL_4_JANUARY-2020), "Climate change poses real threats to our community. Increased flooding, more frequent heat events and drought, and severe storms are all risks our city faces. Addressing climate change locally not only helps reduce these risks, but also presents exciting opportunities to positively impact everyone in our city. These actions will improve our air and water quality, lead to better health outcomes for our residents, and encourage the growth of new green businesses and jobs. Most important, these actions focus on creating a more equitable city. Climate change most impacts vulnerable populations, and it is necessary to prioritize programs and investments that will reduce disparities and increase opportunities for these communities."

Shelby County Mayor Lee Harris said, "This plan provides detailed goals and objectives for reducing our carbon footprint and outlines key actions that will not only help us achieve these goals but will also lead to a healthier, more prosperous, and more equitable community."

We applaud the members of the Memphis City Council, as well as Mayors Harris and Strickland for their work to develop and adopt this plan. We also look forward to working with City and County officials to help make these goals a reality.

Brady Watson

Kansas native Brady Watson attended Kansas State University where he received a bachelor's degree in History, and then a master's degree in Documentary Film and History from Syracuse University. After…

MY PROFILE (HTTPS://CLEANENERGY.ORG/STAFF/BRADY-WATSON/)

Together we're making a lasting impact across the Southeast.

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TVA MISTRUTHS HIGHLIGHT NEED FOR MORE OVERSIGHT OVER UNREGULATED MONOPOLY POWER COMPANY (HTTPS://CLEANENERGY.ORG/BLOG/TVA-MISTRUTHS-HIGHLIGHT-NEED-FOR-MORE-OVERSIGHT-OVER-UNREGULATED-MONOPOLY-POWER-COMPANY/)

TVA CEO Jeff Lyash's mistruths stated recently on TV highlight the need for independent oversight of TVA so that customers are not harmed by the unregulated, federal monopoly treating fantasies as truth.

(https://cleanenergy.org/blog/broward-county-exemplifies-local-leadership-tackling-climate-change/)

May 12, 2021 |

Climate Change (https://cleanenergy.org/category/climate-change/), Florida (https://cleanenergy.org/category/florida/)

BROWARD COUNTY EXEMPLIFIES LOCAL LEADERSHIP TACKLING CLIMATE CHANGE (HTTPS://CLEANENERGY.ORG/BLOG/BROW COUNTY-EXEMPLIFIES-LOCAL-LEADERSHIP-TACKLING-CLIMATE-CHANGE/)

Local climate action, exemplified by Broward County, will continue to be a critical piece to reducing carbon pollution in Florida and securing resilient communities.

(https://cleanenergy.org/blog/oil-pipeline-company-agrees-to-pause-project-memphis-city-council-delays-vote-on-ordinance/)

May 11, 2021 |

Climate Change (https://cleanenergy.org/category/climate-change/), Energy Justice (https://cleanenergy.org/category/energy-justice/), Tennessee (https://cleanenergy.org/category/tennessee/)

OIL PIPELINE COMPANY AGREES TO PAUSE PROJECT, MEMPHIS CITY COUNCIL DELAYS VOTE ON ORDINANCE (HTTPS://CLEANENERGY.ORG/BLOG/OIL-PIPELINE-COMPANY-AGREES-TO-PAUSE-PROJECT-MEMPHIS-CITY-COUNCIL-DELAYS-VOTE-ON-ORDINANCE/)

The proposed Byhalia pipeline saga continues, with the Memphis City Council Public Works committee deciding last week to delay voting on an ordinance which would present a roadblock to the pipeline.

see more related posts > (https://cleanenergy.org/category/energy-policy/)

Mayor Cooper Announces Multiple Initiatives to Combat Climate Change and Promote Sustainability, Signs Global Covenant of Mayors

12/5/2019
Chris Song

Mayor John Cooper today announced that his administration has signed the Global Covenant of Mayors as a precursor to participating in the C40 Cities Climate Leadership Group, a coalition of 94 leading cities around the world focused on tackling climate change and driving urban action that reduces greenhouse gas emissions. Mayor Cooper also introduced multiple local initiatives underway by his administration to address climate change and sustainability in Nashville and Davidson County.

"Since entering office, I began addressing immediate impediments to the function of our city – namely our financial condition," said Mayor Cooper. "But my administration has been keenly aware of other longstanding concerns, including threats to our environment and the protection of our limited natural resources. Members of my staff have been focused on identifying opportunities to improve the stewardship of our city's clean air, water, tree canopy, and other natural amenities."

Nashville's participation in the Global Covenant of Mayors requires ambitious local climate and energy action and a transition to a low-emission and resilient urban environment to benefit public and environmental health and to lay the foundation for a prosperous economy.

"Since Nashville is my home, I am honored to help Mayor Cooper advance our city's work to address the climate crisis," said former Vice President Al Gore. "He is taking important steps forward that should lead to even greater commitments. He is thinking globally and acting locally -- as we all should."

Mayor Cooper's administration will also work toward reducing Nashville's community-scale emissions 30 percent by 2030 and 70 percent by 2050. To lead by example, CO_2-reduction targets for Metro Government will be 40 percent by 2030 and 80 percent by 2050. Using Nashville's most recent emissions inventories as a baseline, these targets were developed upon surveying those adopted by peer and aspirational cities and align with science-based recommendations in the Paris Climate Accord to reduce absolute CO_2 emissions by three percent annually until 2050 in order to hold global warming to 2°C.

Mayor Cooper's initial climate change and sustainability initiatives include:

- solar power array installation atop Historic Metro Courthouse to be included in the next Capital Improvements Budget, expanding Metro's renewable energy portfolio;
- the creation of an "Energy Savings Program" to support energy efficiency efforts in Metro's general government facilities;
- LEED certifications achieved for Sheriff's Office Downtown Campus, Metro Police Department Headquarters and Family Safety Center;
- the establishment of a Sustainability Advisory Board to review active proposals as they are being implemented through legislation; and
- the introduction of legislation with Metro Council members to further strengthen tree protections under the Metro Code.

"As we enjoy the holiday season, it is perhaps likely we will not see a proverbial white Christmas this year," added Mayor Cooper. "But we can certainly work to have a green one. To ensure that our environment is as safeguarded as our pocketbooks, I am proud to announce these initial sustainability projects and policies with the guarantee that more are forthcoming, for the sake of our children and all future Nashvillians."

Following is a detailed list of Mayor Cooper's initial climate change and environmental initiatives:

1. Solar power installations across Metro facilities

A. Metro Courthouse

Among Mayor Cooper's initial proposals is the implementation of a full solar panel array atop the Historic Metropolitan Courthouse. This effort will reduce the building's costs by offsetting consumption with clean, onsite renewable energy.

Initial steps will include conducting a solar feasibility assessment to determine the ideal location and total number of solar panels that can be installed. It is estimated that the courthouse rooftop could accommodate over 200 individual solar panels capable of generating 72 kilowatts of renewable carbon-free energy.

This would constitute the first retrofit of an existing Metro building under the Metro Council's local "Green New Deal" enacted under Ordinance Nos. BL2019-1599 and -1600. This legislation adopted a renewable energy standard outlining staged goals toward eventually achieving 100 percent renewable energy for Metro-owned buildings by 2041. The "Green New Deal" legislation also adopts an energy retrofit program across at least 9 percent of metro government-owned buildings with a goal of achieving at least 20 percent reductions in average energy and greenhouse gas emissions.

The Mayor's Office has instructed the Department of General Services to manage the solar installation and building retrofit. The department currently manages nearly 100 facilities and has had experience and success with managing, monitoring, and reducing energy costs across its facilities.

The Historic Metropolitan Courthouse building, managed by the Department of General Services, currently offsets an average of 3.5 percent of its electricity by solar via a subscription to Music City Solar. The production from 510 solar panels at the city's community solar park in Madison are directed towards the Courthouse's electricity bills.

B. Other solar power array locations forthcoming

Once installed, the Historic Metropolitan Courthouse will join other Metro locations where solar power arrays are being installed, including the Sheriff's Office Downtown Campus (with 144 solar panels generating 50.4 kilowatts), the Metro Police Department Headquarters and Family Safety Center (with 864 solar panels generating 302 kilowatts), and the Bellevue Community Center (with 430 panels generating 150 kilowatts).

C. Metro Water Services 1.7-megawatt solar power facilities

An even more expansive plan is underway at Metro Water Services (MWS), which has initiated plans to install 1.7 megawatts of solar power generating capacity at three of their facilities – two wastewater treatment plants and one water treatment plant. The combined facilities will generate over 2 GWh of electricity annually – enough to power over 100 homes – and will avoid nearly 2,000 tons of greenhouse gas emissions. The MWS procurement process begins December 5, 2019 with publication and release of the RFP. The procurement approach relies upon a third-party ownership model that will result in only marginal capital investment by the department. MWS will then enjoy direct use of the solar power generated at their facilities, offsetting an estimated six million dollars' worth of conventional power over 20 years.

D. Renewable Investment Agreement with TVA for utility-scale solar power

In pursuit of even more substantial utility-scale solar power for Nashville, Mayor Cooper recently directed the Department of General Services to sign an initial agreement with NES and TVA allowing the Mayor's Office to explore a Renewable Investment Agreement (RIA) whereby TVA would procure renewable energy from new renewable generation resources within the Tennessee Valley area for the benefit of Nashville.

While Metro's efforts to develop clean sources of renewable energy are just beginning, the Mayor's Office encourages Nashvillians who have the resources to consider solar installations at their own homes and businesses.

2. Energy Savings Program to improve efficiency

Mayor Cooper has commissioned the Department of General Services with establishing an "Energy Savings Program" to support energy efficiency efforts in Metro's general government facilities with a goal of substantial reductions in energy consumption and costs.

To implement reductions, the Department of General Services will manage an "Energy Savings Revolving Fund" deploying ongoing measurement and tracking of energy savings projects for most Metro department facilities. This approach will provide a broad range of energy solutions, including design and implementation of energy savings projects, energy conservation measures, energy audits, energy infrastructure retrofits, building automation systems, utility expense management, and building retro-commissioning.

To track and manage the projects and energy savings, General Services' sustainability team will be installing a new energy management system. The system will deliver high-quality data tracking used to provide visibility into an asset's energy performance, accurate reporting of Metro's progress towards greenhouse gas emissions reduction goals, and the identification of actionable energy conservation measures. The software will be able to organize, track, visualize, benchmark, and effectively communicate trends of all commodities related to energy consumed by buildings managed by the Department of General Services.

General Services currently manages nearly 100 facilities and has had experience and success with monitoring and reducing energy costs in these facilities. Further, the department has an innovative Center of Responsible Energy staffed with an experienced team knowledgeable in energy management that monitors building automation systems in nearly half of its buildings, a seasoned energy manager, and in-depth expertise in reporting on energy utilization through the Department of Energy's ENERGY STAR Portfolio Manager.

3. LEED certifications for Metro buildings

A. Sheriff's Office Downtown Campus, Metro Police Department Headquarters and Family Safety Center

Achieving cost savings from energy efficiency will be a priority under the Cooper administration. Today, Mayor Cooper is proud to announce the pursuit of green building certification by two Metro-owned facilities.

With the assistance of the Department of General Services, the Sheriff's Office Downtown Campus has just been awarded LEED Silver certification. And the Metro Police Department Headquarters and Family Safety Center is successfully tracking toward LEED Gold certification.

LEED (Leadership in Energy and Environmental Design), developed by the U.S. Green Building Council, is the most widely used green building rating system in the world and an international symbol of efficiency and sustainability. Through design, construction, and operations practices that improve environmental and human health, LEED-certified buildings make the world more sustainable.

The Sheriff's 416,000 square foot campus in downtown Nashville will be the first of its kind to achieve LEED Silver certification in the state of Tennessee. The campus includes 436 detention cells on five levels, 60 behavioral health beds, a medical unit, kitchen and laundry facilities, intake and processing facilities, administrative space and visitation, and staff parking. This state-of-the-art facility achieved LEED certification by implementing practical and measurable strategies and solutions toward sustainability in several areas, including site development, water savings, energy efficiency, materials selection, and indoor environmental quality. More than 84 percent of the construction and demolition debris was diverted from landfills, with 33 percent of the materials containing recycled content and 50 percent of the materials procured regionally. The facility was designed to reduce water consumption by 45 percent and energy use by 21.6 percent, with a portion of the electricity demand generated onsite with rooftop solar panels. Certification is proof that the Sheriff's Office Downtown Campus is being constructed and operated to the highest level of sustainability.

4. Establishment of Sustainability Advisory Board

Among Mayor Cooper's other initial undertakings will be the establishment of a Sustainability Advisory Board that will review actual sustainability initiatives advanced by the Mayor's Office and by the Metro Council.

Previous administrations have convened environmental groups whose well-meaning members ably gathered, discussed, and prepared reports filled with ambitious proposals and recommendations. But today, Metro's problem is not a lack of proposals – it is the implementation of those proposals into actual practice. That is why the Advisory Board will be charged – to review active proposals as they are being implemented through legislation and policy changes.

5. Saving and strengthening Nashville's tree canopy

Locally, Metro's policies must promote and protect efforts to restore a healthy tree canopy. Planting trees is an effective and cost-conscious way to fight climate change.1 The Metro Council has approved important legislation toward the protection of Nashville's tree canopy, yet much more remains to be done. While a wholesale revision to Metro's current Code is suggested by some, such efforts would require substantial costs and labor at a time of significant budgetary constraint. But incremental measures can at least continue the momentum forward until Metro's fiscal house is in order.

To that end, Mayor Cooper is introducing initial legislation with Metro Council Member Angie Henderson to further strengthen tree protections under the Metro Code. Specifically, the legislation will propose the elimination of an exemption to tree density requirements that unintentionally reduces tree volume by nearly 70 percent based solely upon lot dimensions. (See, Metropolitan Code of Laws, sec. 17.24.100.B.2).

Christmas Tree

Sustainable practices for a vital tree canopy can and should include Nashville's annual Christmas Tree – an important symbol where Metro's practices can likewise be of symbolic significance. Therefore, for the first time, the Metro Parks Department will provide a "replacement value plus" for each tree harvested for Public Square holiday decorations. After a Christmas Tree is donated, the Parks Department will plant multiple replacement trees equivalent to twice the caliper inch measurement of the Christmas Tree, literally doubling the diameter volume of replaced trees. Further, the Christmas Tree will be decorated with over 5,000 LED lights powered exclusively by solar energy.

Joining the Global Covenant of Mayors for Climate & Energy

As Metro acts locally, it is important to continue to think globally – being mindful of the impact the city's conduct has upon others around the world. To that end, Mayor Cooper has added his signature to the Global Covenant of Mayors for Climate & Energy, a global coalition of city leaders dedicated to reducing greenhouse gas emissions, making their communities more resilient to the impacts of climate change, and providing access to sustainable energy.

By taking these initial actions, Nashville secures its commitment to local climate and energy action and the transition to a low-emission and climate-resilient urban environment that will benefit the health of the community and lay the groundwork for a prosperous economic future.

# # #

1 (Science, July 5, 2019: Vol. 365. Issue 6448, pp. 76-79)

Back

Climate Action Plan

For

Oak Ridge, Tennessee

Prepared by:

The Oak Ridge
Environmental Quality Advisory Board

September 21, 2010

were conducted for government operations and the community sector using software tools provided by ICLEI and consultations with professionals in the fields of environmental science and energy utilization.

In addition to recommendations from ICLEI resources, throughout the development of the CAP, EQAB also sought and obtained input from the public, City staff and City Council in order to ensure that existing, planned, and proposed GHG reduction measures were included in order to highlight their contributions toward meeting future municipal and community GHG reduction targets. Based on a review of existing, planned, and proposed measures, EQAB recommended, and City Council adopted by resolution in 2009, the following emissions reductions targets:

Municipal Reductions	Community Reductions
10% by 2015	5% by 2015
50% by 2030	30% by 2030
80% by 2050	50% by 2050

While this plan includes recommended reduction measures that range from short-term (0 to 2 years), medium-term (2 to 5 years), to long-term (5 to 10 years), it is meant to be a "living" document which should be updated during the life cycle of these various projects. EQAB recognizes that even during the finalization of this document, the City of Oak Ridge has been continuing to implement energy reduction measures that because of publication and presentation deadlines are not included in this document. In addition, EQAB recognizes that the successful implementation of this CAP will require development of effective community outreach and education programs that encourage citizens to adopt sustainability principles and other emission reduction initiatives and goals.

As noted previously, this CAP does not fully and completely address sustainability as it relates to Oak Ridge. However, recommendations made at the January, 2009 forum that relate to making the City more sustainable that are not included in the CAP will be considered at a later time as appropriate and consistent with the city's sustainability initiative.

[1] ICLEI - Local Governments for Sustainability, http://www.iclie.org
[2] The Environmental Protection Agency, http://www.epa.gov/sustainability/basicinfo.htm

more quickly than the community. Furthermore, the City's ambitious goals illustrate a commitment toward leading the way for the community in emissions reduction practices.

2.3: Adopted Goals

In September 2009, Oak Ridge City Council adopted (by resolution) the following emissions reductions goals:

Municipal Reductions	Community Reductions
10% by 2015	5% by 2015
50% by 2030	30% by 2030
80% by 2050	50% by 2050

Exhibits 2-1 and 2-2 show the GHG emissions that would result from both the municipal and community reduction goals being met.

EXHIBIT 2-1. Municipal GHG Emission Reductions

Municipal GHG Emissions in 2004 (tons eCO_2)	Municipal GHG Emissions with 10% Reduction Goal for 2015 (tons eCO_2)	Municipal GHG Emissions with 50% Reduction Goal for 2030 (tons eCO_2)	Municipal GHG Emissions with 80% Reduction Goal for 2050 (tons eCO_2)
27,101	24,391	13,551	5,420

EXHIBIT 2-2. Community GHG Emission Reductions

Community Greenhouse Gas Emissions in 2004 (tons eCO_2)	Community GHG Emissions with 5% Reduction Goal for 2015 (tons eCO_2)	Community GHG Emissions with 30% Reduction Goal for 2030 (tons eCO_2)	Community GHG Emissions with 70% Reduction Goal for 2050 (tons eCO_2)
693,248	623,923	346,624	138,650

RESOLUTION NO. 20140410-024

WHEREAS, the City of Austin is committed to protecting the long-term health and viability of our community through strategies designed to reduce greenhouse gas emissions and mitigate the effects of climate change; and

WHEREAS, according to the United Nations Intergovernmental Panel on Climate Change (IPCC), which is comprised of the world's leading scientific experts in the field of climate change, to avoid the worst impacts of climate change greenhouse gas emissions need to be cut by at least 80% from 1990 levels by 2050; and

WHEREAS, the City Council passed Resolution No. 20070215-023 that established the framework for the Austin Climate Protection Plan (ACPP), which includes five major goals with supporting objectives: (1) Make all City of Austin facilities, fleets, and operations carbon-neutral by 2020; (2) Make Austin Energy (AE) the leading utility for greenhouse gas reductions; (3) Implement the most energy efficient building codes and aggressively pursue energy efficiency retrofits; (4) Create a community-wide inventory of greenhouse gases, establish short- and long-term emission reduction targets, and a comprehensive plan for meeting those targets; and (5) Develop and implement a program to assist all citizens, businesses, organizations, and visitors in achieving carbon neutrality; and

WHEREAS, as of 2010, greenhouse gas emissions in Travis County were estimated to be 15.2 million metric tons of carbon dioxide-equivalent (CO2e) per year, and approximately 52% of those emissions were created by energy use, 36% from transportation, and 12% from local landfills and manufacturing processes; and

WHERAS, reducing community-wide greenhouse gas emissions, especially from the transportation sector, can have a positive impact on local air quality and result in a healthier community; and

WHEREAS, in April 2010, City Council adopted the AE Resource, Generation, and Climate Protection Plan to 2020, which included specific utility strategies to meet the goals set out in the 2007 ACPP and included an affordability goal; and

WHEREAS, in December 2011, City Council adopted the Austin Resource Recovery Master Plan which includes zero waste goals, carbon footprint reduction efforts, and goals for expanding public/private partnerships; and

WHEREAS, in June 2012, City Council adopted the Imagine Austin Comprehensive Plan, which established goals related to land use and transportation policies; and

WHEREAS, City Council passed Resolution No. 20131121-60 that directed the City Manager to develop climate adaptation strategies as an important missing piece to the existing ACPP, and that report will come back with recommendations for next steps by September 2014; and

WHEREAS, Council has appointed a new Generation Plan Task Force to review the AE Resource, Generation, and Climate Protection Plan to 2020 and make recommendations on the utility's generation mix for the near future; and

WHEREAS, peer cities, including Seattle and Portland, have recently completed updates to their original Climate Action Plans, and the updates incorporate new data and information that led to establishing new long-term goals in line with the IPCC calculations; and

WHEREAS, the City of Austin has made significant progress on the goals set out in the 2007 ACPP, either meeting its goals ahead of time or being on schedule to meet its goals by 2020; and

WHEREAS, the 2007 ACPP and the current AE Resource, Generation, and Climate Protection Plan to 2020 are now reaching a point where an update is needed to ensure the City of Austin and Austin Energy continue as leaders in climate protection efforts; **NOW, THEREFORE,**

BE IT RESOLVED BY THE CITY COUNCIL OF THE CITY OF AUSTIN:

The City Council establishes a goal of reaching net zero community-wide greenhouse gas emissions by 2050 and prefers to achieve this goal as soon as it is feasible. The City Council also recognizes that emissions reductions accomplished sooner are more important and valuable for our city's climate protection efforts.

BE IT FURTHER RESOLVED:

The City Manager is directed to review the goals and objectives within the 2007 Austin Climate Protection Plan and work with stakeholders to create an action plan for each major sector (energy, transportation, and waste/industrial) responsible for the community-wide greenhouse gas emissions in Austin in order to meet the new long-term goal. The action plans should include secondary goals and measures for sector-specific factors such as renewable energy, building energy use reductions, vehicle miles traveled, waste diversion rates, and more. The plans should determine what is achievable for each sector and how the other sectors could make up for any shortfalls in reaching the interim community-wide goals.

BE IT FURTHER RESOLVED:

The sector action plans should include greenhouse gas reductions that will be achieved by implementing existing City plans and also include new actions that could reduce emissions in the short- and long-term. The action plans should take into consideration regional factors that may present challenges or opportunities, including:

- population and business growth,
- available and emerging technology,
- potential costs and benefits,
- climate preparedness and resilience, and
- barriers where the City does not exert direct control over community emissions.

BE IT FURTHER RESOLVED:

The stakeholder input process should include a mix of public input sessions, discussions with relevant Boards and Commissions, consideration of the results from the 2014 Generation Plan Task Force, and the formation of technical advisory groups to work with city staff to develop the action plans.

BE IT FURTHER RESOLVED:

The recommendations from stakeholders and city staff should also include:

- measurable interim greenhouse gas reduction targets, starting with 2020 and periodic targets until 2050,
- when and how annual progress reports will occur, and
- how often to conduct comprehensive updates to the climate protection plan.

BE IT FURTHER RESOLVED:

The City Manager shall provide a progress update to City Council by September 1, 2014, including a framework for meeting short- and long-term community-wide greenhouse gas emissions reduction goals. The City Manager should combine all applicable greenhouse gas emission reduction strategies and climate change resiliency plans into one comprehensive Climate Protection Plan document to be presented for community review and Council adoption by March 1, 2015.

ADOPTED: April 10, 2014 **ATTEST:** ______________ For
Jannette Goodall
City Clerk

net-zero

Austin COMMUNITY 2015 CLIMATE PLAN

net-zero

Letter from the Steering Committee


Photo by Lydia Jarjoura

Dear Mayor and City Council,

In 2014, City Council had the vision to put Austin on a path to economic and environmental sustainability and to establish our city as a global leader in meeting the challenges posed by climate change. The continuing drought is a stark reminder that climate change is one of the biggest threats to our economy and way of life in Central Texas. Scientists stress that it is also one of the biggest challenges that our planet has ever faced—but it does not need to be. Through your leadership today, Austin will set an example to communities around the world and become a powerhouse in the new green economy.

We are honored to have been working with numerous stakeholders and City departments to answer Council's request for a revised and comprehensive climate protection plan. The Austin Community Climate Plan will establish a blueprint to achieve net-zero community-wide greenhouse gas emissions by 2050, or sooner, if feasible.

We know that meeting this target is not just about addressing the threats that climate change poses, but also about spurring creativity, rewarding ingenuity, and generating opportunities so that everyone in Austin can participate, benefit, and prosper. We also know that meeting this challenge will require change—change in how we generate and use energy, how we get around town, how businesses measure prosperity, and how we deal with waste. We are optimistic that we can meet the net-zero target in ways that will lower energy bills, make transportation more flexible, clean the air we breathe, conserve water, and create local jobs.

We also know that the risks of not tackling the challenges posed by climate change will come at a great social, economic, and environmental cost—in health impacts to our most vulnerable citizens, in loss of property from natural disasters, and in increased pollution and drought. We are already experiencing these impacts; in 2011, we faced terrible wildfires, the loss of trees and woodlands from both wildfires and drought, and rising utility bills to keep us cool during a record-breaking, hot summer. This is likely to become the new normal in Texas for our children and grandchildren unless we take action.

However, the benefits to be gained are vast. Some people support carbon-free energy with solar panels. Some companies have invested in fuel-efficient fleets and electric vehicles that lower overhead costs. We are already increasing the density of some neighborhoods and are continually adding more bike lanes. We are investing in clean

How Do I
FIT IN?

Large Companies and Employers

Co-Benefits:

HEALTH

SECURITY

TIME

Justin is the Vice President of Business Development for a large, multinational company with offices in three buildings on a corporate campus in North Austin. His job is to ensure that the company leads the competition in their industry, so he focuses on enhancing the company's reputation, attracting and retaining the best talent, and delivering a quality product that customers will demand. He is finding that the best employee candidates expect the company to provide transportation options to and from work. Customers are also asking Justin about what the company does to give back to the community and about its impact on the environment. Implementing strategies in the Austin Community Climate Plan will provide Justin and other large employers in Austin with trip reduction strategies and employee commuting programs that help reduce emissions and increase employee satisfaction and retention. The plan also will make it easier for Justin to access programs to help with efficiency upgrades to his company's offices, as well as maximize the amount of waste kept out of the landfill.

Refer to the Technical Appendices for more detail on Actions TDM-1, TDM-4, TDM-7, TDM-8, VFE-1, BIE-1, BIE-2, BIE-3, RE-4, OD-1, OD-4

CITY OF DENTON

SIMPLY SUSTAINABLE

A Framework for Denton's Future

sustainable DENTON

June 2020

Focus Area and Goals:

WATER

- Protect and restore Denton's water bodies
- Maintain high level of drinking water quality
- Invest in sustainable stormwater, watershed infrastructure, management and education
- Ensure wastewater is collected, treated, and discharged in accordance with all regulatory requirements
- Take measures to encourage reductions in per capita water consumption

AIR QUALITY

- Improve regional air quality and take actions to improve non-attainment status
- Take actions to reduce air pollutant emissions, including greenhouse gases and emissions from government operations
- Set reduction targets for municipal and community greenhouse gas emissions
- Annually Update Greenhouse Gas Inventory and Contribution Analysis
- Assess community hazards and vulnerabilities
- Create a Greenhouse Gas Mitigation Plan

ENERGY

- To have under contract by the end of 2020 sufficient renewable energy supplies to achieve and maintain the 100% renewable energy supply objective
- Encourage energy conservation and efficiency in new and existing homes and businesses
- Ensure efficient energy use in city government facilities through demand reduction in both new construction and building retrofits
- Continue to require exceptional energy efficiency building standards for new construction

LAND USE

- Encourage land use and code/zoning patterns that positively affect energy use and the environment
- Preserve open space, natural areas, and tree canopy
- Minimize water use, promote stormwater quality, and reduce stormwater quantity through management measures
- Encourage redevelopment of infill areas and brownfield sites
- Create and Improve park and open space opportunities within 10 minute walking distance of residents' homes
- Partner with city departments and local organizations to implement tree planting goals to increase the tree canopy to 40 percent by 2040.

Chapter 2: Air Quality and Greenhouse Gas Management

"When one tugs at a single thing in nature, he finds it attached to the rest of the world."

-John Muir

Air quality impacts our health and our environment. Denton is located in a non-attainment area for ozone; air pollution levels in the region persistently exceed national air quality standards set by the United States Environmental Protection Agency (EPA). High ozone levels can cause shortness of breath and coughing. It is also linked to lung diseases such as asthma and emphysema. Greenhouse Gases and Ozone forming pollutants share many of the same sources. Through Greenhouse Gas management and regional air quality efforts, both GHG mitigation and air quality improvements can be accomplished with shared strategies.

Climate change is the rise in global temperatures resulting in part from increased levels of greenhouse gases (GHGs). Recognizing the importance of this issue Denton initially signed the US Conference of Mayors Climate Protection Agreement in 2005.

Goals

1. Improve regional air quality and take actions to improve non-attainment status
2. Take actions to reduce air pollutant emissions, including greenhouse gases and emissions from government operations
3. Set reduction targets for municipal and community greenhouse gas emissions
4. Annually Update Greenhouse Gas Inventory and Contribution Analysis
5. Assess community hazards and vulnerabilities
6. Create a Greenhouse Gas Mitigation Plan

Successes to Date and Ongoing Initiatives

Air quality is not just a local issue - it is affected by pollutants throughout the region and thus requires regional solutions. The City has formed partnerships with regional organizations, including North Central Texas Council of Governments (NCTCOG), North Texas Clean Air Coalition (NTCAC), ICLEI - Local Governments for Sustainability, Denton County Transportation Authority (DCTA), and Dallas Regional Mobility Coalition (DRMC). Together, the City and these organizations can use their collective resources to identify and implement regional air quality improvements and make joint decisions to improve air quality. The City also recognizes ozone action days. During ozone season (May through November) employees and residents are encouraged to make clean air choices.

Each year, the City will complete a Greenhouse Gas (GHG) emissions inventory for municipal operations and the community-at-large. The inventory provides an assessment for establishing GHG emissions reduction targets and developing action plans to achieve those targets.

Sustainability Metrics:

Key Performance Indicators	Targets
Air Quality Index (AQI)	AQI is a regional issue that is not only influenced by local City of Denton efforts, yet still important to track
GHG Emissions- Municipal Government Operations (Metric Tons of Carbon Dioxide Equivalent)	Reduce GHG emissions
GHG Emissions- Community-wide per capita (Metric Tons of Carbon Dioxide Equivalent)	Reduce GHG emissions per capita
Annual Municipal Fleet Fuel Consumption	Reduce use of traditional fuels; Increase alternative fuel consumption as percentage of total fuel consumption
Number of Alternative Fuel Vehicles (AFV) (Hybrids, CNG, Electric, etc.) in Municipal Vehicle Fleet	Increase number of AFVs
Percentage of GHG emissions from Municipal Fleet (2018 Baseline)	25% by 2025

Strategy #1

Implement Sustainable Municipal Fleet Program

The City has recently enacted an updated "sustainable fleet policy." The policy comes from a regional effort to improve local air quality. Purchases, operations, efficiency, and necessity are some of the criteria used to evaluate the efficiency of the City's vehicle fleet. The City has developed a comprehensive sustainable fleet program to identify opportunities and actions the City can take to improve air quality through fleet operations. The goal is to have a more sustainable fleet using the most appropriate vehicle, operated efficiently, and properly maintained. The intended results of this policy are to reduce\emissions, improve fuel efficiency, and effectively manage the operating funds required to run the City's fleet.

Understanding fleet performance enables the City to take targeted actions to improve efficiency. The City of Denton's Fleet Services currently uses a computerized management system. Fleet Services maintains an inventory of fleet vehicles and monitors fuel consumption, fuel economy, mileage, maintenance schedules, and repair costs on a monthly basis.

Strategy #2

Continue and Expand GHG Program for Municipal and Community Operations

As a member of ICLEI-Local Governments for Sustainability and signatory to the 2005 U.S. Conference of Mayors Climate Protection Agreement, the City is committed to addressing GHG emissions from its own facilities and operations. The City completes an annual GHG emissions inventory for municipal operations and forecast GHG emissions to assess the "business as usual" scenario of emissions growth over time. These emissions forecasts can help determine the City's emissions scenario projected forward, and help set a feasible emissions reduction target and timeline.

Strategy #3

Create and Implement a Greenhouse Gas Mitigation Plan

Goals 1, 2, 3, and 6 can be encompassed into the single strategy of a GHG mitigation plan. GHG mitigation is typically one of the first parts of any climate action, or community resilience plan, and is designed to limit the impacts of climate related hazards. The City will first identify a target, and will then select the actions best suited for Denton to meet that goal. This strategy has the added benefit of improved air quality as greenhouse gases, ozone precursor pollutants, and other emissions that reduce air quality share similar sources.

UPDATE

The Denton community has reduced their GHG emissions by 22% since 2006. Reductions are anticipated to decrease further as Denton continues to implement actions that lower their carbon footprint.

Chapter 3: Energy Conservation and Efficiency

"We shall require a substantially new manner of thinking if mankind is to survive"
-Albert Einstein

The current emphasis on improving energy efficiency is a result of several dynamics—air quality attainment, GHG reduction, demand management, and ensuring a consistent supply of power to Denton residents. The City recognizes the importance of energy conservation and efficiency to Denton's citizens, environment, and economy. Patterns of energy use for industrial, commercial, residential, and transportation sectors are important indicators of community sustainability. Globally, population growth, industrialization, and urbanization have led to the upward trend in energy consumption. National demand for electricity has also continually grown, despite the increases in energy costs and energy efficiency improvements. According to Energy Outlook 2020 produced by the U.S. Energy Information Administration, buildings and transportation sectors make up a large portion of primary energy use. Because buildings require a large amount of energy in the United States, understanding the distribution of energy consumption is an important step in setting goals for energy reduction.

Goals

1. To have under contract by the end of 2020 sufficient renewable energy supplies to achieve and maintain the 100% renewable energy supply objective
2. Encourage energy conservation and efficiency in new and existing homes and businesses
3. Ensure efficient energy use in city government facilities through demand reduction in both new construction and building retrofits
4. Continue to require exceptional energy efficiency building standards for new construction

City of Georgetown Texas

City of Georgetown Texas > Archived > Why Georgetown is 100 percent renewable

Why Georgetown is 100 percent renewable

Feb 22, 2019

Update: This is a news post from February 2019. The City electric utility discontinued claiming 100 percent renewable status later in 2019 after selling renewable energy credits to generate revenue for the utility.

Reports by a local newspaper and an anti-renewable energy advocacy organization have attempted to question Georgetown's status as an electric utility that uses 100 percent renewable energy.

Georgetown is credited with the energy it pays to put into the statewide electric grid. Since April 2017, the City has been credited with putting more renewable energy into the grid than Georgetown customers consumed. According to the statewide renewable energy accounting system overseen by the Public Utilities Commission, Georgetown's customers have been using and paying for all-renewable energy since April 2017.

The Electric Reliability Council of Texas manages the statewide electric grid. ERCOT also tracks renewable energy production for the City. The City is able to determine its energy consumption based on data from customer meters. When determining what percent of an electric utility's energy portfolio is renewable, the energy produced is compared to the energy consumed. For example, in 2018:

- Georgetown contracted for 1,067 megawatt hours of energy.
- Of that, 822 megawatt hours were from renewable sources.
- Georgetown customers consumed 678 megawatt hours.

In 2018, the total energy consumption by Georgetown customers was less than the total energy produced by renewable sources. That means Georgetown qualifies as being 100 percent renewable in Texas.

The City does not physically use renewable energy every second of every day, but the City does produce more renewable energy than its customers consume. As long as this trend continues, Georgetown will be considered 100 percent renewable. All utilities in Texas base their renewable percentages using this method.

The City has never claimed that the electrons produced by its energy contracts are the same electrons consumed in Georgetown. In fact, a commentary published by the Austin American-Statesman on Aug. 11 states, "[t]he city did not set-out to influence other energy providers or shakeup the state grid. We know that Texas is reliant on traditional sources of energy. We know it is impossible to track an electron produced in West Texas all the way to Georgetown. However, we also know that state attributes all of wind farm and solar farm production with Georgetown."

Contrary to some reports, the City does not have a policy to be 100 percent renewable in its energy supply. In 2014 and 2015, the City selected wind and solar energy providers because of the long-term cost stability and reduced regulatory risk. The City's goal is to have 30 percent of its energy from renewables by 2030.

Texas' Energy Grid

ERCOT manages the flow of electric power for 90 percent of the state's electric load. This interconnected systems means all sources of energy enter into and are consumed off the statewide grid.

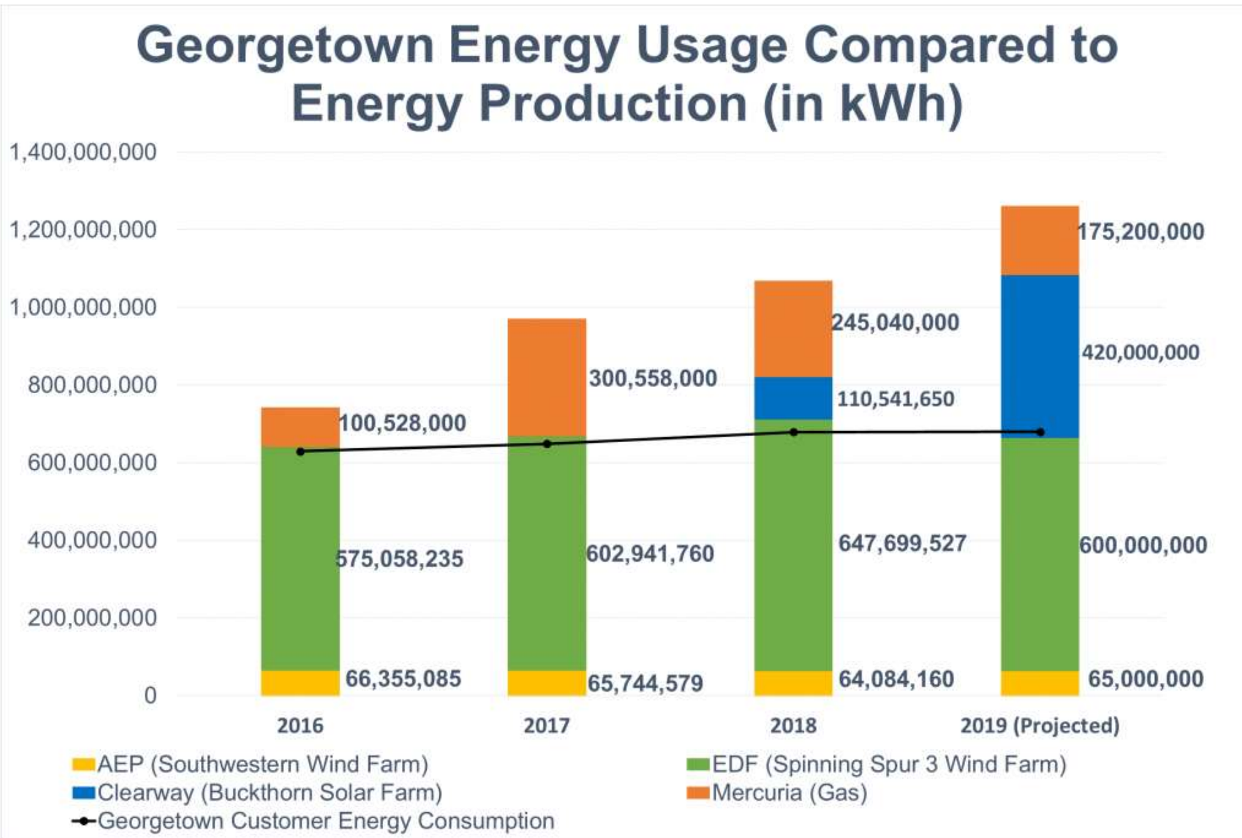
Georgetown is reliant upon energy from the grid to ensure customers receive reliable energy. As a member of ERCOT, the City of Georgetown is obligated to purchase, place, and ultimately provide energy to customers using the ERCOT-managed grid.

The City is under contract to purchase energy from four different providers. The two largest energy providers are Spinning Spur 3, a wind farm near Amarillo, and Buckthorn, a solar farm near Fort Stockton.

The third source of energy is a smaller wind farm operated by American Electric Power (AEP) which primarily covers Southwestern University's energy needs.

The final energy contract is with Mercuria for natural gas-based energy. This contract was initiated and is a short-term power supply, set to expire in 2022.

The energy production for each of these contracts, as well as Georgetown's electric consumption, is included below.



As the graphic illustrates, since 2017 Georgetown's wholesale energy contracts produced more renewable energy than our customers consumed.

The State of Wisconsin

OFFICE OF THE GOVERNOR

EXECUTIVE ORDER #38

Relating to Clean Energy in Wisconsin

WHEREAS, climate change poses a serious threat to Wisconsin's natural resources, public health, communities, tourism, and economy;

WHEREAS, past research by the Wisconsin Initiative on Climate Change Impacts has shown that by the middle of the century, statewide average annual temperatures are likely to warm by 6 to 7 degrees Fahrenheit, and a recent report from the Union of Concerned Scientists suggests that under the current trajectory, by 2050 Wisconsin could see two weeks per year of dangerous heat – with heat indexes above 100 degrees – analogous to the current climate in states such as Alabama and South Carolina;

WHEREAS, increasing instances of extreme weather events like flooding are devastating Wisconsin communities. Research by the Wisconsin Initiative on Climate Change Impacts shows that climate change is likely to cause a general increase in precipitation across the state, with extended dry periods during the summer and flooding during periods of heavy rain;

WHEREAS, climate change poses significant threats to communities that lack the resources and geographic mobility to adapt to changes, including pronounced threats to the cultural resources, economic vitality, and human health of Native Nations;

WHEREAS, protection of Wisconsin's iconic agricultural, hunting, fishing, and outdoor recreation opportunities remains critical to our heritage, quality of life, economy, and ability to attract and retain businesses in diverse industries;

WHEREAS, the air emissions released as a result of fossil fuel combustion cause a wide variety of adverse health impacts including asthma attacks, pneumonia, cardiovascular disease, chronic and acute bronchitis, lower respiratory ailments, upper respiratory ailments, heart attacks, neurological deficits, immune system deficits, and cancer;

WHEREAS, Wisconsin sends, on average, more than $12 billion out of the state each year to import fossil fuels including coal, natural gas, and petroleum;

WHEREAS, a transition to a clean energy economy will generate thousands of family-supporting jobs;

WHEREAS, Wisconsin is a member of the United States Climate Alliance and has pledged to support the carbon reduction goals of the 2015 Paris Climate Accord; and

WHEREAS, our state has a responsibility to current and future generations of Wisconsinites to act to prevent continuing damage to our climate and to invest in solutions that help to mitigate the changes that have already occurred.

NOW, THEREFORE, I, TONY EVERS, Governor of the State of Wisconsin, by the authority vested in me by the Constitution and the Laws of the State, hereby:

1. Order the Department of Administration to create the Office of Sustainability and Clean Energy.

2. The Office of Sustainability and Clean Energy shall be charged with the following:

    a. In partnership with other state agencies and state utilities, achieve a goal of ensuring all electricity consumed within the State of Wisconsin is 100 percent carbon-free by 2050.

    b. Ensure the State of Wisconsin is fulfilling the carbon reduction goals of the 2015 Paris Climate Accord.

    c. Develop a clean energy plan to assist the State of Wisconsin in adapting to and mitigating the harm from climate change by using clean energy resources and technology. The Office of Sustainability and Clean Energy shall coordinate with the Department of Natural Resources, the Department of Transportation, the Public Service Commission, the Department of Agriculture, Trade and Consumer Protection, other state agencies, Native Nations, local governments, utilities, businesses, and other stakeholders to develop and implement the clean energy plan.

    d. Promote clean energy workforce training, in partnership with the University of Wisconsin System, Wisconsin Technical College System, private and non-profit workforce development programs and labor organizations, and the Wisconsin Manufacturing Extension Partnership.

    e. Foster innovation, research, and business development within the renewable energy, energy efficiency and sustainability sectors.

    f. Develop energy efficiency, sustainability and renewable energy standards for all new and existing state facilities, office buildings, and complexes.

IN TESTIMONY WHEREOF, I have hereunto set my hand and caused the Great seal of the State of Wisconsin to be affixed. Done at the Capitol in the City of Madison this sixteenth day of August in the year of two thousand nineteen.

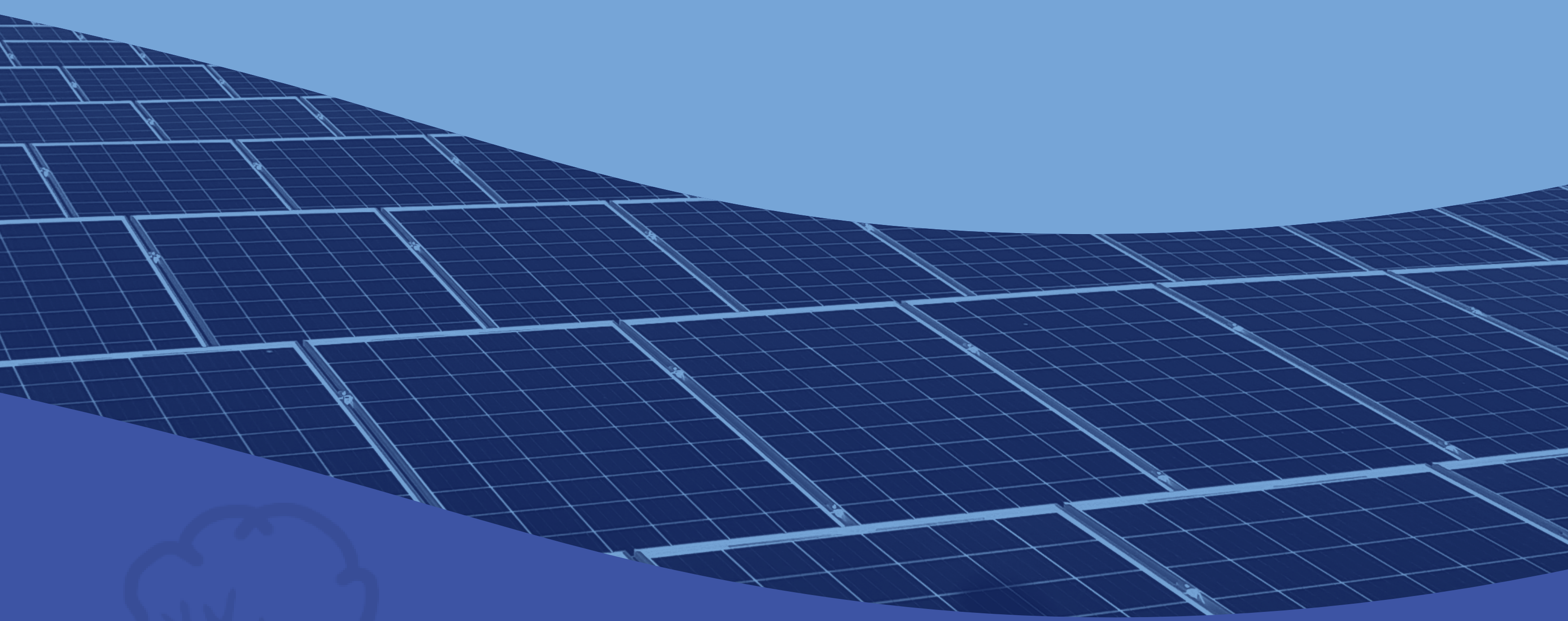
TONY EVERS
Governor

By the Governor:

DOUGLAS LA FOLLETTE
Secretary of State

Eau Claire

Renewable Energy Action Plan



INTRODUCTION

The City of Eau Claire has committed to transition away from a fossil-fuel-based economy to mitigate and respond to the threat of climate change. Tackling global climate change at the local level is imperative to take responsibility and to address human and environmental risks. It also brings numerous co-benefits to the community including improved health, air and water quality, essential service resiliency, and economic development.

The purpose of this Renewable Energy Action Plan (REAP) is to lay out a pathway to meet the City's twin goals of carbon neutrality and 100% renewable energy by 2050. It charts out a holistic course across five major sectors: commercial buildings and industry, residential buildings, transportation, waste, and biodiversity. Strategies include direct action on programs, policies, and land use decisions; community-led campaigns to change individual behavior; and engagement with partners such as energy utilities to work across jurisdictions and solve shared challenges.

A REAP Steering Committee was created to help develop this plan. The group was compromised of 40 plus community stakeholders representing various points of view, but it will take everyone in the community to accomplish the goals.

This plan covers a 10-year timeframe to meet the City's 2030 interim goal of a 30% greenhouse gas reduction below 2015 levels. Longer-term, more transformational strategies will be needed beyond that time period and will be the focus of future planning work. The strategies outlined in this plan, combined with a decarbonizing electricity grid, set the City on course to meet its 2030 carbon reduction goal.

Figure 1. REAP Steering Committee's Word Cloud Responses to why this plan is important

COMMUNITY BACKGROUND

Eau Claire's Commitment to Carbon Neutrality

The consequences of land use change and burning significant levels of fossil fuels over the past 100 years have caused a serious quality-of-life threat. The warming planet is having profound effects on nature and society. The results are showing in ecosystem change and more extreme weather that affect human life, communities, property, infrastructure and the economy.[1] Risk management concerning climate change is a growing concern for federal and state agencies, local governments, power companies, the insurance and finance industries, socially responsible corporations, agribusiness, and more.

Eau Claire's annual average temperature has warmed from 43.8°F in 1960 to 46.6°F in 2010, a difference of 2.8 degrees. Climate modeling specific to Wisconsin predicts that by 2050 warming could here increase to 50.1°F for a total of 6.3°F over 90 years.[2] Results mean more extreme precipitation events and flooding, shorter winters, drought, and greater vector-borne diseases. These can then trigger negative cascade effects on the local community's social, ecological, and economic well-being.

In June 2017, the Eau Claire City Council directed the City's Sustainability Advisory Committee and staff to analyze what the community and municipal operations needed to do locally to support global and national policy on climate change. The *Towards a Renewable City Executive Summary Report*[3] recommended several goals consistent with The Paris Agreement.[4] The international treaty seeks to mitigate the impacts of climate change by holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels. The City Council by resolution adopted the report's community and municipality recommendations on March 13, 2018.[5] They are as follows and form this plan's framework:

- Achieve carbon neutrality by 2050
- Use incremental carbon drawdown targets to reach neutrality
- Use a 2015 greenhouse gas inventory baseline
- Obtain 100% renewable energy by 2050

[1] Fourth National Climate Assessment, Volume II: Impacts, Risks, and Adaptation in the United States at https://nca2018.globalchange.gov/

[2] Wisconsin Educational Communications Board and University of Wisconsin-Madison at https://climatewisconsin.org/story/temperature-change

[3] City of Eau Claire Towards a Renewable City Executive Summary Report. Sustainability Advisory Committee, December 2017 at https://www.eauclairewi.gov/home/showdocument?id=23645

[4] The Paris Agreement at https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

[5] Eau Claire City Council 2050 Goals Resolution at https://www.eauclairewi.gov/home/showdocument?id=23643

Vision & Guiding Principles

The REAP Steering Committee, through survey responses and workshop feedback, developed the following vision and guiding principles to steer the focus of this planning effort. The vision provides a unifying umbrella for the planning process and its ongoing implementation.

Eau Claire's Renewable Energy Action Plan will be guided by an evidence-based, transparent, equitable, and inclusive process to meet the goals of 100% renewable energy and carbon neutrality by 2050.

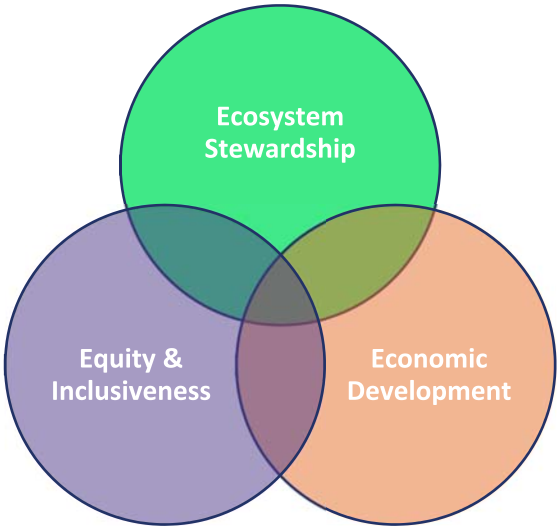
These ongoing efforts will strengthen our leadership in sustainability and renewable energy development for generations to come.

In the process of developing the principles, the Steering Committee relied on The Natural Step four system conditions that the City adopted in 2009. These are to reduce dependency on fossil fuels, manufacture of toxic chemicals, and encroachment on nature, as well as to meet the justice, safety, health, and social needs of the community.[8] The guiding principles below help prioritize the plan strategies and emphasize other values and goals beyond carbon savings. Social equity and inclusiveness, in particular, must address present barriers and future generations. Those with less or no ability should not be sidelined or cast to circumstances that undermine their basic needs. However, a plan can only go so far — equity and the other principles should be intentionally designed into strategies during implementation.

Equity and Inclusiveness: *Our work will engage and support the entire community, increasing benefits for under-resourced populations.*

Economic Development: *We will develop and implement ideas that maximize community investment and local economic opportunity.*

Ecosystem Stewardship: *We will preserve, protect, and enhance the natural world around us, for our benefit and for generations to come.*



[8] City of Eau Claire's eco-municipality resolution at https://www.eauclairewi.gov/home/showdocument?id=550

19-0471
Proposed Amended for Council 7/11/19

Resolution adopting sustainability goals transitioning to carbon neutrality and 100% renewable energy by 2050.

SECOND AMENDED RESOLUTION

WHEREAS, ~~climate scientists agree that~~ local climate change impacts will likely continue to include excessive flooding, worsening heat waves, increasingly severe and more frequent droughts, diebacks of native tree species, reduced winter sports opportunities, increased presence of algal blooms on area lakes and ponds, and loss of suitable trout stream habitat in Wisconsin; and

~~WHEREAS, the Paris Climate Agreement is an international treaty that seeks to stabilize the global climate system by "holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels"; and~~

WHEREAS, ~~climate scientists~~ the ~~International~~ Intergovernmental Panel on Climate Change ~~(IPPC)~~(IPCC) ~~have~~ has determined ~~this upper temperature~~ limiting the increase in global average temperatures to 1.5°C (2.7°F) above pre-industrial levels to be the best feasible scenario in managing climate change impacts (such as extreme weather events and sea level rise) that threaten public safety, infrastructure, private property, and economic prosperity; and

WHEREAS, essential goals toward ~~adhering to the Paris Climate Agreement~~ staying under 1.5°C locally would include carbon neutrality and 100% of energy coming from renewable sources by 2050; and

WHEREAS, the February 4, 2019 Council on Wisconsin Strategies report, “Wisconsin Opportunity in Domestic Energy Production: The Economic and Health Benefits of 100% In-State Energy Production,” concludes that producing 100% of the state's energy needs by in-state renewable sources would result in a statewide economic benefit of more than $28 billion plus addition of more than 160,000 jobs and social, environmental, and health benefits of decreased pollution and carbon emissions; and

WHEREAS, these recommendations align with the Common Council’s core value of "judicious investment in public resources and protection of natural and cultural resources"; and

WHEREAS, these recommendations succeed the City's 2009 *Strategic Plan for Sustainability* commitment of 25% renewable electricity and transportation fuels by 2025; and

WHEREAS, the City envisions a climate and energy planning process that will reflect community values and promote stakeholder participation to develop low-carbon means to reach these goals. Stakeholders include residents, low-income and minority populations, large and small businesses, local utilities, the educational community, institutions, the building and construction sector, transportation providers, waste companies and many others; and

WHEREAS, the process to achieve these ambitious goals represents a journey that needs to be realistic and sensitive to unintended impacts. Careful and ongoing planning is necessary to understand what is practical in the short term while ~~ratchetting up~~ emphasizing efforts in the mid and long-term target ranges, where technological advancements occur and costs decline;

WHEREAS, Mayor Kabat has signed the Mayors for 100% Clean Energy Endorsement supporting the goal of 100% clean, renewable energy in our city and is a member of the bi-partisan Climate Mayors, committed to adopt, honor and uphold Paris Climate Agreement goals.

NOW, THEREFORE, BE IT RESOLVED by the Common Council of the City of La Crosse that it adopts the following sustainability goals:

1) Achieve municipality and community carbon neutrality by 2050 with incremental drawdown targets of 5% by 2020, 20% by 2025, 30% by 2030, 45% by 2035, 60% by 2040, 80% by 2045, and 100% by 2050.

2) Obtain 100% renewable energy by 2050 for the municipality and city, utilizing all available economic incentives and technical assistance.

BE IT FURTHER RESOLVED that a 2015 greenhouse gas baseline will be used to evaluate progress.

BE IT FURTHER RESOLVED that the City will undertake planning and action initiatives to assist the municipality and community in achieving these sustainability goals. City staff will provide a status report to the Common Council on each of the above target dates.

BE IT FURTHER RESOLVED that all purchasing decisions that come before the Common Council for approval, which impact our goals of carbon neutrality and renewable energy, shall include a cost benefit analysis and a measurement of the contribution the purchase will have towards reaching our stated goals. Such analysis shall include, at a minimum, the initial purchase cost differential, and if significant the relative operation and maintenance costs of the competing options.

I, Teri Lehrke, certify that this resolution was duly and officially adopted by the Common Council of the City of La Crosse on July 11, 2019.

Teri Lehrke
____

Teri Lehrke, City Clerk
City of La Crosse, Wisconsin

100% RENEWABLE Madison

ACHIEVING 100% RENEWABLE ENERGY & ZERO NET CARBON FOR CITY OPERATIONS & LEADING THE COMMUNITY

NOVEMBER 2018

Acknowledgements

Thank you to the people who have contributed to provide information for this report.

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Denise DeMarb, District 16 Alder

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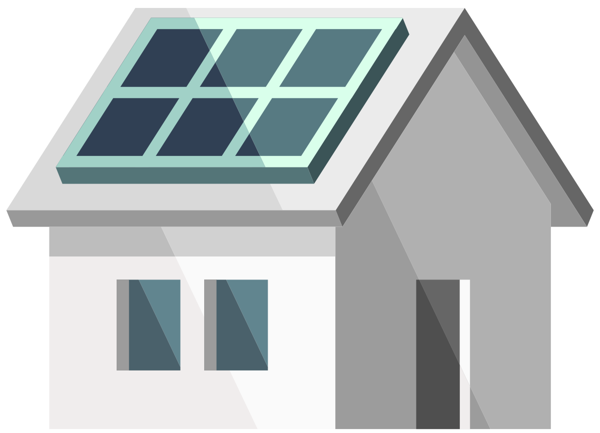
Disclaimer:
This report was prepared by Hammel, Green and Abrahamson, Inc. (HGA) and Navigant Consulting, Inc. (Navigant), separately, for the City of Madison, Wisconsin. The work presented in this report represents HGA's and separately, Navigant's, professional judgment based on the information available at the time this report was prepared. The two entities, HGA, and separately, Navigant, are not responsible for the reader's use of, or reliance upon the report, nor any decisions based on the report. HGA, and separately, Navigant, makes no representations or warranties, expressed or implied. Readers of the report are advised that they assume all liabilities incurred by them, or third parties, as a result of their reliance on the report, or the data, information, findings and opinions contained in the report.



Executive Summary

In March 2017, the City of Madison became the 25th city in North America to set a goal of achieving **100% RENEWABLE ENERGY AND ZERO NET CARBON EMISSIONS.**[1] Across the US, over 97 cities, more than five counties, and two states, have also adopted ambitious 100% clean energy goals. Six cities in the US have already hit their targets. These six cities now generate 100% of their community-wide energy uses from renewable sources.[2] The City of Madison must achieve similar success, with local government operations leading the way. We don't have much time. According to a recent report from the Intergovernmental Panel on Climate Change (IPCC), global net human-caused emissions of carbon dioxide (CO2) would need to fall by about 45 percent from 2010 levels by 2030, reaching 'net zero' around 2050.[3] Despite the lack of climate leadership at the nation's capital as evidenced by the US withdrawal from the Paris Agreement,[4] there is a steady resolve for climate leadership in Madison and the greater Madison region.

In joining other cities around the US and the world, the City of Madison is demonstrating its commitment to using low carbon strategies to meet community-wide economic, environmental, and social challenges. Powering city operations with 100% renewable energy will enable city officials to accomplish multiple city policy objectives including job creation and economic development, cost savings to city taxpayers, promoting racial equity and social justice, contributing to long-term public health and vitality through improved air and water quality, and resilience in the face of more extreme weather events.[5] Recent extreme weather events underscore the need for city officials to take bold climate action now.

This report has four parts.

1. **Recent sustainability successes from City of Madison local government operations and the greater Madison area community.**
2. **An overview of three time-based scenarios that city officials can use to accomplish renewable and net zero goals**
3. **Details about the three scenarios for Madison's low-carbon future**
4. **Additional suggestions to accelerate progress toward reaching 100% renewable energy and zero net carbon goals for local government operations and for the larger Madison area community.**

[1] City of Madison Resolution, Legislative File 45569 (3/21/07).
[2] The Sierra Club, "Ready for 100," https://www.sierraclub.org/ready-for-100/commitments.
[3] Intergovernmental Panel on Climate Change (IPCC) The report finds that limiting global warming to 1.5°C would require "rapid and far-reaching" transitions in land, energy, industry, buildings, transport, and cities. https://www.ipcc.ch/news_and_events/pr_181008_P48_spm.shtml
[4] United Nations Framework Convention on Climate Change (UNFCC), "The Paris Agreement central aim is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius."
[5] WKOW Chief Meteorologist Robert Lindmeier presented information from Climate Central and the Citizens Climate Lobby at a public meeting on September 27, 2017. He listed risks from climate change such as severe weather events, flooding, drought, health impacts, and risk of fire, among others. His full presentation is available at: www.madison100renewableenergy.com.

Three scenarios were developed to demonstrate how local government can achieve the **100% RENEWABLE ENERGY AND ZERO NET CARBON** goal between 2020 to 2030 by:

1. **Reducing energy demand from local government operations through energy efficiency and behavioral measures (i.e., demand-side measures)**
2. **Supplying electricity through renewable energy and to the extent possible, generating renewable energy locally (i.e., supply-side measures)**
3. **Supplying remaining energy needs from Renewable Energy Credits (RECs) and carbon offsets as a bridge strategy, while local government continues to invest in efficient transportation, energy efficiency, and renewable energy as opportunities arise.**

The three scenarios developed meet the City goal of **100% RENEWABLE ENERGY AND ZERO NET CARBON** in a way that, in the long term, is likely to positively impact the financial situation of the City by having positive net present values (NPV), contributing to green jobs and economic development and promoting public health, racial equity and social justice. These scenarios feature demonstrable project-based action by local government operations — investing in efficient buildings and facilities for local government, the water distribution system, city street lights and traffic lights, renewable energy, efficient and electric fleet and transit vehicles, and REC purchases. The scenarios present policy options for city officials based on different amounts of investments and the timeframe for required investments. Scenario 1 has the least initial capital investment requirement but also the smallest positive net present value. Scenario 2 and 3 have increasing capital investments over longer terms but also have greater net present values than Scenario 1 due to more operational savings. Greater investments in efficient government facilities and vehicles in Scenario 2 and 3 include larger estimated co-benefits for the community — resulting in the potential for more significant impacts in the forms of local green jobs, economic development, public health, racial equity and social justice. Measures in each scenario are grouped by demand-side, supply side, and transportation strategies. Scenarios in this report assume that current policy, technology and economic conditions and barriers identified in Section 1.3 remain in place.

Scenario 1: 100% Renewable Energy and Zero Net Carbon by 2020

The Scenario 1 objective is to quickly reach the goal of **100% RENEWABLE ENERGY AND ZERO NET CARBON** for city operations. By 2020, city government will cut its carbon emissions by 15% with at least 10% of municipal operations' electricity sourced by self-generated renewable energy. The city will expand its current efficiency investments in city facilities and implement green city fleet and pilot programs to gain early momentum. Investments in self-generated renewables include installing at least 1 MW of Behind-the-Meter Phase 1 solar projects at city buildings. City officials will continue to work with local utilities to encourage development of larger solar arrays. Investments in RECs and/or carbon offsets that meet the city's standards for additionality make up the remaining 85% of the carbon balance.

Scenario 2: 100% Renewable Energy and Zero Net Carbon by 2023

The Scenario 2 objective is to implement a broad range of efficiency measures and accelerate current plans for electrifying vehicle and transit fleets while investing in renewable energy for city operations. By 2023, city government will cut its carbon emissions by 40% with at least 15% of municipal operations' electricity sourced by self-generated renewable energy. Investments in RECs and/or carbon offsets make up the remaining 60% of carbon emissions in this scenario. In Scenario 2, the city will invest in a combination of energy efficiency measures in city buildings, streetlights and water distribution, renewable energy installations, transportation measures and accelerating the electrification of city fleet and Metro transit vehicles to achieve 50% electric buses by 2023. These measures were selected based on cost-effectiveness and their ability to be implemented quickly by local government. Investments for green city fleet measures provide favorable carbon abatement potential. Investments in electric vehicles were selected based on vehicles with the highest miles traveled and the lowest cost options for electric vehicles—currently passenger vehicles and light trucks or SUVs. Phase 1 solar will be completed leading to at least 3 MW of solar at municipal locations.

Scenario 3: 100% Renewable Energy and Zero Net Carbon by 2030

The Scenario 3 objective is to implement known measures to reduce the carbon footprint from city operations and minimize the reliance of external RECs or carbon offsets. By 2030, city government will cut its carbon emissions by 55% with at least 25% of municipal operations' electricity sourced by self-generated renewable energy. Investments in RECs and/or carbon offsets make up the remaining 45% of carbon emissions balance. This path is most consistent with the Paris Agreement requirements, involving more extensive investment over a longer period. Energy efficiency measures with short and longer paybacks are included, such as HVAC retrofits in buildings, in addition to water distribution and street and traffic lights. The City will invest in greening its fleet with all vehicles being converted to operate on electricity or compressed natural gas from non-fossil sources by 2030. Electrification of the fleet enables the City to economically further expand its internal renewable energy generation, adding additional renewable generation opportunities to Phase 1 and Phase 2 behind-the-meter solar on city buildings.

In the last section of the report, additional suggestions are presented to accelerate progress toward reaching **100% RENEWABLE ENERGY AND ZERO NET CARBON** goals for local government operations and for the larger Madison area community. For example, as Metro Transit buses and city fleet vehicles are electrified, the city should add additional solar, energy storage and electric vehicle charging capacity to accommodate these vehicles and to further plan for electric vehicle charging infrastructure for the community. Appendices located at the end of this report include details about this study and information about national and international resources for climate action.

In summary, the energy ecosystem is changing. Renewable energy, energy storage and electric vehicle markets are undergoing rapid technological innovation and price declines. A balanced approach of investments in energy efficiency, transportation strategies, and renewable energy installations, along with RECs and carbon offsets, is key to reaching the **100% RENEWABLE ENERGY AND ZERO NET CARBON** goal quickly and cost-effectively.

In order to ensure that Madison stays focused on its ambitious sustainable journey, City officials should review their plans every two years to confirm progress and update milestones due to the rapidly changing economic, technology, and policy landscape. As the energy landscape continues to evolve, the most effective strategies to reach the City of Madison's goals will also evolve.

City officials have an urgent need for future climate planning and implementation while promoting Madison's vibrant culture to retain and attract the people who will continue to make contributions for our community, our planet, and our shared prosperity. With its clean energy and carbon reduction goals firmly in place, the City of Madison is well-positioned to maximize the value of its energy and climate transition for local government operations and for the broader community.

TABLE ES-1: 100% RENEWABLE ENERGY AND ZERO NET CARBON TIMELINE MENU

SCENARIO	ACTIONS	BENEFITS/OUTCOMES
SCENARIO 1 **100% Renewable Energy and Zero Net Carbon by 2020**	**Efficiency (Demand)** Develop RCx program **Renewable Generation (Supply)** Efficiency (Demand) Develop RCx program Renewable Generation (Supply) Behind-the-Meter Solar (1 MW) Utility Fuel Mix (MGE and Alliant) Utility Solar Project (MGE RER or Alliant) **Transportation** Green Fleet Measures Fleet Passenger Car EV Procurement Fleet Light Duty EV Procurement Landfill CNG Pilot First Three Electric Buses Arrive in Madison **Policy** RECs and Carbon Offsets	•15% carbon reduction with 10% self-generated renewable energy •85% RECs and carbon offsets •$7M investment over 3 years; IRR 15% •Cost savings to city of $18M by 2030 •Reduce total carbon emissions by 200,000 tons by 2030 •Societal co-benefits range from $10M - $76M by 2030
SCENARIO 2 **100% Renewable Energy and Zero Net Carbon by 2023**	**All Scenario 1 Measures** **Efficiency (Demand)** Lighting Retrofits HVAC Control Retrofits Street Lights Water Distribution **Renewable Generation (Supply)** Behind-the-Meter Solar (Phase 1) **Transportation** 50% Electric Buses Landfill CNG Fueling **Policy** RECs and Carbon Offsets	•40% carbon reduction with 15% self-generated renewable energy •60% RECs and carbon offsets •$57M investment over 6 years; IRR 17% •Cost savings to city of $66M by 2030 •Reduce total carbon emissions by 372,000 tons by 2030 •Societal co-benefits range from $18M - $141M by 2030
SCENARIO 3 **100% Renewable Energy and Zero Net Carbon by 2030**	**All Scenario 1 & 2 Measures** **Efficiency (Demand)** HVAC Retrofits Plug Load Management Strategies Building Envelope Improvements **Renewable Generation (Supply)** Behind-the-Meter Solar (Phase 2) **Transportation** 100% Electric Buses Mid-Duty EV Procurement Heavy Duty CNG Procurement **Policy** RECs and Carbon Offsets	•55% carbon reduction with 25% self-generated renewable energy •45% RECs and carbon offsets •$95M investment over 13 years; IRR 17% •Cost savings to city of $78M by 2030 •Reduce total carbon emissions by 426,000 tons by 2030 •Societal co-benefits range from $21M - $162M by 2030

Source: HGA

Resolution No. 19-2-2328
Monona Common Council

CITY OF MONONA RESOLUTION TO ADDRESS CLIMATE CHANGE THROUGH 100 PERCENT CLEAN[1] ENERGY AND RESILIENCE[2]

WHEREAS, the City of Monona is committed to creating a vibrant future for our community by taking responsible and effective action to arrest global warming and become resilient to the devastating risks of climate change on our health and well-being, ecosystems and economy; and

WHEREAS, the Mayor is a 2017 signatory to the Climate Mayors' Pledge to adopt and uphold the Paris Climate Agreement to limit global temperature rise to 1.5 degrees Celsius; and

WHEREAS, the City has been committed to reducing its carbon footprint since resolving in 2010 to generate 25 percent of its energy from renewable sources locally by 2025 as an Energy Independent Community; and

WHEREAS, the City adopted a Comprehensive Plan in 2014 and a Sustainability Plan in 2015 that addresses climate change, is a partner in the Dane County Energy and Climate Commission to move deep decarbonization County-wide, and is developing a comprehensive clean energy action plan in 2019; and

WHEREAS, the City has installed solar energy projects on four of five of its largest City-owned building rooftops; and

WHEREAS, the City is committed to ensuring all residents enjoy the benefits of energy efficiency and renewable energy, electrified transportation, fair utility rates, and employment opportunities of a clean energy economy; and

WHEREAS, youth and future generations will be most severely impacted by climate change, and it is the duty of current leaders to act promptly and resolutely to mitigate climate change for their benefit; and

WHEREAS, the City acknowledges that low-income residents and other vulnerable communities are often most burdened by energy rates and climate impacts: and,

WHEREAS, the economic impacts of severe climate events will become unaffordable to Monona taxpayers as the August 2018 flooding clearly demonstrated, so that mitigating climate change while improving the resilience of City infrastructure is the prudent, fiscally responsible thing to do; and

WHEREAS, climate scientists agree unequivocally that local climate change impacts will continue to include increasingly severe and more frequents droughts, worsening heat waves, excessive flooding, dieback of native tree species, reduced winter sports opportunities, increased prevalence of algal blooms on area lakes and ponds; and loss of suitable trout stream habitat in Wisconsin; and

WHEREAS, community-based, regenerative environmental infrastructure development can benefit the entire City, and positively enhance our ecosystems, provide jobs, add to economic activity, and provide equity benefits; and

WHEREAS, use of distributed solar and other renewable energy sources, paired with energy storage, and backed up by renewable co-generation, is an important strategy to build disaster resilience in the City; and

[1] **Clean energy** is defined as energy efficiency plus emission-free renewable energy.
[2] **Resiliency** is the strengthening of the ability of people and ecosystems to withstand and respond to severe events and ongoing climate changes.

WHEREAS, the City's energy use could be served by existing renewable energy technologies at reasonable cost, and the economic opportunities from a clean energy transition greatly exceed the diminishing economic opportunities from fossil fuels; and

WHEREAS, given the accelerating rate of climate change, as detailed in the Intergovernmental Panel on Climate Change (IPCC) Special Report on Global Warming SR15 and in the Fourth National Climate Assessment, it is urgent that energy consumers, the City, and the utility serving the City must take strong, swift action to reduce carbon emissions, and shift to 100 percent renewable electricity by 2030, which is within practical and economic reach; and

WHEREAS, Monona's utility provider, Madison Gas & Electric, which has pledged to increase its energy mix to at least 30% renewable energy by 2030 with at least an 80% reduction in carbon dioxide emissions by 2050 from 2005 levels, will be a key partner in creating additional cost-effective renewable energy generation, electrified transportation, energy efficiency improvements, and a progressive grid to assist the City in achieving its clean energy and resilience goals; and

WHEREAS, achieving these energy goals will require concerted action from individuals and the community, in urban and rural areas county-wide, from local and state governments, and from businesses and utilities.

NOW, THEREFORE, BE IT RESOLVED, by the Common Council of the City of Monona, Dane County, Wisconsin, the City affirms its ongoing commitment to intensify its action to meet the green house reduction goals of the Paris Climate Agreement, and opposes the rollback of science and climate policy at the federal and state levels; and

BE IT FURTHER RESOLVED, that, given energy efficiency is a key and economical choice for meeting energy needs and reducing our carbon footprint, the City will advance energy efficiency and conservation projects, programs and outreach; and

BE IT FURTHER RESOLVED, that the City will increase green infrastructure such as urban tree canopy, green streets, green roofs, electric vehicle charging stations, and bike and pedestrian infrastructure as an effective strategy to reduce energy consumption and increase public health and well-being along with other climate resiliency strategies;

BE IT FURTHER RESOLVED, the City will meet its 100% renewable energy goals for city operations including buildings, infrastructure and fleet by:

a) reducing its energy use for city operations by at least 15% by 2030, 40% by 2040 and 50% by 2050; and
b) meeting 35% of its electric needs for City operations through renewable energy resources by 2025 and 100% by 2030; and
c) meeting 65% of all City operations energy needs with renewable energy by 2030, 85% by 2035, and 100% by 2040; and

BE IT FURTHER RESOLVED, the City will work to achieve its 100% renewable energy goal community-wide by establishing goals with increasing targets to:

a) reduce community-wide energy use at least 10% by 2030, and 40% by 2050; and
b) meet 35% of community-wide electric needs through renewable energy resources by 2025, 50% by 2030, 75% by 2035, and 100% by 2040; and
c) meet 20% of community-wide energy needs with renewable energy by 2030, 80% by 2040, and 100% by 2050; and

BE IT FURTHER RESOLVED, the City will support energy resources and programs that benefit low-income residents and create more equity in energy use, rates and jobs in the community; and

BE IT FURTHER RESOLVED, the City will prioritize renewable resources and programs during the transition to 100 percent renewable energy; and, when purchasing renewable energy credits (RECs), will prioritize those that generate new renewable energy in Wisconsin; and

BE IT FURTHER RESOLVED, the City will prioritize community-based development of renewable energy in Dane and surrounding counties; and

BE IT FURTHER RESOLVED, the City will collaborate with other governmental and public entities locally and regionally to facilitate all clean energy measures; and

BE IT FURTHER RESOLVED, the City will prioritize local and micro-grid-based renewable energy projects over remote generation and transmission, and provide renewable energy and energy storage at key public facilities to reduce vulnerability to main electric grid failure; and

BE IT FURTHER RESOLVED, the City will develop resiliency strategies to deal with anticipated changes and severe climate events associated with climate change; and

BE IT FURTHER RESOLVED, that this resolution requires that the Mayor, City Council, Committees, Commissions and staff actively reduce climate change impacts by amending and developing plans, ordinances, policies and budgets to move Monona toward being a 100% renewable energy and resilient city in order to create a healthier, safer and more prosperous community.

Adopted this 4th day of March 2019.

BY ORDER OF THE CITY COUNCIL
CITY OF MONONA, WISCONSIN

~~Mary K. O'Connor~~ Douglas S. Wood
~~Mayor~~ Acting Mayor

ATTEST:

Joan Andrusz
City Clerk

Approval Recommended By: Sustainability Committee – 2/13/19

Council Action:
Date Introduced: 2-18-19
Revised: 3-4-19
Date Approved: 3-4-19
Date Disapproved: ______

RESOLUTION # 2018-32

RESOLUTION TO ADDRESS GLOBAL WARMING THROUGH CLEAN ENERGY

WHEREAS, the City of Middleton ballot referendum results on climate change in November 2016 showed a strong 81 percent mandate from our residents in support of mitigating climate change; and

WHEREAS, the mayor is a 2017 signatory to the Mayors' Pledge to support the Paris Climate Agreement; and

WHEREAS, the City has been committed to gradually reducing its carbon footprint since resolving to become an Energy Independent Community in 2008; and

WHEREAS, the City intervened in MGE's 2014 rate case at the PSC to support electric rates that encourage energy efficiency and renewable energy that are fair to all users; and

WHEREAS, the City has installed solar energy projects at City-owned buildings and cooperated with Madison Gas & Electric (MGE) to install a large community-solar array to provide clean electricity to its residents and businesses on the Middleton Operations Center roof; and

WHEREAS, low-income residents are often most burdened by energy rates and climate impacts, and the City is committed to ensuring all residents enjoy the benefits of energy efficiency and renewables, electrified transportation, fair utility rates, and employment opportunities; and

WHEREAS, youth and future generations will be more severely impacted by climate change, and it is the duty of current leaders to act promptly and resolutely to mitigate climate change for their benefit; and

WHEREAS, use of distributed solar and other renewable energy sources, paired with energy storage, and/or backed up by renewable co-generation, is an important strategy to build disaster resilience in the City; and

WHEREAS, in 2016, 88 percent of electricity delivered to Middleton consumers by Madison Gas & Electric was generated from fossil fuels - 68% coal and 22% natural gas (vs. the national average of 30% coal and 35% NG); and

WHEREAS, the City's energy use could be served by existing renewable energy technologies at reasonable cost, and the economic opportunities from a clean energy transition greatly exceed any economic opportunities from fossil fuels; and

WHEREAS, community-based environmental infrastructure development can benefit the entire City, and provide jobs, add to economic activity, and provide equity benefits; and

WHEREAS, given the accelerating rate of climate change, energy consumers, the City, and the utility serving the City must take strong action imminently to reduce carbon emissions, and shift to 100 percent renewable electricity by 2035 within practical and economic reach; and

WHEREAS, achieving these energy goals will require concerted action from individuals and the community, in urban and rural areas, from local and state governments, and from businesses and utilities; and

WHEREAS, climate scientists agree that local climate change impacts will continue to include increasingly severe and more frequents droughts, worsening heat waves, excessive flooding, dieback of native tree species, reduced winter sports opportunities, increased prevalence of algal blooms on area lakes and ponds; and loss of suitable trout stream habitat in Wisconsin; and

WHEREAS, virtually the entire world united in December 2015 with the Paris Climate Agreement to agree to attempt to limit global temperature rise to 1.5 degrees C; yet, federal and Wisconsin state government have since withdrawn from the Paris Climate Agreement and deny the urgency of climate change.

NOW, THEREFORE, BE IT RESOLVED, that given energy efficiency is the City's first and most economical choice for meeting energy needs and reducing our carbon footprint, the City will prioritize energy efficiency and conservation projects, programs and outreach; and

BE IT FURTHER RESOLVED, that the City will increase green infrastructure such as urban tree canopy, green streets, green roofs, electric vehicle charging stations, and bike and pedestrian paths as an effective strategy to reduce energy consumption and increase public health and well-being along with other climate resiliency strategies;

BE IT FURTHER RESOLVED, the City will reduce its energy use for city operations at least 15% by 2030, and 50% by 2050; and

BE IT FURTHER RESOLVED, the City will work to reduce community wide energy use at least 10% by 2030, and 40% by 2050; and

BE IT FURTHER RESOLVED, the City will meet 25 percent of its electric needs for City operations through renewable energy resources by 2025, 80 percent by 2030, and 100 percent by 2035; and

BE IT FURTHER RESOLVED, the City establishes goals to meet 66 percent of all City operations energy needs with renewable energy by 2030, 88 percent by 2035, and 100 percent by 2040; and

BE IT FURTHER RESOLVED, the City establishes goals with increasing targets to meet 20 percent of community-wide electric needs through renewable energy resources by 2025, 66 percent by 2030, 88 percent by 2035, and 100 percent by 2040; and

BE IT FURTHER RESOLVED, the City establishes goals to meet 21 percent of community-wide energy needs with renewable energy by 2030, 80 percent by 2040, and 100 percent by 2050; and

BE IT FURTHER RESOLVED, the City will prioritize energy resources and programs that benefit low-income residents and create more equity in energy use, rates and jobs in the community; and

BE IT FURTHER RESOLVED, the City opposes the rollback of science and climate policy at the federal and state levels and affirms its ongoing commitment to the goals of the Paris Climate Agreement and the City's responsibility to meet its greenhouse gas reductions based on the Paris Climate Agreement; and

BE IT FURTHER RESOLVED, the City will prioritize renewable resources and programs over purchasing renewable energy credits (RECs) to reduce reliance on RECs during the transition to 100 percent renewable resources; and

BE IT FURTHER RESOLVED, the City will prioritize community-based development of renewable energy in Dane and surrounding Counties; and

BE IT FURTHER RESOLVED, the City will collaborate with other governmental and public entities locally and regionally to facilitate all energy measures; and

BE IT FURTHER RESOLVED, the City will prioritize local and micro-grid-based renewable energy projects over remote generation and transmission, and provide renewable energy and energy storage at key public facilities to reduce vulnerability to main electric grid failure; and

BE IT FURTHER RESOLVED, the City will develop a resiliency plan to deal with anticipated changes associated with climate change.

The above and foregoing Resolution was duly adopted at a regular meeting of the Common Council of the City of Middleton on _____ day of ______________, 2018.

APPROVED:

By:________________________________
Gurdip Brar, Mayor

ATTEST:

____
Lorie J. Burns, City Clerk

Vote:
Ayes: _______
Noes: _______
Adopted: _______

Total Energy-Related Carbon Dioxide Emission Projection Range for 9 Scenarios in EIA's 2021 Annual Energy Outlook
(West North Central, East North Central, East South Central, West South Central)

Scenario Name	Scen. #	2020	2021	2022	2023	2024	2025	2026	2027
Reference case	1	2,476	2,522	2,592	2,563	2,524	2,487	2,521	2,503
High economic growth	2	2,476	2,555	2,628	2,620	2,601	2,570	2,609	2,599
Low economic growth	3	2,476	2,491	2,535	2,506	2,460	2,404	2,430	2,399
High oil price	4	2,476	2,543	2,599	2,575	2,531	2,486	2,500	2,486
Low oil price	5	2,476	2,531	2,575	2,538	2,492	2,447	2,481	2,463
High oil and gas supply	6	2,477	2,529	2,587	2,552	2,530	2,491	2,534	2,544
Low oil and gas supply	7	2,476	2,528	2,583	2,549	2,512	2,464	2,458	2,417
High renewable cost	8	2,476	2,522	2,591	2,560	2,525	2,491	2,530	2,518
Low renewable cost	9	2,476	2,522	2,592	2,558	2,512	2,465	2,487	2,456

Total Energy-Related Carbon Dioxide Emission Projection Range for 9 Scenarios in EIA's 2021 Annual Energy Outlook
(West North Central, East North Central, East South Central, West South Central)

Scen. #	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
1	2,505	2,508	2,504	2,506	2,499	2,501	2,505	2,499	2,504	2,505	2,504	2,511	2,517
2	2,606	2,617	2,620	2,628	2,629	2,641	2,659	2,670	2,687	2,704	2,723	2,743	2,764
3	2,393	2,390	2,383	2,376	2,370	2,371	2,373	2,366	2,361	2,356	2,354	2,354	2,352
4	2,475	2,481	2,476	2,483	2,486	2,505	2,512	2,517	2,521	2,524	2,533	2,536	2,547
5	2,459	2,453	2,447	2,450	2,453	2,456	2,462	2,467	2,475	2,488	2,496	2,510	2,520
6	2,559	2,580	2,584	2,592	2,598	2,610	2,618	2,626	2,636	2,648	2,656	2,669	2,678
7	2,395	2,377	2,368	2,364	2,361	2,359	2,351	2,348	2,350	2,354	2,356	2,357	2,357
8	2,521	2,528	2,528	2,530	2,531	2,536	2,548	2,550	2,558	2,562	2,571	2,581	2,588
9	2,442	2,453	2,449	2,449	2,445	2,443	2,449	2,439	2,442	2,446	2,449	2,453	2,447

Total Energy-Related Carbon Dioxide Emission Projection Range for 9 Scenarios in EIA's 2021 Annual Energy Outlook
(West North Central, East North Central, East South Central, West South Central)

Scen. #	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**
1	2,525	2,539	2,552	2,566	2,569	2,576	2,587	2,602	2,615	2,630
2	2,792	2,817	2,839	2,857	2,867	2,885	2,907	2,932	2,962	2,991
3	2,350	2,350	2,351	2,359	2,355	2,356	2,359	2,364	2,370	2,377
4	2,558	2,568	2,582	2,594	2,601	2,614	2,622	2,629	2,648	2,666
5	2,530	2,542	2,553	2,561	2,563	2,572	2,582	2,593	2,611	2,632
6	2,692	2,710	2,738	2,770	2,786	2,797	2,807	2,817	2,823	2,843
7	2,360	2,370	2,374	2,376	2,366	2,366	2,366	2,367	2,367	2,369
8	2,595	2,613	2,634	2,650	2,663	2,678	2,690	2,704	2,720	2,740
9	2,449	2,461	2,466	2,467	2,466	2,460	2,467	2,466	2,466	2,475

NREL

U.S. Solar Photovoltaic System and Energy Storage Cost Benchmark: Q1 2020

David Feldman, Vignesh Ramasamy, Ran Fu, Ashwin Ramdas, Jal Desai, and Robert Margolis

National Renewable Energy Laboratory

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy
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Contract No. DE-AC36-08GO28308

Technical Report
NREL/TP-6A20-77324
January 2021

U.S. Solar Photovoltaic System and Energy Storage Cost Benchmark: Q1 2020

David Feldman, Vignesh Ramasamy, Ran Fu,
Ashwin Ramdas, Jal Desai, and Robert Margolis

National Renewable Energy Laboratory

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Technical Report
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National Renewable Energy Laboratory
15013 Denver West Parkway
Golden, CO 80401
303-275-3000 • www.nrel.gov

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List of Acronyms

AC	alternating current
ASP	average selling price
BNEF	Bloomberg New Energy Finance
BOS	balance of system
CA NEM	California Net Energy Metering
CdTe	cadmium telluride
CF	capacity factor
CPI	Consumer Price Index
c-Si	crystalline silicon
DC	direct current
DOE	U.S. Department of Energy
EPC	engineering, procurement, and construction
FICA	Federal Insurance Contributions Act
GPRA	Government Performance and Reporting Act
HVAC	heating, ventilating, and air conditioning
ITC	investment tax credit
LBNL	Lawrence Berkeley National Laboratory
LCOE	levelized cost of energy
LCOS	levelized cost of storage
LCOSS	levelized cost of solar-plus-storage
Li-ion	lithium-ion
MACRS	Modified Accelerated Cost Recovery System
MLPE	module-level power electronics
MM	million
MW_{AC}	megawatts alternating current
MW_{DC}	megawatts direct current
NEC	National Electrical Code
NEM	net energy metering
NREL	National Renewable Energy Laboratory
O&M	operation and maintenance
PERC	passivated emitter and rear cells
PII	permitting, inspection, and interconnection
PPA	power-purchase agreement
PV	photovoltaic(s)
Q	quarter
SETO	Solar Energy Technologies Office (DOE)
SG&A	selling, general, and administrative
TPO	third-party ownership
USD	U.S. dollars
V_{DC}	volts direct current
W_{AC}	watts alternating current
W_{DC}	watts direct current
W_p	watts peak

Executive Summary

This report benchmarks U.S. solar photovoltaic (PV) system installed costs as of the first quarter of 2020 (Q1 2020). We use a bottom-up method, accounting for all system and project development costs incurred during installation to model the costs for residential, commercial, and utility-scale PV systems, with and without energy storage. We attempt to model typical installation techniques and business operations from an installed-cost perspective. Costs are represented from the perspective of the developer/installer; thus, all hardware costs represent the price at which components are purchased by the developer/installer, not accounting for preexisting supply agreements or other contracts. Importantly, the benchmark also represents the sales price paid to the installer. Therefore, it includes profit in the cost of the hardware[1]; the profit the installer/developer receives is reported as a separate cost category on top of all other costs to approximate the final retail price paid to the installer/developer. However, we do not include any additional profit, such as a developer fee or price gross-up, which is common in the marketplace. We adopt this approach owing to the wide variation in developer overhead and profit in all three sectors (residential, commercial, and utility-scale), where project pricing depends greatly on the region and project specifics such as local retail electricity rate structures, local rebate and incentive structures, competitiveness of the environment, and overall project or deal structures. Benchmarks also assume a business environment without any impact from novel coronavirus pandemic. Finally, our benchmarks are national averages calculated using average values across all states. Table ES-1 summarizes the first-order benchmark assumptions.

Table ES-1. Benchmark Assumptions

Unit	Description	
Values	2019 U.S. dollars (USD)a	
System Sizes	PV systems are quoted in direct current (DC) terms; inverter prices are converted by DC-to-alternating current (AC) ratios; storage systems are quoted in terms of kilowatt-hours or megawatt-hours (kWh or MWh) of storage or the number of hours of storage at peak capacity.	
PV Sector	**Description**	**Size Range**
Residential	Residential rooftop systems, monocrystalline silicon modules	4kW–7 kW
Commercial	Commercial rooftop with ballasted racking and fixed-tilt ground-mounted systems, monocrystalline silicon modules	100 kW–2 MW
Utility-scale	Ground-mounted systems, monocrystalline silicon modules, fixed-tilt and one-axis tracking	5–100 MW

[a] The dollar-per-watt total cost values are benchmarked as three significant figures, because the model inputs, such as module and inverter prices, use three significant figures.

[1] Profit is one of the differentiators between “cost” (aggregated expenses incurred by a developer or installer to build a system) and “price” (what an end user pays for a system).

Based on our bottom-up modeling, the Q1 2020 PV cost benchmarks are:

- \$2.71 per watt DC (W_{DC}) (or \$3.12/W_{AC}) for residential PV systems
- \$1.72/W_{DC} (or \$1.96/W_{AC}) for commercial rooftop PV systems
- \$1.72/W_{DC} (or \$1.91/W_{AC}) for commercial ground-mount PV systems
- \$0.94/W_{DC} (or \$1.28/W_{AC}) for fixed-tilt utility-scale PV systems
- \$1.01/W_{DC} (or \$1.35/W_{AC}) for one-axis-tracking utility-scale PV systems
- \$26,153–\$28,371 for a 7-kW residential PV system with 3 kW/6 kWh of storage and \$35,591–\$37,909 for a 7-kW residential PV system with 5 kW/20 kWh of storage
- \$2.07 million–\$2.13 million for a 1-MW commercial ground-mount PV system colocated with 600 kW/2.4 MWh of storage
- \$171 million–\$173 million for a 100-MW PV system colocated with 60 MW/240 MWh of storage.

Figure ES-1 puts our Q1 2020 PV-only benchmark results in context with the results of previous National Renewable Energy Laboratory (NREL) benchmarking analyses. When comparing the results across this period (2010–2020), it is important to note that:

1. Values are inflation-adjusted using the 2019 Consumer Price Index (CPI). Thus, historical values from our models are adjusted and presented as real USD instead of nominal USD. In previous year's models, we inflation-adjusted values based on a partial year of CPI data. For example, in the Q1 2018 benchmark report (Fu, Feldman, and Margolis 2018), all values are quoted in 2018 USD; however, the inflation adjustment is based on the average CPI Index of Q1 2018 (January through March 2018). Because the benchmark reports are produced before the end of the calendar year, indexing them to the full-year average CPI in that year is not possible. To better correct for inflation, in this year's report, we quote values in previous year's dollars (2019 USD). In 2018, the CPI-All Urban Consumers Index is 248.8 for the first three months and 251.1 for the whole year (and 255.7 for 2019).
2. Cost categories are aggregated for comparison purposes. "Soft Costs—Others" represents permitting, inspection, and interconnection (PII); transmission line (if any); sales tax; and engineering, procurement, and construction (EPC)/developer overhead and profit. These costs are broken out in the report for each subsector.
3. The current versions of our cost models make a few significant changes from the versions used in our previous Q1 2018 benchmark report (Fu, Feldman, and Margolis 2018). To better distinguish the historical cost trends over time from the changes to our cost models, we also calculate Q1 2019 and Q1 2020 PV benchmarks using the Q1 2018 versions of the residential, commercial, and utility-scale PV models. Appendix A provides a detailed discussion of the changes made to the models between previous versions (Fu, Feldman, and Margolis 2018) and this year's versions.
4. Our Q1 2019 and Q1 2020 benchmarks use monocrystalline PV modules, whereas all historical benchmarks used multicrystalline PV modules. This switch reflects the overall trend occurring in the U.S. market.
5. For previous editions of this report, we assumed a land acquisition cost of \$0.03/W. Based on Wiser et al. (2020), which stated that most utility-scale PV projects do not own the land on which the PV system is placed, we have reclassified land costs from an upfront capital expenditure (land acquisition) to an operating expenditure (lease payments) for 2019 and 2020.

From 2010 to 2020, there was a 64%, 69%, and 82% reduction in the residential, commercial rooftop, and utility-scale (one-axis) PV system cost benchmark, respectively. A significant portion of that reduction can be attributed to total hardware costs (module, inverter, and hardware balance of system [BOS]), with module prices dropping 85% over that period. Overall, modeled PV installed costs across the three sectors have experienced different recent changes. The inflation-adjusted system cost differences between Q1 2019 and Q1 2020 are a $0.06/W_{DC}$ reduction for residential PV, a $0.04/W_{DC}$ reduction for commercial rooftop PV, and a $0.01/W_{DC}$ reduction for utility-scale PV. Table ES-2 shows the benchmarked values for all three sectors and the drivers of cost decreases and increases.

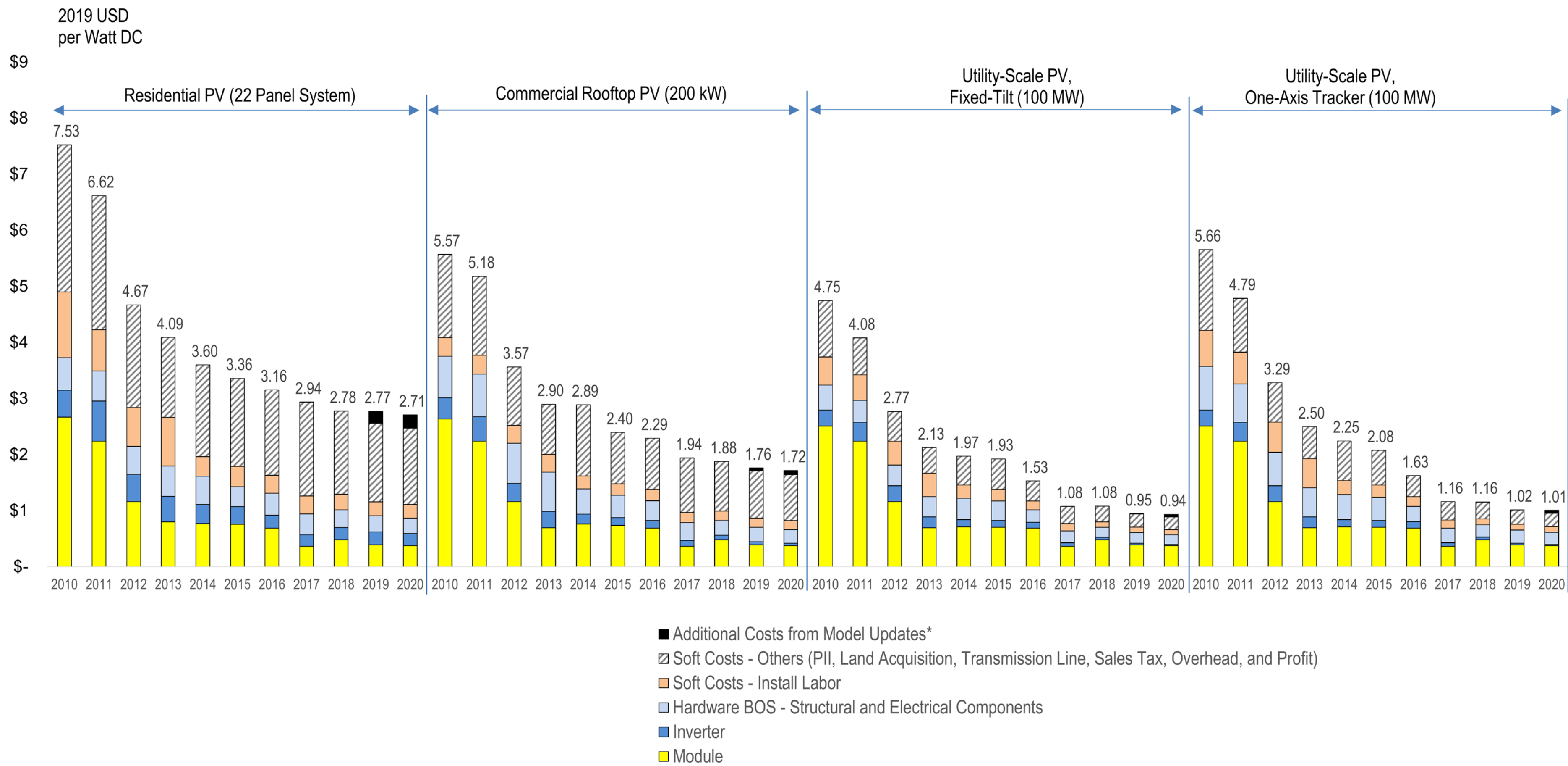

Figure ES-1. NREL PV system cost benchmark summary (inflation-adjusted), 2010–2020

* The current versions of our cost models make a few significant changes from the versions used in our Q1 2018 benchmark report (Fu, Feldman, and Margolis 2018) and incorporate costs that had previously not been benchmarked in as much detail. To better distinguish the historical cost trends from the changes to our cost models, we also calculate Q1 2019 and Q1 2020 PV benchmarks using the Q1 2018 versions of the residential, commercial, and utility-scale PV models. The “Additional Costs from Model Updates” category represents the difference between modeled results. Using the previous costs models, the Q1 2019 and Q1 2020 benchmarks are calculated to be: Q1 2019 = $2.56/$W_{DC}$ and Q1 2020 = $2.47/$W_{DC}$ (residential PV); Q1 2019 = $1.71/$W_{DC}$ and Q1 2020 = $1.64/$W_{DC}$ (commercial PV); Q1 2019 = $0.94/$W_{DC}$ and Q1 2020 = $0.89/$W_{DC}$ (utility-scale PV, fixed-Tilt); Q1 2019 = $1.01/$W_{DC}$ and Q1 2020 = $0.96/$W_{DC}$ (utility-scale PV, one-axis tracker). Appendix A provides a detailed discussion of the changes made to the models between last year’s versions (Fu, Feldman, and Margolis 2018) and this year’s versions.

Table ES-2. Comparison of Q1 2019 and Q1 2020 PV System Cost Benchmarks

Sector	Residential PV	Commercial Rooftop PV	Utility-Scale PV, One-Axis Tracking
Q1 2019 benchmarks in 2019 USD/W_{DC}	$2.77	$1.76	$1.02
Q1 2020 Benchmarks in 2019 USD/W_{DC}	$2.71	$1.72	$1.01
Drivers of cost decrease	• Higher module efficiency (from 19.2% to 19.5%) • Decrease in BOS hardware and supply chain costs	• Higher module efficiency • Lower material & equipment costs in some categories	• Higher module efficiency • Lower material & equipment costs in some categories • Movement of land acquisition cost from upfront capital expenditures into operation & maintenance
Drivers of cost increase	• Higher labor wages • Higher module costs	• Higher labor wages • Higher module costs	• Higher labor wages • Higher steel prices • Higher module and inverter costs

Hardware costs remained relatively flat, year-on-year, in Q1 2020, as shown in Figure ES-1, resulting in no change to the percentage of non-hardware, or "soft," costs.[2] Figure ES-2 shows the contribution of soft costs to total costs over time.[3] Also, soft costs and hardware costs interact. For instance, module efficiency improvements have reduced the number of modules required to construct a system of a given size, thus reducing hardware costs. This trend has also reduced soft costs from direct labor and related installation overhead.

[2] Soft cost = total cost – hardware (module, inverter, structural and electrical BOS) cost.
[3] A stagnant or rising soft cost proportion in the last two years in Figure ES-2 indicates soft costs declined more slowly than did hardware costs; it does *not* indicate soft costs increased on an absolute basis. Historical contributions of soft costs to total utility-scale PV costs differ in this figure from previous versions, because values in previous figures were representative of fixed-tilt systems, whereas these values are representative of a one-axis tracking system.

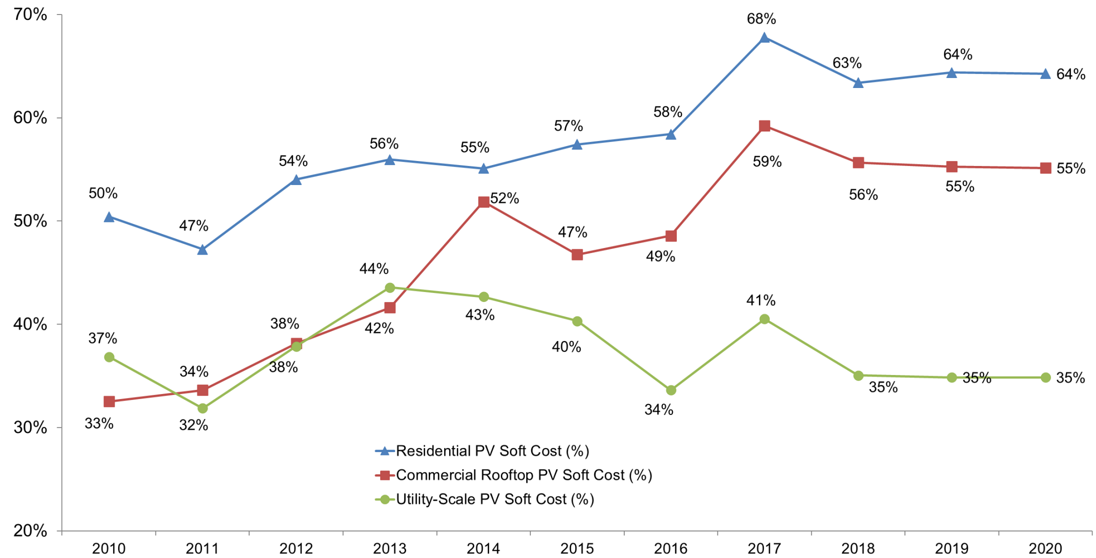

Figure ES-2. Modeled trend of soft cost as a proportion of total cost by sector, 2010–2020

Our bottom-up system cost models enable us to investigate regional variations, system configurations (e.g., module-level power electronics [MLPE] versus non-MLPE, fixed-tilt versus one-axis tracking, and small versus large system size), and business structures (e.g., small installer versus national integrator, and EPC versus developer). Different scenarios result in different costs, so consistent comparisons can only be made when cost scenarios are aligned. The data in this annual benchmark report inform the formulation of and track progress toward the U.S. Department of Energy Solar Energy Technologies Office's (SETO's) Government Performance and Reporting Act cost targets.

The changes in installed cost—along with improvements in operation, system design, and technology—have resulted in changes in the cost of electricity (Figure ES-3). Compared with system prices when SETO's levelized cost of energy (LCOE) targets were announced in 2010, U.S. residential and commercial PV systems are 93% and 97% toward achieving the 2020 targets, respectively, and U.S. utility-scale PV systems achieved their 2020 SETO target three years early. In recognition of both the transformative solar progress to date and the potential for additional innovation, SETO extended its goals in 2016 to reduce the unsubsidized LCOE by 2030 to 3¢/kWh (utility-scale PV), 4¢/kWh (commercial PV), and 5¢/kWh (residential PV). Continued research and development, public and private partnerships, and business innovations are necessary to achieve SETO's 2030 LCOE targets.

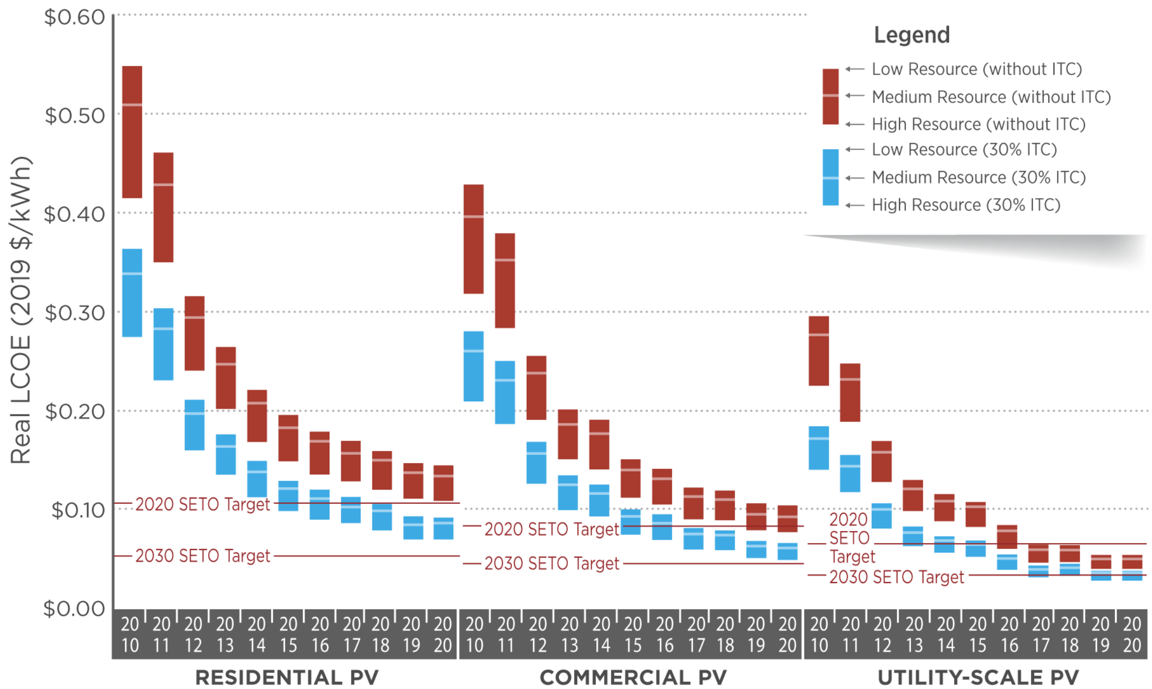

Figure ES-3. NREL PV LCOE benchmark summary (inflation-adjusted), 2010–2020

We updated our methods and model structure in this year's version; 2019 and 2020 LCOEs are higher than they would have been using previous models. Appendix A provides a detailed discussion of the changes made to the models between the previous versions (Fu, Feldman, and Margolis 2018) and this year's versions. LCOE is calculated for each scenario under a range of capacity factors, but all other values remain the same.[4] ITC = federal investment tax credit.

We also conducted a cost analysis of PV-plus-storage systems. Figures ES-4 and ES-5 put our Q1 2020 PV-plus-storage benchmark results in context with the results of previous NREL benchmarking analyses. Figure ES-4 shows 9% and 8% reductions in utility-scale PV-plus-storage benchmarks between 2018 and 2020 for DC-coupled and AC-coupled systems, respectively. Approximately 28%–30% of total cost reductions can be attributed to lithium-ion battery and bidirectional inverter cost reductions. Although there are some configuration differences between AC-coupled and DC-coupled systems (e.g., the inverter, structural BOS, and electrical BOS), the total cost difference between them is only 1%. For an actual project, cost savings may not be the only factor in choosing between DC- or AC-coupling. Additional factors—such as retrofit considerations, system performance (including energy loss due to clipping), design flexibility, and operation and maintenance—should be considered.

[4] Capacity factors were calculated using the locations: Phoenix, AZ (high solar resource); Kansas City, MO (medium solar resource); and New York City, NY (low solar resource).

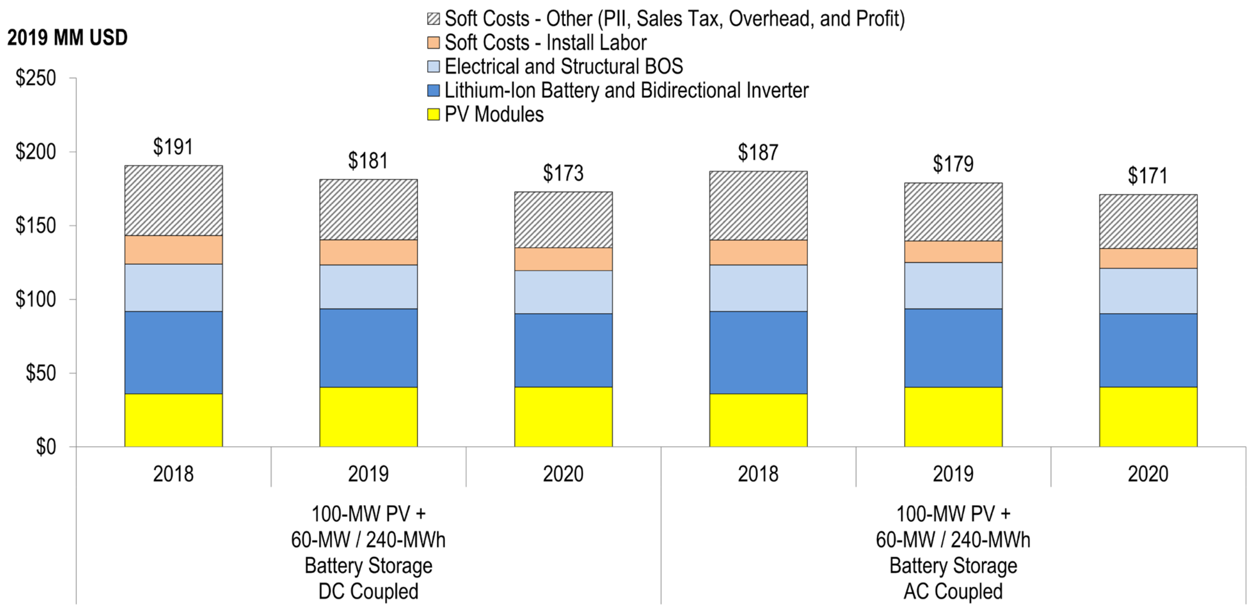

Figure ES-4. Utility-scale PV-plus-storage system cost benchmark summary (inflation-adjusted), 2018–2020, DC-coupled and AC-coupled

The Q1 2018 utility-scale PV-plus-storage benchmark (Fu, Remo, and Margolis 2018) was calculated at a different time than the Q1 2018 utility-scale PV benchmark (Fu, Feldman, and Margolis 2018) and includes different assumptions for PV system costs, including PV module costs. MM = million.

Figure ES-5 shows the 11% and 25% reductions in residential PV-plus-storage benchmarks between 2016 and 2020 for AC-coupled less-resilient and more-resilient cases, respectively. Most of these reductions can be attributed to reductions in the cost of PV modules and AC-coupled batteries. The cost reductions occurred despite the rated capacity of the 22-module system increasing from 5.6 kW to 7.0 kW between 2016 and 2020.

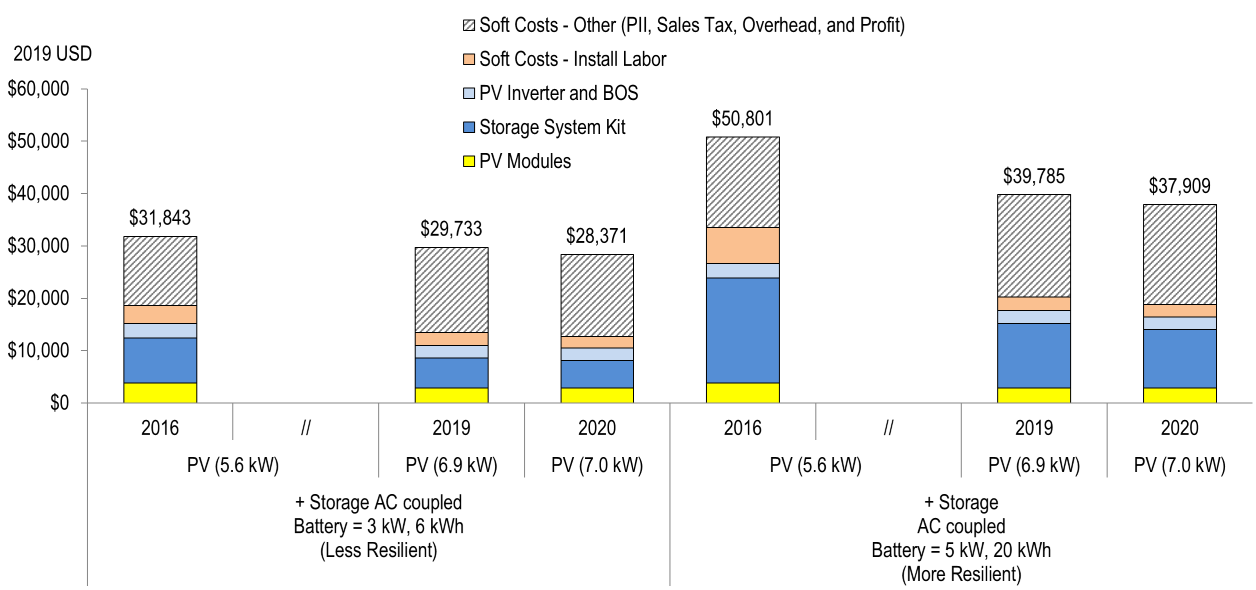

Figure ES-5. Residential PV-plus-storage system cost benchmark summary (inflation-adjusted), 2016, 2019, and 2020

Finally, for this year's benchmark report, we derive a formula for the levelized cost of solar-plus-storage (LCOSS) to better demonstrate the total cost of operating a PV-plus-storage plant, on a per-MWh basis. Figure ES-6 shows the resulting LCOSS for a colocated AC-coupled PV-plus-storage systems for each market segment, as well as the LCOE of standalone PV systems. For residential PV-plus-storage, LCOSS is calculated to be $201/MWh without the federal ITC and $124/MWh with the 30% ITC. For commercial PV-plus-storage, it is $113/MWh without the ITC and $73/MWh with the 30% ITC. For utility-scale PV-plus-storage, it is $83/MWh without the ITC and $57/MWh with the 30% ITC.[5]

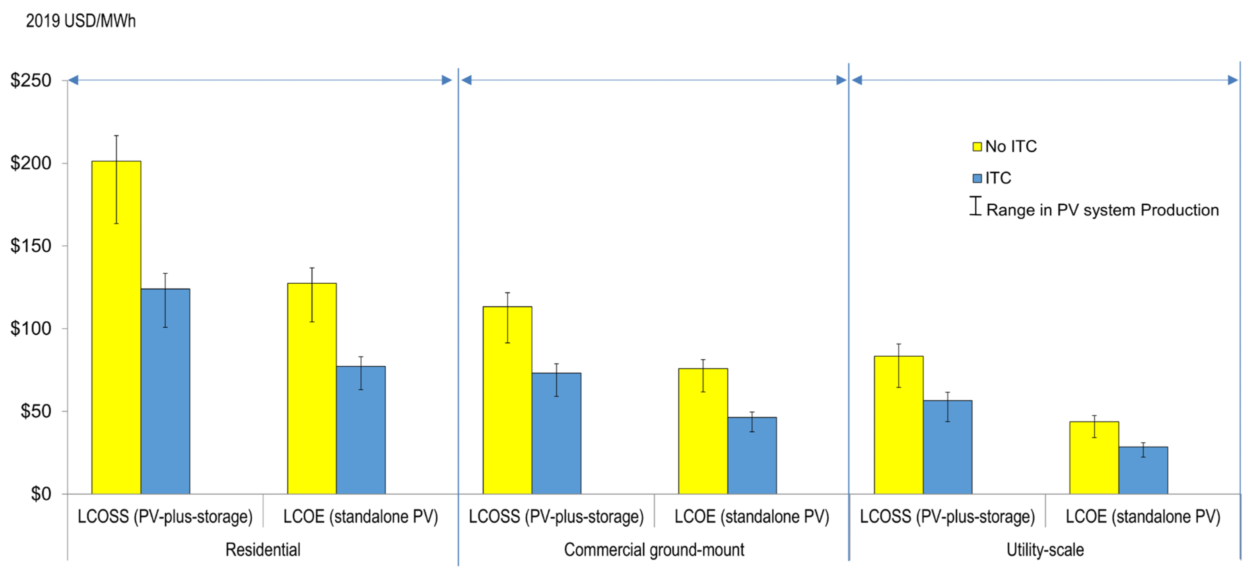

Figure ES-6. LCOSS for AC-coupled PV-plus-storage systems and LCOE for PV standalone systems, by market segment, Q1 2020

LCOSS and LCOE are calculated for each scenario under a medium resource location. The LCOSS and LCOE ranges are based on high and low capacity factor assumptions; all other values remain the same.

[5] We use the same inputs and assumptions for the ITC and non-ITC cases, despite the fact that the inputs in the LCOSS calculation assume the owner of the PV-plus-storage system operates the plant so they can claim the ITC on the storage equipment. In reality, an owner would likely operate a PV-plus-storage system differently without the ITC. Additionally, we assume projects can qualify as starting construction before 2020, allowing them to claim a 30% ITC, instead of the 26% ITC for projects starting construction in 2020.

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1 Introduction

This report continues previous tracking of photovoltaic (PV) cost reductions by benchmarking the costs of U.S. residential, commercial, and utility-scale PV, energy storage, and PV-plus-storage systems built in the first quarter (Q1) of 2020.[6] It was produced in conjunction with several related research activities at the National Renewable Energy Laboratory (NREL) and Lawrence Berkeley National Laboratory (LBNL), which are documented by Barbose and Darghouth (2019), Bolinger, Seel, and Robson (2019),[7] Chung et al. (2015), Feldman et al. (2015), and Fu et al. (2016).

Our benchmarking method includes bottom-up accounting for all *necessary* system and project-development costs incurred when installing residential, commercial, and utility-scale systems, and it models the Q1 2019 and Q1 2020 costs for such systems excluding any previous supply agreements or contracts. In general, we attempt to model the typical installation techniques and business operations from an installed-cost perspective, and our benchmarks are national averages. The residential PV-only benchmark and the commercial rooftop PV-only benchmark average costs by inverter type (string inverters, string inverters with direct current [DC] optimizers, and microinverters), weighted by inverter market share. The residential PV-only benchmark is further averaged across small installer and national integrator business models, weighted by market share. All benchmarks include variations—accounting for the differences in size, equipment, and operational use (particularly for storage)—that are currently available in the marketplace. All benchmarks assume nonunionized construction labor; residential and commercial PV systems predominantly use nonunionized labor, and the type of labor required for utility-scale PV systems depends heavily on the development process. All benchmarks assume the use of monofacial monocrystalline silicon PV modules. Benchmarks using cadmium telluride (CdTe) or bifacial modules could result in significantly different results.[8] The data in this annual benchmark report inform the formulation of and track progress toward the U.S. Department of Energy (DOE) Solar Energy Technologies Office's (SETO's) Government Performance and Reporting Act (GPRA) cost targets.

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[6] Previous cost benchmark reports include reports published for Q1 2018 PV (Fu, Feldman, and Margolis 2018), 2018 PV-plus-storage (Fu, Remo, and Margolis 2018), 2017 PV (Fu et al. 2017), 2016 PV (Fu et al. 2016), and 2015 utility-scale PV (Fu et al. 2015).
[7] LBNL compares the bottom-up cost results of various entities, including our results.
[8] In this report, we focus on the installation costs of crystalline-silicon modules, but a significant portion of U.S. utility-scale PV systems use CdTe modules. From 2010–2019, CdTe accounted for approximately 30% of U.S. utility-scale PV deployment (EIA 2020). This portion of the market is particularly noticeable given that CdTe modules only represented 4% of global PV shipments over the same period. Similarly, a growing number of U.S. systems are beginning to use bifacial modules, with transparent backs, which generate electricity from both sides of the module—as opposed to traditional monofacial modules, which typically have opaque backsheets. Because of the relative newness of bifacial modules, we do not have sufficient data on their current U.S. market share.

Our modeled costs can be interpreted as the sales price an engineering, procurement, and construction (EPC) contractor or developer might charge for a system before any developer fee or price gross-up (although our costs do include development costs). We use this approach because of the wide variation in developer profits in all three sectors (residential, commercial, and utility-scale), where project pricing depends highly on region and project specifics such as local retail electricity rate structures, local rebate and incentive structures, competitive environment, and overall project or deal structures.

The current versions of our cost models make a few significant changes from the versions used in our previous Q1 2018 benchmark report (Fu, Feldman, and Margolis 2018). To better attribute the historical cost trends over time from the changes to our cost models, we also calculate Q1 2019 and Q1 2020 PV benchmarks using the Q1 2018 versions of the residential, commercial, and utility-scale PV models. Appendix A provides a detailed discussion of the changes made to this year's models from previous versions (Fu, Feldman, and Margolis 2018).

The remainder of the report is organized as follows. Section 2 describes our model inputs and sources. Sections 3, 4, and 5 show specific model inputs and outputs for residential, commercial, and utility-scale PV-only systems, including historical trends in system costs and the levelized costs of energy. Sections 6, 7, and 8 show specific model inputs and outputs for residential, commercial, and utility-scale PV-plus-storage systems, including a limited set of historical trends in system costs and the levelized cost of PV-plus-storage. Finally, Section 9 puts the results in context and offers conclusions.

2 Model Inputs and Sources

This section describes our model inputs and sources. Section 2.1 describes one of our main data sources for the system characteristics and business models of residential and commercial PV,[9] the 2019 edition of Tracking the Sun (Barbose and Darghouth 2019). Sections 2.2 through 2.5 detail the inputs from the Tracking the Sun data set that affect PV system cost. Sections 2.6 through 2.8 detail our cost input assumptions for the highest-cost components (inverters, modules, and battery packs), and Section 2.9 describes our levelized cost of energy (LCOE) calculation methods.

2.1 Tracking the Sun Data Set

We use data from the 2019 edition of Tracking the Sun (Barbose and Darghouth 2019) to benchmark generic system characteristics, such as module efficiency, system size, and direct- to alternating-current (DC-to-AC) ratio for commercial and residential systems, as well as choice of power electronics and installer type for residential PV standalone systems. Tracking the Sun is based on a data set compiled primarily from state agencies, utilities, and other organizations that administer PV incentive programs, solar renewable energy credit registration systems, or interconnection processes. The full sample, from 30 states, includes most U.S. grid-connected residential and nonresidential PV systems, but it excludes all ground-mounted PV systems larger than 5 MW_{AC} and therefore excludes U.S. utility-scale PV systems. In total, it consists of more than 1.6 million individual PV systems installed through year-end 2018, including roughly 250,000 systems installed in 2018. These systems represent 81% of all U.S. residential and nonresidential systems installed cumulatively through 2017 and 76% of installations in 2018. The authors have also taken various steps to clean and standardize the raw data to ensure its accuracy. Because the analysis—and publication—of the Q1 2019 and Q1 2020 modeled benchmarks occur before 2019 and 2020 characteristic data are available, we use 2018 Tracking the Sun values for the market share of inverters and national integrators, and we rely on the California Net Energy Metering (CA NEM) Interconnection data set for module efficiency.

2.2 Module Efficiency

Figure 1 displays module efficiency data from the Tracking the Sun data set from 2010 to 2018, along with data from the CA NEM Interconnection data set through Q1 2020.[10] Since 2010, efficiencies for monocrystalline and multicrystalline modules have steadily improved, with the capacity-weighted average multicrystalline module efficiency, for 60- and 72-cell modules, increasing 0.3%–0.4% each year in absolute terms, on average. CA NEM values line up very

[9] To represent commercial PV systems, we apply the characteristics of nonresidential PV systems in the Tracking the Sun data set that are larger than 100 kW (and smaller than 5 MW_{AC} for ground-mount systems). In addition to rooftop commercial PV systems, the data set includes ground-mounted commercial PV systems as well as systems for industrial applications, government sites, non-profits, and schools.

[10] We use CA NEM data for the average module efficiency of utility-scale PV systems as well, even though the data set does not include any utility-scale PV systems. We think this is justifiable, because PV modules can be used for either application, and there is no comparable utility-scale PV data set to calculate average module efficiency in that sector. That being said, there may be some discrepancies with real-world data, because significantly more CdTe is deployed in the utility-scale PV sector than in the residential and commercial sectors. Module efficiency values from CA NEM include only 60-cell and 72-cell modules from its data set to better correspond with the pricing data we use. SunPower IBC panels, for example, are more efficient and have a different cell count, but also come at a price premium.

closely with the national averages reported in Tracking the Sun. CA NEM reports a Q1 2020 capacity-weighted average monocrystalline module efficiency of 19.5%. Because module selection may vary by region and sector, the capacity-weighted average module efficiencies (and module prices) may be different in some regions and sectors.[11]

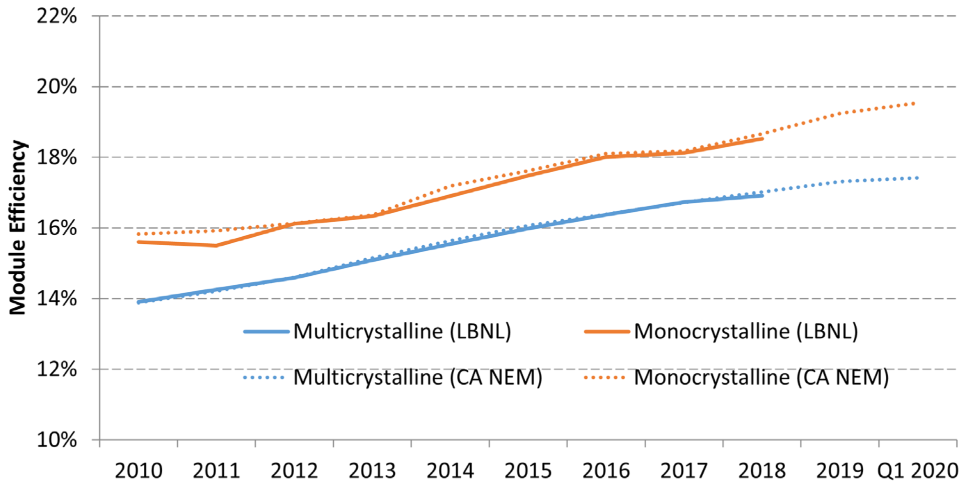

Figure 1. Capacity-weighted average module efficiency trends from the Tracking the Sun (LBNL) and *CA NEM* data sets,[a] 2010–2020

[a] Barbose and Darghouth (2019), CA NEM (2020)

In this year's report, we model systems using monocrystalline PV modules rather than the multicrystalline modules we modeled previously (Fu, Feldman, and Margolis 2018). When we started benchmarking PV system prices in 2010, most U.S. PV systems used multicrystalline modules. However, there has been an overall shift in the United States to using more monocrystalline modules since 2016. For example, CA NEM reports that multicrystalline's percentage of installed PV systems in California peaked over the decade in 2013–2015 at approximately 70%, but as of Q1 2020 had shrunk to 16% (Figure 2). Across the United States, the percentage of distributed PV systems that installed multicrystalline modules dropped from 65% in 2015 to 11% in 2018 (Barbose and Darghouth 2019). Much of this shift can be attributed to the rapid manufacturing expansion and associated reduction in price of passivated emitter and rear cells (PERC) monocrystalline technology. Monocrystalline modules sell at a premium over multicrystalline modules, but their higher efficiency can reduce the LCOE of PV systems.

We compare the 2019 total system cost between PV systems using monocrystalline modules and those using multicrystalline modules in residential, commercial rooftop, and utility-scale PV systems in Section 3.7.1, Section 4.3.1, and Section 5.3.1.

[11] The residential sector has historically used a higher percentage of monocrystalline panels than other sectors.

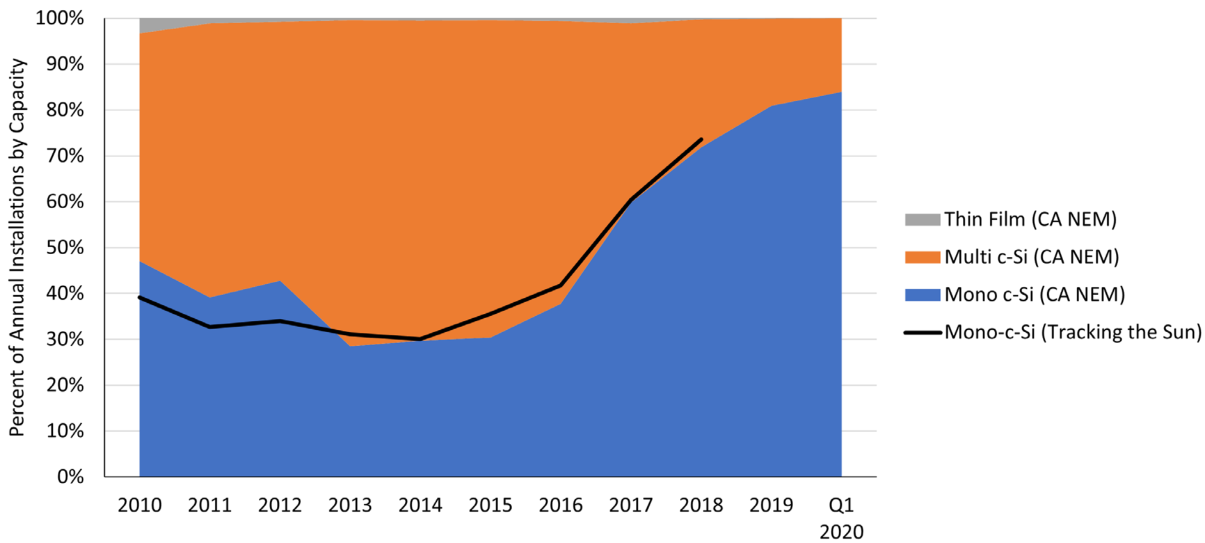

Figure 2. CA NEM and Tracking the Sun PV Installations by Technology, 2010–Q1 2020

Sources: Barbose and Darghouth (2019), CA NEM (2020). c-Si = crystalline silicon.

2.3 PV System Size

Figure 3 displays median PV system sizes from the 2019 edition of Tracking the Sun. Residential system sizes steadily increased from 2010 to 2018. As in previous years, we assume a 22-module design for our residential PV system benchmark, which results in a system size of 6.3 kW, based on the assumed 2018 average multicrystalline module efficiency. This is slightly smaller than the 2018 median size of 6.4 kW from Tracking the Sun; in 2019 and 2020, our residential PV system benchmarks are larger (6.6 kW and 7.0 kW, respectively) owing to efficiency improvements over time and the switch in our model to the use of monocrystalline modules. Commercial system sizes have varied more, which likely reflects the wide range of users (e.g., office buildings, malls, and retail stores). Limiting commercial systems to those larger than 100 kW (the minimum size we model for commercial systems in this report and the vast majority of commercial PV installed capacity each year), the median system size has ranged from 200 kW to 350 kW for rooftop systems and 400 kW to 1,200 kW for ground-mount applications. We use 200 kW and 500 kW as the baseline cases in our commercial rooftop and ground-mount PV models, respectively.

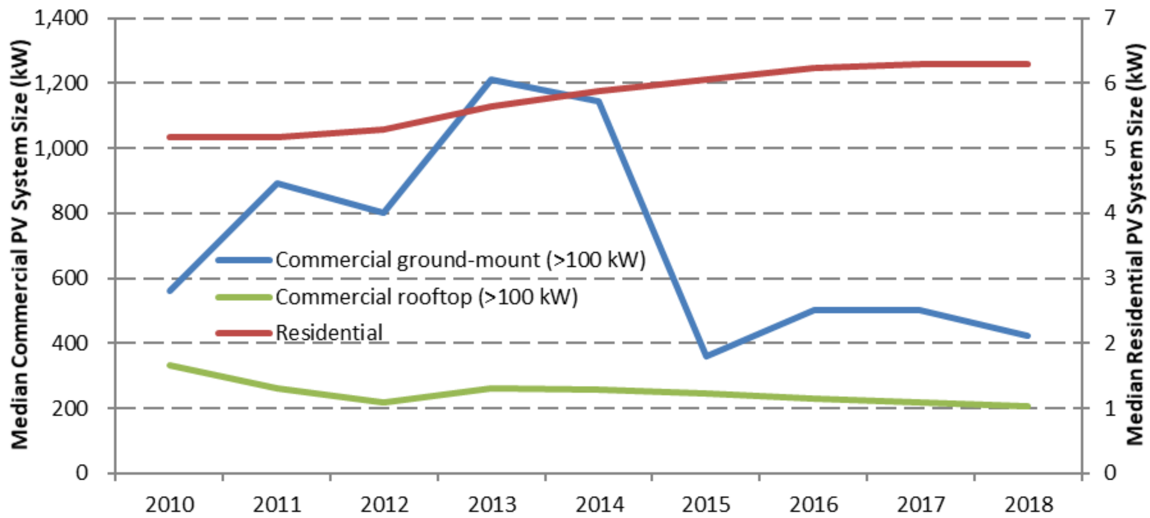

Figure 3. Median PV system size trends from the Tracking the Sun data set,[a] 2010–2018

[a] Barbose and Darghouth (2019)

2.4 Module-Level Power Electronics

Microinverters and DC power optimizers are collectively referred to as module-level power electronics (MLPE). By allowing designs with different roof configurations (e.g., orientations and tilts), constantly tracking the maximum power point for each module, and providing rapid-shutdown at the module level (required in some states), MLPE provide an optimized design solution at the module level. In 2018, MLPE reached 86% of the total Tracking the Sun residential data set (Figure 4).

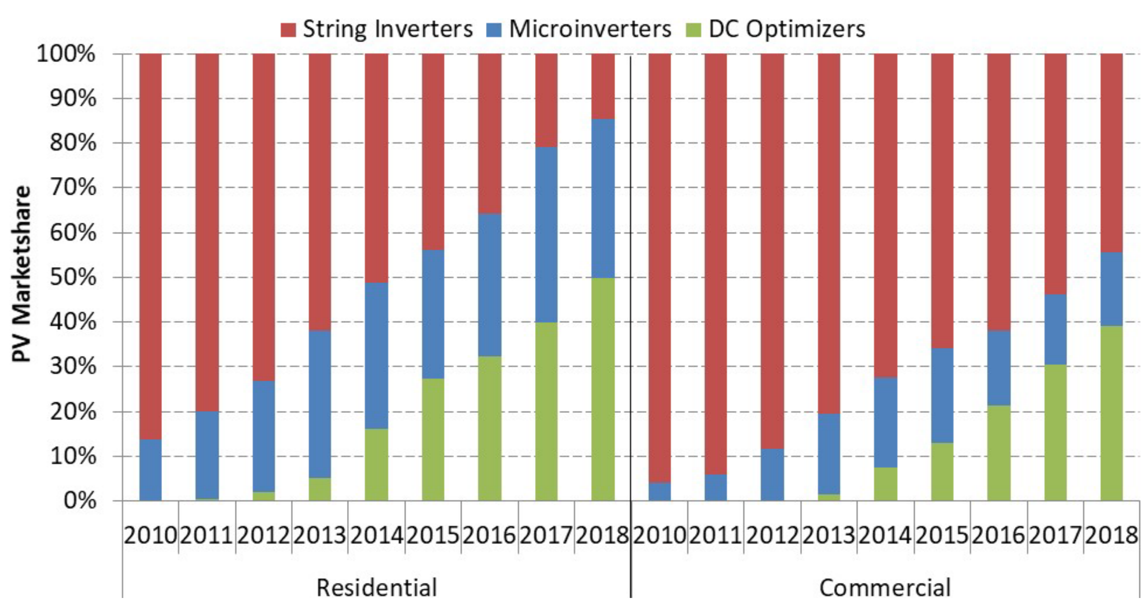

Figure 4. U.S. residential and commercial inverter market from the Tracking the Sun data set,[a] 2010–2018

[a] Barbose and Darghouth (2019)

For residential system costs, we model the string inverter, power optimizer, and microinverter options separately, and we use their market shares (14.6%, 49.8%, and 35.6%) in our Q1 2020 model for the weighted-average case. MLPE growth has been slower in the commercial rooftop sector, although it has started to accelerate in the past few years, reaching a share of 55% in 2018. In past years, we only assumed string inverters for the commercial PV benchmark, rather than weighting by MLPE share; this year, we also weight the commercial rooftop PV benchmark by MLPE share (45% for three-phase string inverters, 39% for power optimizers, and 16% for microinverters), because of changes to the National Electrical Code (NEC).

For safety reasons, rapid-shutdown codes were implemented at the array level in the 2014 NEC and at the module level in the 2017 NEC, for rooftop PV systems. Although the 2014 NEC required array-level rapid-shutdown, systems were also required to have the ability to reduce system voltage quickly, so that no wires were energized more than five feet inside a building or 10 feet from a PV module array. Commercial rooftop PV systems accomplished this by having the three-phase string inverters within 10 feet of the PV array to provide the disconnect, but string-level inverters often cannot be located within 10 feet of a residential PV system. Therefore, residential PV systems either required the installation of an additional combiner box with a single array-level disconnect, or the more popular option: MLPE. Because the 2017 NEC requires rapid shutdown at the module level for rooftop applications, the switch from the 2014 NEC to the 2017 NEC has a larger impact on commercial rooftop PV systems.

As of July 1, 2020, 34 states and Puerto Rico had adopted the 2017 or 2020 NEC rapid-shutdown code (with California and South Carolina implementing it in 2020), and 11 states had adopted the 2014 NEC (Table 1).

Table 1. Rapid-Shutdown Codes: Progress by State

Code	Rapid-Shutdown	State
2020 NEC	Yes (module-level)	Massachusetts
2017 NEC	Yes (module-level)	Alaska, Arkansas, California, Colorado, Connecticut, Georgia, Hawaii, Idaho, Iowa, Kentucky, Maine, Michigan, Minnesota, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, North Carolina, North Dakota, Ohio (commercial), Oregon, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Washington, Wisconsin, Wyoming, West Virginia, and Puerto Rico
2014 NEC	Yes (array-level, within 10 feet)	Alabama, Delaware, Florida, Louisiana, Maryland, Montana, New York, Ohio (residential), Oklahoma, Pennsylvania, Virginia
2011 NEC	No	Washington, D.C.
2008 NEC	No	Indiana
No statewide NEC adoption	No	Arizona, Illinois, Kansas, Mississippi, and Missouri

Source: NEMA (2020)

2.5 Small Installers versus National Integrators in the Residential PV Model

Our residential PV benchmark is based on two different business structures: "small installer" and "national integrator." We define small installers as businesses that engage in lead generation, sales, and installation but *do not* provide financing solutions in-house, although they may partner with a larger company to offer customers loans, leases, or power-purchase agreements (PPAs). National integrators perform all small installer functions, *and* they directly provide financing and system monitoring for third-party-ownership (TPO) systems.[12] In our models, the difference between small installers and national integrators is manifested in (1) differences in module and inverter prices that are due to the buying power of national integrators and (2) differences in customer acquisition, permitting, inspection, and interconnection (PII), and overhead cost categories, where national integrators are modeled with higher expenses for customer acquisition (relying less on referrals and spending more time on growing markets) and PII (due to higher cancellation rates). Although national integrators provide financing solutions, we do not incorporate financing costs into the benchmark.

As shown in Figure 5, residential TPO systems have lost market share to the direct business model since 2015, led by small installers. We use 38% national integrator and 62% small installer market shares to compute the national weighted-average case in our Q1 2020 residential PV model.

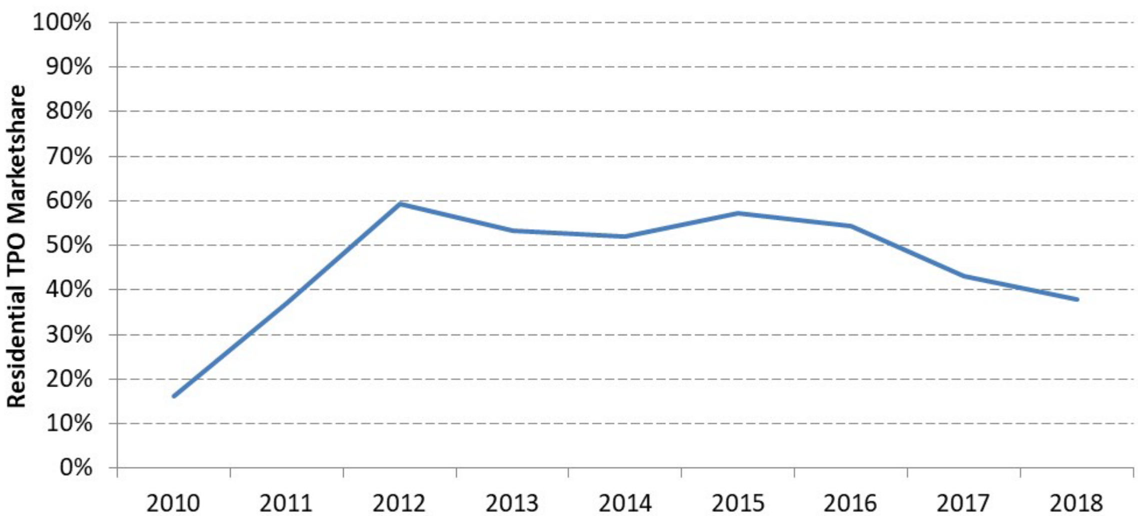

Figure 5. TPO market share in Tracking the Sun data set,[a] 2010–2018

[a] Barbose and Darghouth (2019)

[12] For modeling purposes, we separate the residential market into small installers and national integrators using TPO market share. In reality, there are a wide range of business models and installer sizes. Most TPO providers are national integrators and offer mostly TPO products. Even small installers that offer financing typically get that financing from a larger, national company, so their costs would be borne by that model as well. In short, it is a simplification, but we think a reasonable one.

2.6 Inverter Prices and DC-to-AC Ratios

As shown in Figure 6, we source inverter prices, including MLPE prices, from the Wood Mackenzie (Wood Mackenzie 2020) database, which contains typical U.S. prices from Tier 1 suppliers to developers in the market. For Q1 2020 modeling, we convert the U.S. dollar (USD) per W_{AC} inverter prices from Wood Mackenzie (2020) to 2019 USD/W_{DC} using the Consumer Price Index (CPI) and the DC-to-AC ratios shown in Table 2. We model systems using an average DC-to-AC ratio, but a wide variety of DC-to-AC ratios are reported for U.S. PV systems.

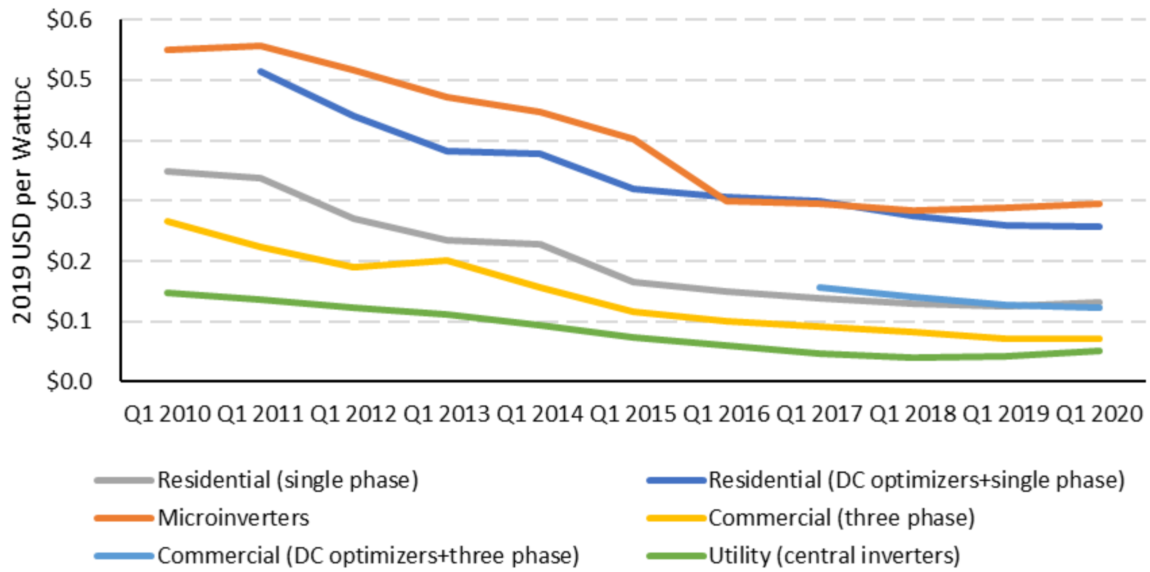

Figure 6. Inverter prices from Wood Mackenzie, 2010–2020

Data are from Wood Mackenzie (2014a, 2014b, 2019a, 2020) and Wood Mackenzie and SEIA (2020). Data are also supplemented, in 2010 and 2011, using revenue per-watt shipped data from Enphase (2019) for microinverters.

Table 2. Q1 2020 Inverter Price Conversion (2019 USD)

Inverter Type	Sector	USD/W_{AC}	DC-to-AC Ratio[a]	USD/W_{DC}
Single-phase string inverter	Residential PV (non-MLPE)	0.15	1.11	0.14
Microinverter	Residential and commercial PV (MLPE)	0.34	1.16	0.29
DC power optimizer, single-phase string inverter	Residential PV (MLPE)	0.30	1.16	0.26
Three-phase string inverter	Commercial PV (non-MLPE)	0.08	1.11	0.07
DC power optimizer, three-phase string inverter	Commercial PV (MLPE)	0.14	1.16	0.12
Central inverter	Utility-scale PV (fixed-tilt)	0.07	1.37	0.05
Central inverter	Utility-scale PV (1-axis tracker)	0.07	1.34	0.05

All inverter prices include the cost of monitoring equipment.

[a] We updated the inverter DC-to-AC ratios using LBNL data (Bolinger, Seel, and Robson 2019; Barbose and Darghouth 2019).

2.7 Module Prices

We assume an ex-factory gate (spot or first-buyer) price of \$0.41/W_{DC} for Tier 1 monocrystalline modules in Q1 2020, based on Wood Mackenzie and SEIA (2020). As Figure 7 shows, U.S. spot prices declined substantially between 2014 and 2016, and they approached global spot prices. In 2017, however, U.S. spot prices rose as global spot prices continued to decline. Several factors, including U.S. policy on imported modules, may have contributed to the divergence between U.S. and global spot prices. In early 2018, U.S. spot prices began to drop again; in Q1 2020, U.S. module prices continued to fall, dropping close to their lowest recorded levels, but monocrystalline modules were still trading at a significant premium over the global module average selling price (ASP). In the past few years, the U.S. market has had such an increasing demand for monocrystalline modules that by 2020 there was not enough demand for multicrystalline modules to give an "apples-to-apples" comparison of U.S. spot pricing in Q1 2020; therefore, when comparing the two technologies, we model Q1 2019 costs. In Q1 2019, we assume an ex-factory gate price of \$0.40/W_{DC} for Tier 1 monocrystalline modules and \$0.33/W_{DC} for Tier 1 multicrystalline modules, based on Wood Mackenzie and SEIA (2020).

Although commercial and utility-scale PV developers typically can procure modules at or near the spot price, residential national integrators and small installers incur additional supply chain costs (Figure 8). Historical inventory can create a price lag (approximately six months) for the market module price in the residential sector when the modules from previous procurements are installed in today's systems. In our Q1 2020 residential PV benchmark, this supply chain cost equates to a \$0.02/W (6%) premium. We assume small installers and national integrators are both subject to a 15% (\$0.06/W) premium on the spot price for module shipping and handling (Fu, Feldman, and Margolis 2018). Small installers are subject to an additional 20% (\$0.09/W) premium owing to small-scale procurement (Bloomberg 2018), which is consistent with an assumed 20% premium in the Q1 2017 residential PV benchmark (Fu et al. 2017). Both types of companies are also subject to 5% sales tax (weighted national average), bringing the small installer's monocrystalline module cost to \$0.61/W and the national integrator's cost to \$0.52/W.

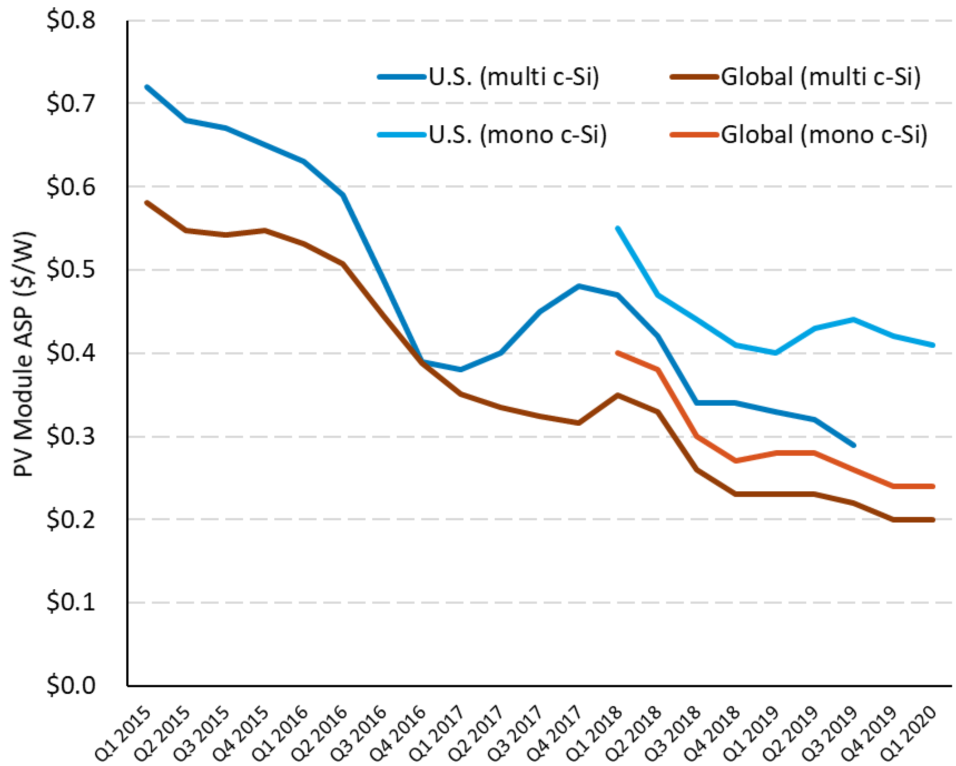

Figure 7. Ex-factory gate prices (spot prices) for U.S. and global multicrystalline and monocrystalline modules, from Wood Mackenzie and SEIA (2020) data

Global monocrystalline module prices before 2018 are from PVinsights (2019).

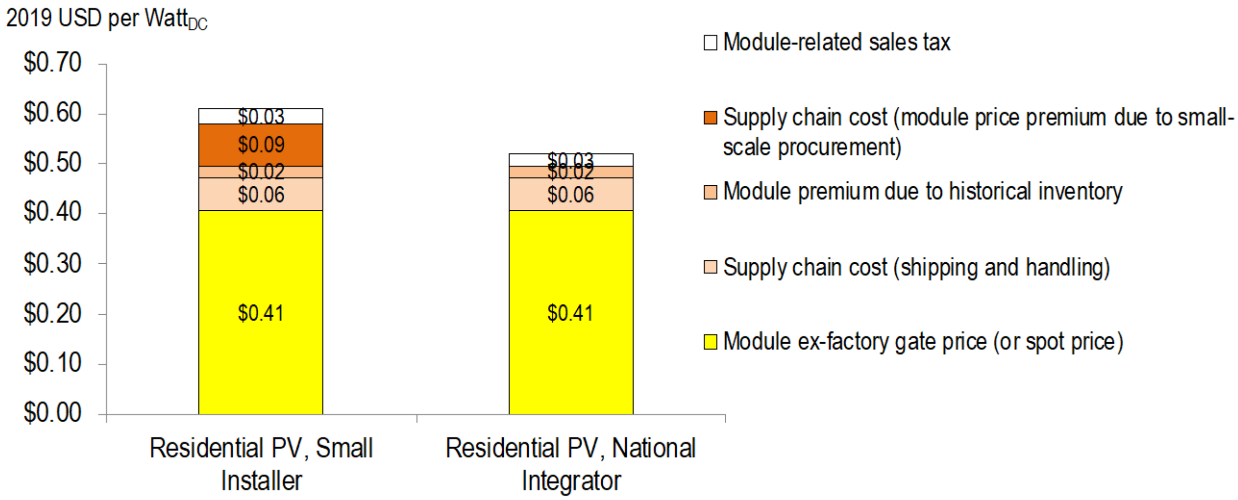

Figure 8. Total residential PV module market costs (2019 USD)

2.8 Battery Storage

As Figure 9 shows, lithium-ion (Li-ion) battery spot prices declined substantially (87%) between 2010 and 2019. From 2018 to 2019 alone, prices dropped 13%. The Li-ion battery pack price from Bloomberg New Energy Finance (BNEF) refers to the volume-weighted average of automotive and stationary storage. The stationary battery market has a slightly higher price. There is also price variation for different battery durations. In previous years, we used the volume-weighted average (i.e., the "Li-ion battery pack" price) because of a lack of data for stationary storage with different durations. In this year's report, we use BNEF (2019b) stationary storage cost data, differentiated by market segment and hours of storage. Although not referenced in this report, BNEF also provides commercial and utility battery rack data for 30-minute and 2-hour storage products.

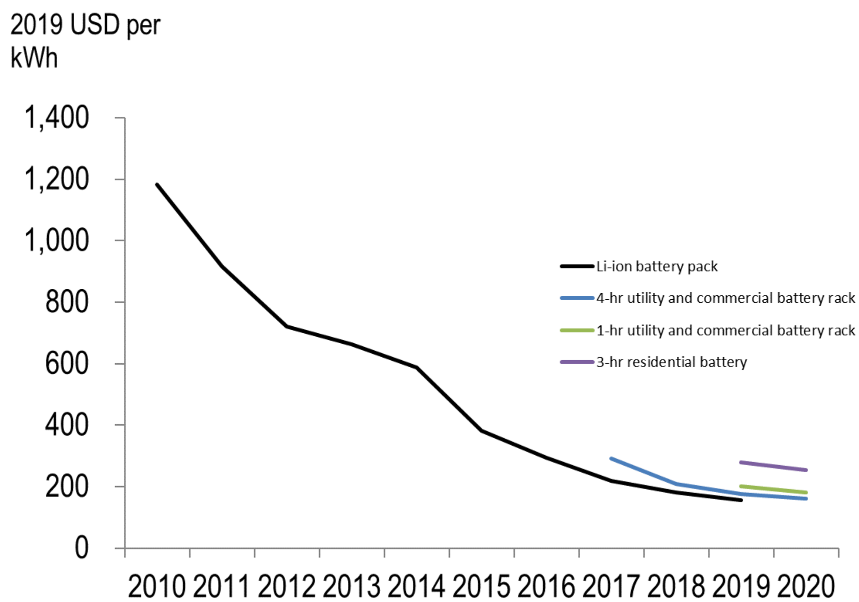

Figure 9. Ex-factory gate prices (spot prices) for Li-ion batteries by product, from BNEF (2018, 2019a, 2019b) data

2.9 PV LCOE Methods

Although LCOE is not a perfect metric to measure the competiveness of PV within the energy marketplace, it does incorporate many PV metrics—beyond upfront installation costs—that are important to energy costs. For a previous edition of this report (Fu et al. 2017), we performed a literature review to determine inputs not already benchmarked in the report. When LCOE assumptions were not found in the selected literature in a given year, straight-line changes were assumed between any two values. This year, we inform the inputs using ongoing NREL benchmarking work. We input these assumptions into NREL's System Advisor Model, a performance and financial model,[13] to calculate real LCOEs (considering inflation) for various locations.

Annual Degradation

In January 2018, NREL and DOE interviewed nine independent engineers and PV project financiers; they said they assume an annual PV module degradation of 0.7% per year. For certain projects with specific project and system characteristics that have been well vetted, some independent engineers assume a 0.5% annual degradation (Feldman, Jones-Albertus, and Margolis 2018). Because this lower value only applies to specific projects, we benchmark the higher degradation rate.

Operation and Maintenance

In fiscal year 2018, a PV operation and maintenance (O&M) working group that was convened under the sponsorship of DOE's SETO developed a model to calculate the cost associated with PV system O&M (Walker et al. 2020). Measures of O&M in the cost model correlate to the PV O&M services described by a best practices guide (NREL et al. 2018). Some of the O&M cost drivers in the model are informed by actuarial failure and repair data from Sandia National Laboratories (Klise et al. 2018), but current default values reflect the best judgement of the working group for measures with unavailable data. In the current version of the model, labor rates, inverter replacement cost, discount rate, inflation rate, and capital expenditures are adjusted to fiscal year 2019. Apart from these updates, actuarial failure and repair data are updated for a few measures (insulated-gate bipolar transistor matrix, broken modules, inverter fan motors, inverter reboot, damaged racking, tracker controller, and tracker bearings) (Gunda and Homan forthcoming). For this version, five additional line measures (land lease, property taxes, insurance, asset management, and security) are added based on feedback collected by LBNL from U.S. solar industry professionals (Wiser et al. 2020).

O&M costs in the Walker et al. (2020) O&M cost model include preventive maintenance, scheduled at regular intervals with costs increasing at an inflationary rate, as well as corrective maintenance to replace components. The model derives corrective maintenance by multiplying the replacement cost, including labor, by the probability that a failure will occur each year based on actuarial data. Component failure probabilities for each year are calculated using a Weibull, log-normal, or other distribution based on actual data, when possible.

As shown in Figure 10, 133 measures in the cost model are sorted into nine O&M cost categories: inverter replacement, operations administration, module replacement, components

[13] See https://sam.nrel.gov/.

parts replacement, system inspection and monitoring, module cleaning and/or vegetation and pest management, land lease, property tax, and insurance, asset management, and security.The current benchmarks are \$28.94/kW$_{DC}$/yr (residential), \$18.55/kW$_{DC}$/yr (commercial; roof mount), \$18.71/kW$_{DC}$/yr (commercial; ground mount), \$16.32/kW$_{DC}$/yr (utility-scale, fixed-tilt), and \$17.46/kW$_{DC}$/yr (utility-scale, single-axis tracking).

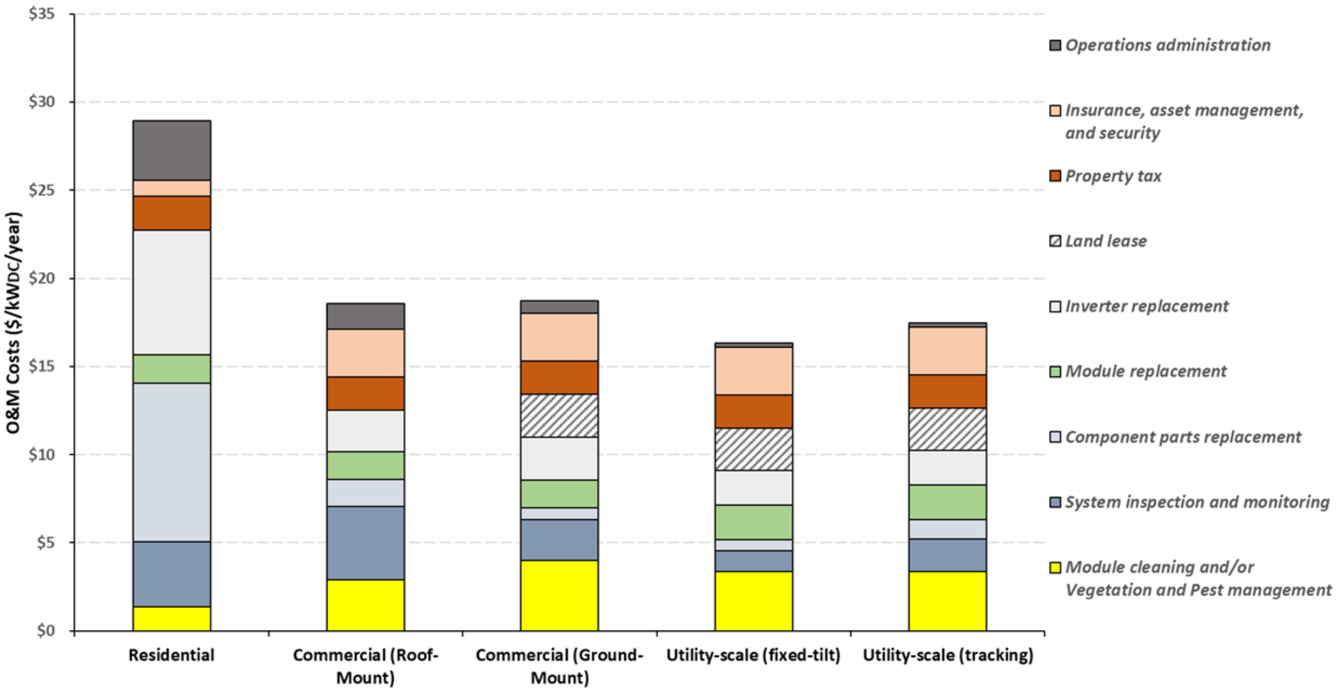

Figure 10. Q1 2020 residential, commercial, and utility-scale O&M costs by category

System Losses

Energy losses occur between PV generation and output to the grid owing to AC and DC wiring losses, soiling, inverter mismatches, and shading and snow loading for certain systems. We aggregate the losses into two categories: 9.5% of electricity lost from preinverter derate (DC losses) and 2.0% of energy lost from inverter efficiency (AC losses).

Based on data analyzed by NREL, previous system loss benchmarks are consistent with current performance in the field, so these benchmarks have not been changed for 2020. We do assume a higher-voltage inverter in this year's utility-scale PV benchmark: 1,500 V rather than the 1,000 V used previously. However, increasing voltage typically has a negligible overall impact on losses. On the DC side, increasing voltage reduces conductor losses per length of conductor, yet system layouts typically move to longer string lengths, resulting in similar overall losses on the DC side (although cost is reduced). On the AC side, AC loss factors have little to do with the DC system voltage, so the AC losses will typically not change with higher DC voltages.

Financing

The 2019 and 2020 financing assumptions are based on Feldman, Bolinger, and Schwabe (2020); financing costs in that report are lower than in previous benchmark work (Feldman, Lowder, and Schwabe 2016; Feldman and Schwabe 2017, 2018). All data compiled for these reports are derived from a combination of basic literature reviews, product research, and interviews with industry professionals.

The financing values represent current financing structures, which depend on the investment tax credit (ITC). Although the ITC represents a net positive for projects, financing costs (but not LCOE) would be lower without the ITC (Feldman, Bolinger, and Schwabe 2020). In our benchmark reports, we have historically reported LCOE with current financing costs (which are based on owners using the ITC) without an ITC, which is incongruous. In this year’s report, we calculate LCOE assuming long-term steady-state financing assumptions, with no ITC and with interest rates higher than current historically low levels.

3 Residential PV Model

This section describes our residential PV model's structure, inputs, and assumptions (Section 3.1); expanded "other soft costs" modeling" (3.2); model output (3.3); differences between modeled output and reported costs (3.4); differences between retrofits and new construction (3.5); additional costs typical of residential PV installation (3.6); and historical PV price (3.7) and LCOE (3.8) trends.

3.1 Residential Model Structure, Inputs, and Assumptions

We model a 7.0-kW residential rooftop system using 60-cell, monocrystalline, 19.5%-efficient modules from a Tier 1 supplier and a standard flush mount, pitched-roof racking system. Figure 11 presents the cost drivers and assumptions, cost categories, inputs, and outputs of the model. Table 3 presents modeling inputs and assumptions in detail.

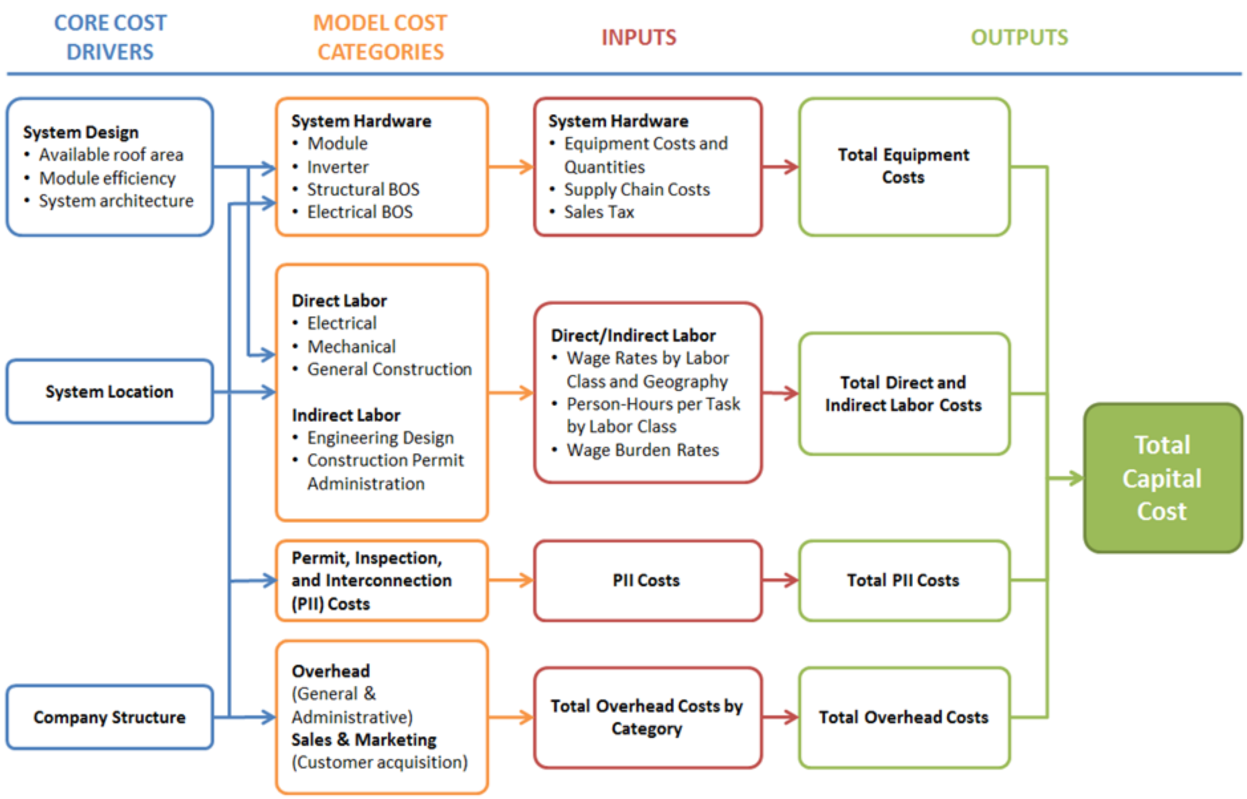

Figure 11. Residential PV: Model structure

BOS = balance of system

Table 3. Residential PV: Modeling Inputs and Assumptions

Category	Modeled Value	Description	Sources
System size	7.0 kW	Average installed size per system	Barbose and Darghouth 2019; CA NEM 2020
Module efficiency	19.5%	Average module efficiency	CA NEM 2020
Module price	$0.41/W_{DC}$	Ex-factory gate (first buyer) price, Tier 1 monocrystalline modules	Wood Mackenzie and SEIA 2020
Inverter price	Single-phase string inverter: $0.14/W_{DC}$ DC power optimizer single-phase string inverter: $0.26/W_{DC}$ Microinverter: $0.29/W_{DC}$	Ex-factory gate (first buyer) prices, Tier 1 inverters	Wood Mackenzie 2020; Wood Mackenzie and SEIA 2020
Structural BOS (racking)	$0.08/W_{DC}$	Includes flashing for roof penetrations and all rails and clamps	NREL 2020
Electrical BOS	$0.18–$0.28/W_{DC}$ Varies by inverter option	Conductors, switches, combiners and transition boxes, as well as conduit, grounding equipment, monitoring system or production meters, fuses, and breakers	Model assumptions, NREL 2020
Supply chain costs (percentage of equipment costs)	Varies by installer type and location	15% costs and fees associated with shipping and handling of equipment Additional 6% cost for historical inventory Additional 20% small-scale procurement for module-related supply chain costs for small installers Additional 20% for inverter-related supply chain costs for small installers and 10% for national integrators	BLS 2019; NREL 2020; model assumptions
Sales tax	National average: 5.1%	Sales tax on the equipment	RSMeans 2017
Direct installation labor	Electrician: $27.47 per hour Laborer: $18.17 per hour Hours vary by inverter option	Modeled national average labor rates	BLS 2019; NREL 2020

Category	Modeled Value	Description	Sources
Burden rates (percentage of direct labor)	Total nationwide average: 18%	Workers compensation, federal and state unemployment insurance, Federal Insurance Contributions Act (FICA), builder's risk, and public liability	RSMeans 2017
PII	$0.23/W_{DC}$ for small installers $0.25/W_{DC}$ for national integrators Varies by location	Completed and submitted applications, fees, design changes, and field inspection	NREL 2020
Sales and marketing (customer acquisition)	$0.38/W_{DC}$ (small installer) $0.50/W_{DC}$ (national integrator) Varies by location	Initial and final drawing plans, advertising, lead generation, sales pitch, contract negotiation, and customer interfacing	NREL 2020
Overhead (general and administrative)	$0.27/W_{DC}$ (small installer) $0.28/W_{DC}$ (national integrator) Varies by location	Rent, building, equipment, staff expenses not directly tied to PII, customer acquisition, or direct installation labor	NREL 2020
Profit (%)	17%	Fixed percentage margin applied to all direct costs including hardware, installation labor, direct sales and marketing, design, installation, and permitting fees	Fu et al. 2017

3.2 Expanded "Other Soft Costs" Modeling

In this year's benchmark analysis, we expand our modeling of customer acquisition, engineering, PII, and overhead. In addition to providing finer cost granularity, we include additional costs borne by many U.S. installers that were not captured in previous editions; therefore, our benchmarked soft costs in this report are higher than those in previous reports. The first four cost categories estimate costs by looking at the necessary steps taken to sell, engineer, permit, and interconnect a residential PV system. Each task requiring staff time is categorized by department (e.g., sales and permitting). The last category, overhead, estimates costs by itemizing expenses of all staff time and resources necessary to operate a residential PV installation company, but which are not directly tied to a specific installation. Each method is described in detail below.

Customer acquisition costs are estimated by breaking down the process into the following steps: advertisement, lead generation, qualifications/first sales pitch, and final sales pitch. Within each step are various methods that may be used to acquire a customer. The cost contribution to total PV system cost for each step is calculated by multiplying (1) the average cost per occurrence (based on a fee or an hourly wage and the number of hours) by (2) the estimated percentage of national sales that use this step divided by (3) the average conversion from this step to an installed system. Multiplying the cost per occurrence by the estimated percentage of national sales is done to provide a national average, whereas dividing by the average conversion is needed to account for the costs incurred by the company from potential customers who do not end up purchasing a PV system from the installer. The data in this section were compiled from public securities filings (i.e., 10-Ks), analyst reports and presentations, as well as conversations with those involved in the residential PV customer acquisition business.

Engineering costs summarize the costs associated with designing initial and final system plans. The cost contribution to total PV system cost for each step is calculated by multiplying (1) the average cost per occurrence (or hourly wage multiplied by the number of hours) by (2) the estimated percentage of national sales that use this step divided by the (3) average conversion from this step to an installed system. Multiplying the cost per occurrence by the estimated percentage of national sales is done to provide a national average, whereas dividing by the average conversion is needed to account for the costs incurred by the company from potential customers who do not end up purchasing a PV system from the installer. The data in this section were compiled by averaging costs reported from private conversations with residential PV installers.

Permitting, inspection, and interconnection categories summarize the costs associated with applying for and receiving a permit or interconnection agreement from an "authority having jurisdiction." The cost contribution to total PV system cost for each permitting or interconnection step is calculated by multiplying (1) the average cost per occurrence (either a fee, cost [e.g., mileage], or hourly wage multiplied by the number of hours) by (2) the estimated percentage of national sales that use this step divided by (3) the average conversion from this step to an installed system. Multiplying the cost per occurrence by the estimated percentage of national sales is done to provide a national average, whereas dividing by the average conversion is needed to account for the costs incurred by the company from potential customers who do not end up purchasing a PV system from the installer. The data in this section were compiled by averaging costs reported from private conversations with residential PV installers.

Overhead summarizes the costs associated with providing the business platform and infrastructure to sell, permit, install, and interconnect a residential PV system. It is divided into two large categories: business expenses (e.g., rent, office equipment, and professional services) and staff expenses. Staff expenses for national integrators include the "C-suite" executives, treasurers, customer service staff, supply chain staff, and information technology staff; staff expenses for small installers include principals, engineers, sales team members, and administrators. The model also estimates the total staff time attributed directly to selling, engineering, permitting, and interconnecting a PV system, as well as the percentage of time for each position associated with direct project costs. The number of hours spent on projects is calculated by multiplying the hours spent per PV system for an individual cost category by the number of systems built in that year. For example, if 10 sales-hours were required per system installed, on average, and 400 PV systems were installed in a year, total sales staff time spent on projects in that year would be 4,000 hours. Furthermore, if sales staff spent two thirds of their time directly on projects, total sales staff time would be 6,000 hours per year (or 4,000 divided by two thirds). The 6,000 hours translates into three staff members (i.e., 6,000 divided by 2,000—the number of work-hours in a year [50 weeks, 40 hours per week—assuming two weeks of vacation per year]). Annual salary is estimated by (1) multiplying the hourly wages for staff associated directly with projects (based on private conversations with installers) by the number of paid hours in a year (52 × 40) or (2) for those not directly associated with projects, by estimating the average salary of that position in a company, using available published data. Base salaries are also grossed to account for other corporate costs, such as benefits, FICA, and bonuses. Total staff, per category, is based on the number of systems installed, the number of megawatts installed, or the ratio of employee category per total staff size.

3.3 Residential Model Output

Figure 12 presents the U.S. national benchmark from our residential PV model. Market shares of 62% for small installers and 38% for national integrators are used to compute the national weighted average. String inverter, power optimizer, and microinverter options are each modeled individually, and the "mixed" case applies their market shares (14.6%, 49.8%, and 35.6%) as weightings.

Figure 13 shows a sensitivity analysis for the mixed case, with cost categories that vary by location and hardware specification. Inverter type has the largest impact on installed system cost, with use of string inverters resulting in $2.47/$W_{DC}$ and use of microinverters resulting in $2.83/$W_{DC}$.

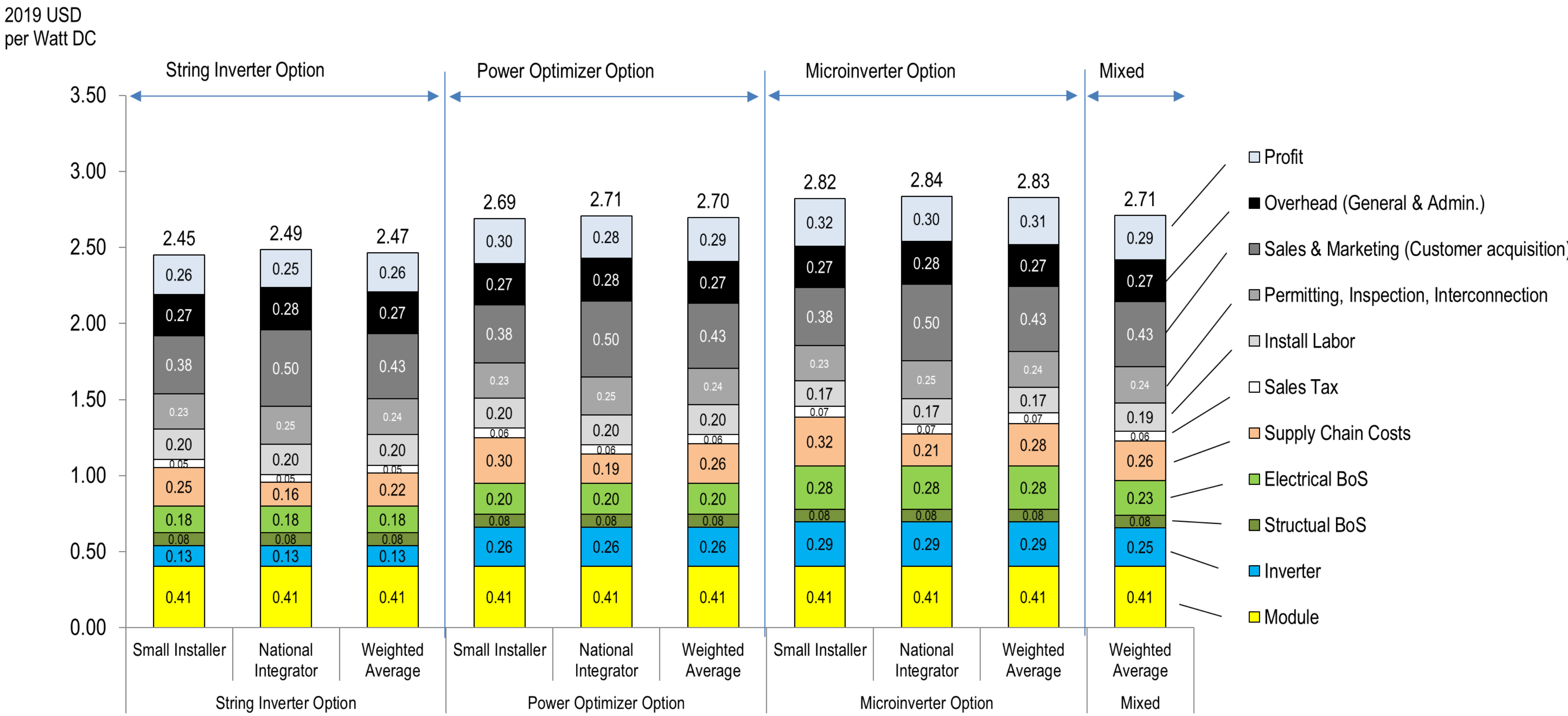

Figure 12. Q1 2020 U.S. benchmark: 7.0-kW residential PV system cost (2019 USD/W_{DC})

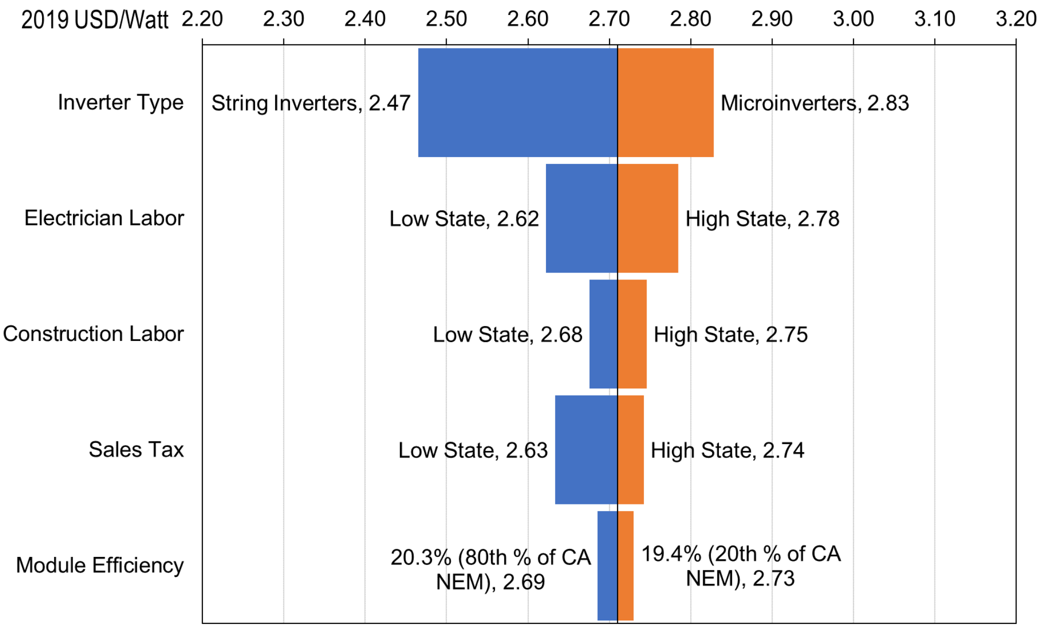

Figure 13. Sensitivity analysis for the Q1 2020 benchmark: Mixed 7.0-kW residential system cost (2019 USD/W$_{DC}$)

3.4 Residential Model Output versus Reported Costs

As shown in Figure 14, our bottom-up modeling approach yields a different cost structure than those reported by public solar integrators in their corporate filings (e.g., Sunrun 2020, Vivint Solar 2020). Because national integrators sell and lease PV systems, they practice a different method of reporting costs than do businesses that only sell goods. Many of the costs for leased systems are reported over the life of the lease rather than the period in which the system is sold; therefore, determining the actual costs at the time of sale is difficult. Although Sunrun and Vivint Solar report system costs in their corporate filings on a quarterly basis (but not “profit” per system), the limited transparency in the public filings makes it difficult to determine the underlying costs as well as the timing of those costs. Because of the lack of available reported company costs, explaining these differences entirely is difficult, and this topic is worthy of future research. Explanations of the difference in reported cost could include the following:

1. Reported companies may spend more on customer acquisition costs to grow market share.
2. Reported companies’ customer acquisition costs consist of leasing, loan, and cash purchase options. Non-cash purchase options may have higher customer acquisition costs than the cash purchase model in this report. National installers also have recently spent considerable effort retraining sales teams as they have shifted focus toward offering customers a direct ownership option rather than a lease or PPA. Retraining a sales staff can be a multi-month process and add considerable expense (Wood Mackenzie and SEIA 2018). Moreover, fewer systems may be sold during the transition process, which would increase customer acquisition costs on a per-watt basis.
3. Part of the difference in installation costs could come from preexisting contracts or older inventory that national integrators used in systems installed in Q1 2020.

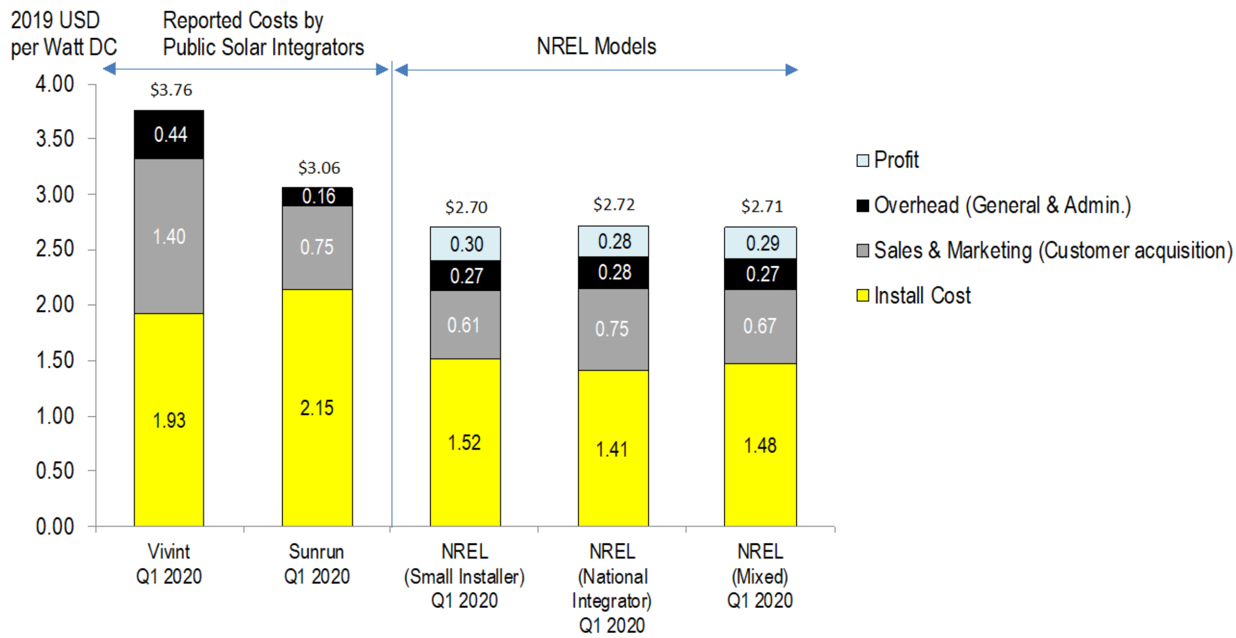

Figure 14. Q1 2020 NREL modeled cost benchmark (2019 USD/W_{DC}) versus Q1 2020 company-reported costs

The PII cost category is included in sales and marketing.

3.5 Retrofits versus New Construction

As discussed by Ardani et al. (2018), the residential PV sector has a significant opportunity to reduce costs by installing PV systems when new homes are constructed; this is unlike most of the current market, in which existing homes are retrofitted with PV systems. For comparative purposes, we build a "new construction" business structure, using the expanded modeling in this year's version of the residential PV model for customer acquisition, engineering, PII, and overhead. The new construction case assumes residential PV systems are part of the standard features of a new production home, which is akin to the legislation passed in California mandating such a practice; some developers in other states also offer production homes in new developments with residential PV systems as a default feature.[14] As indicated in Figure 15, new builds are $0.65/W less expensive than retrofits; this is due to substantially lower customer acquisition and PII costs, as well as reduced costs through efficiencies in labor and structural BOS.

[14] Many of the cost savings achieved by integrating solar into production homes may not translate to custom new home PV projects, from third-party vendors, because there may still be a sales process and coordination between firms for site work (e.g., framing, roofing, electrical, plumbing, and communications), the PV design may need to be changed with design changes to home (e.g., installation of skylights), and there may be a longer time frame between contract closing and the date the system is placed in service.

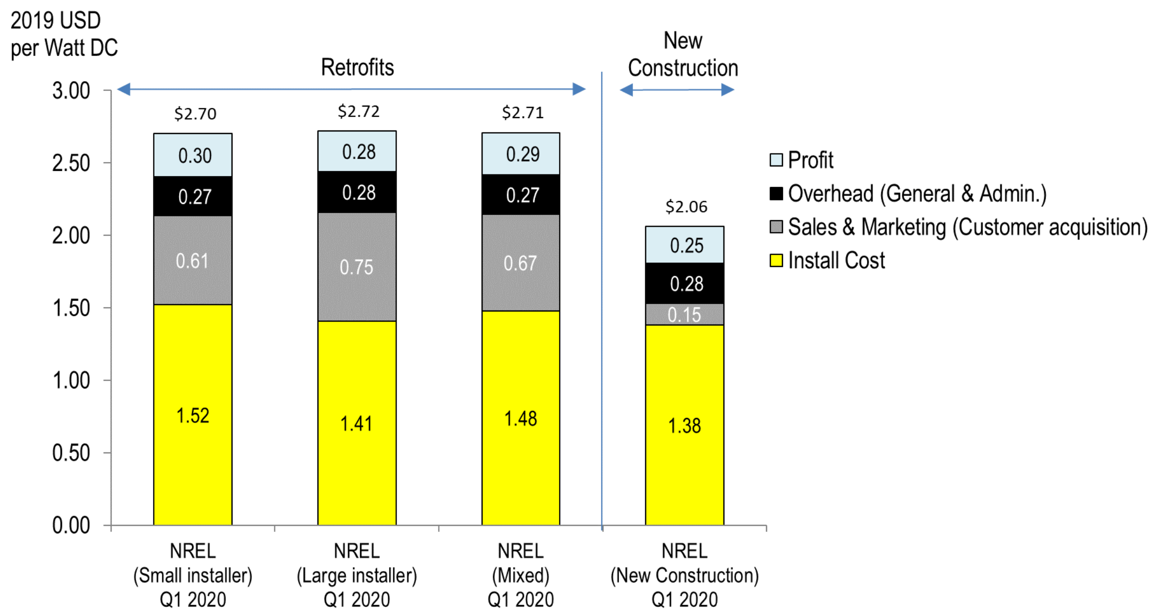

Figure 15. Q1 2020 NREL residential PV modeled cost benchmark (retrofit) versus Q1 2020 NREL residential PV modeled cost benchmark (new construction)

Cost reduction for PV in new construction occurs for a variety of reasons. There are virtually no customer acquisition costs, because the new home comes with a PV system as a standard option. Some costs are borne by the installer (e.g., "holding the customer's hand" through the PV installation and interconnection process as well as PII costs). However, PII is significantly more streamlined, because it is part of the larger permitting process for a home (or development), and installers almost never incur costs due to customer cancellation. Finally, the installation process takes less time because it is incorporated into building the roof and other parts of the new home, while material cost savings are realized by building the roof and the electrical system seamlessly with the PV system.

3.6 Additional Costs Typical of Residential PV Installation

Our benchmarking method includes bottom-up accounting for all *necessary* system and project-development costs incurred when installing U.S. residential PV systems. This year, we calculate additional hardware, installation labor, and roofing costs that are often incurred for many PV systems. Because of requirements in some authorities having jurisdiction, or for a particular building, additional hardware and installation labor costs must be incurred. These costs include partial or full reroofing, adding another disconnect, upgrading a transformer, upgrading a main panel, or being forced (for permitting or interconnection reasons) to install a smaller system than originally designed. Not all U.S. projects must incur these costs, so the average additional contribution to total PV system cost for each step is calculated by multiplying the average cost per occurrence (either material costs or hourly wage multiplied by the number of hours) by the estimated percentage of national sales that use this step, divided by the average conversion from this step to an installed system. Figure 16 summarizes the results of this analysis. The extra cost categories can add 10% to the benchmark system cost.

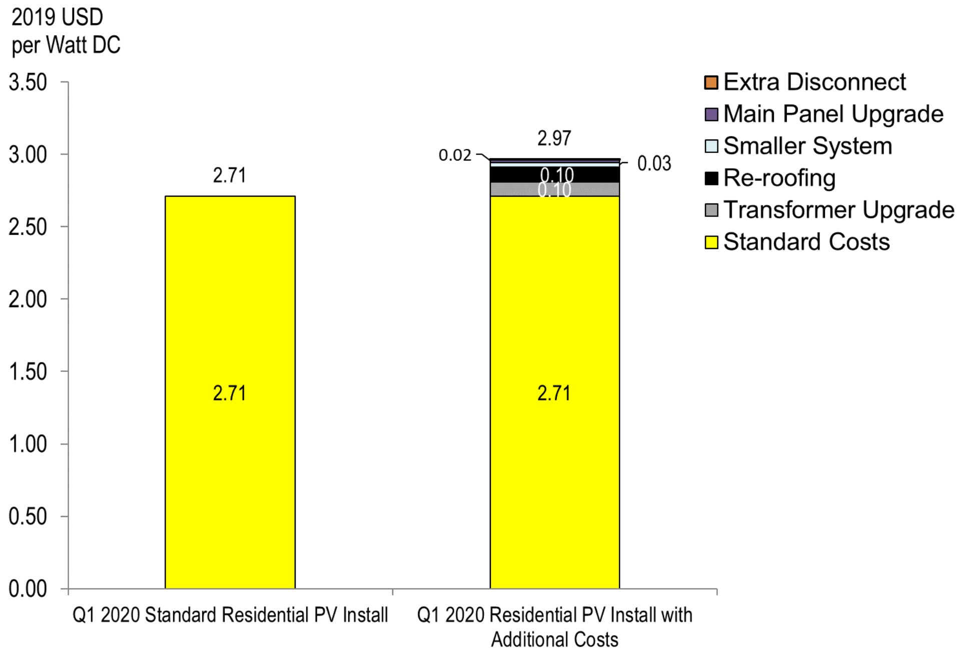

Figure 16. Standard residential PV installation costs versus cost for systems with necessary additions

3.7 Residential PV Price Benchmark Historical Trends

NREL began benchmarking PV system costs in 2010 to track PV costs against SETO targets and to examine cost-reduction opportunities for achieving these goals.[15] Since then, NREL has produced eight additional benchmarks. The current version of our residential cost model makes a few significant changes from the version used in our Q1 2018 benchmark report (Fu, Feldman, and Margolis 2018). To better distinguish the historical cost trends over time from the changes to our cost models, we also calculate Q1 2019 and Q1 2020 PV benchmarks using the Q1 2018 version. Appendix A provides a detailed discussion of the changes made to the models between previous reports (Fu, Feldman, and Margolis 2018) and this year's report. Figure 17 summarizes the reduction in residential PV system cost benchmarks between 2010 and 2020.[16] The "Additional Costs from Model Updates" category represents the difference between modeled results calculated using the current model versus the previous model. Using the previous cost model, the Q1 2019 and Q1 2020 benchmarks are \$2.56/W_{DC} and \$2.47/W_{DC}, respectively.

[15] The original, overarching 2020 SETO goal for solar was to reach levelized cost parity with a new thermal plant, which was estimated to be 6¢/kWh without subsidies, or a system installed cost of \$1/W. SETO later separated commercial and residential PV to have their own goals of costs below retail rates, which were estimated to be 7¢/kWh and 9¢/kWh, or system installed costs of \$1.25/W and \$1.50/W, respectively (all 2020 targets are quoted in nominal USD). In recognition of both the transformative solar progress to date and the potential for additional innovation, SETO extended its goals in 2016 to reduce the unsubsidized cost of energy by 2030 to 3¢/kWh, 4¢/kWh, and 5¢/kWh for utility-scale PV, commercial PV, and residential PV (all 2030 targets are quoted in nominal USD).
[16] Each year's PV system cost benchmark corresponds to the NREL benchmark calculted in Q4 of the previous year or Q1 of the current year (e.g., 2010 = Q4 2009, 2017 = Q1 2017).

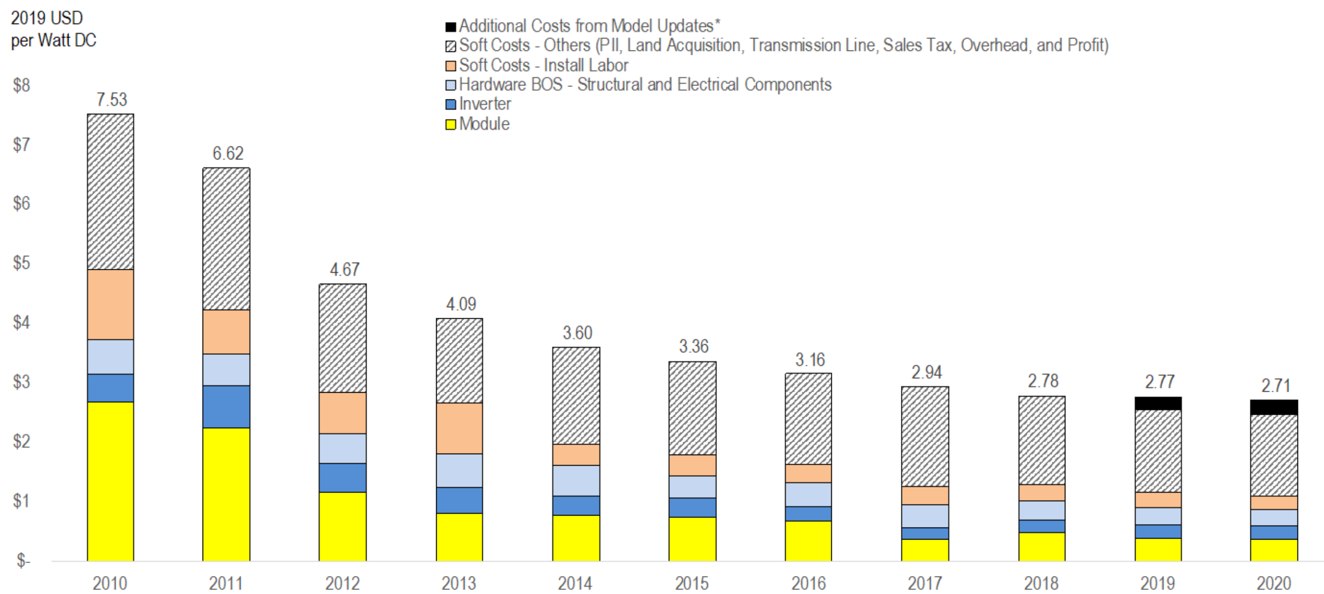

Figure 17. NREL residential PV system cost benchmark summary (inflation adjusted), 2010–2020

* The current version of our cost model makes a few significant changes from the version used in our Q1 2018 benchmark report (Fu, Feldman, and Margolis 2018) and incorporates costs that had previously not been benchmarked in as much detail. To better distinguish the historical cost trends from the changes to our cost models, we calculate Q1 2019 and Q1 2020 PV benchmarks using the Q1 2018 version of the residential PV model. The "Additional Costs from Model Updates" category represents the difference between modeled results. Using the previous cost model, the Q1 2019 and Q1 2020 benchmarks are calculated to be $2.56/W_{DC}$ and $2.47/W_{DC}$, respectively.

As demonstrated in Figure 17, from 2010 to 2020, there was a 64% reduction in the residential PV system cost benchmark. Approximately 57% of that reduction can be attributed to total hardware costs (module, inverter, and hardware BOS), with module prices dropping 85% over that period. An additional 20% can be attributed to labor costs, which dropped 84% over the period. The final 22% is attributable to other soft costs, including PII, sales tax, overhead, and net profit.[17] From 2019 to 2020, there was a 2% reduction in the residential PV system cost benchmark.

Comparing Multicrystalline and Monocrystalline PV Systems

In this year's report, we model systems using monocrystalline PV modules, unlike previous editions of this report (Fu et al. 2018), for which we modeled multicrystalline PV modules. In the past few years, the U.S. market has had an increasing demand for monocrystalline modules; by 2020, there is not enough demand for multicrystalline modules to give an apples-to-apples comparison of U.S. spot pricing. Figure 18 compares Q1 2019 residential PV system pricing when using monocrystalline versus multicrystalline modules, and it shows the change in price of a residential PV system using monocrystalline modules between Q1 2019 and Q1 2020.

[17] Although the residential PV system model always assumes a 22-panel design for all years, the rated size of the system increases owing to improvements in efficiencies. Therefore, some of the cost reduction can be attributed to an increase in system size.

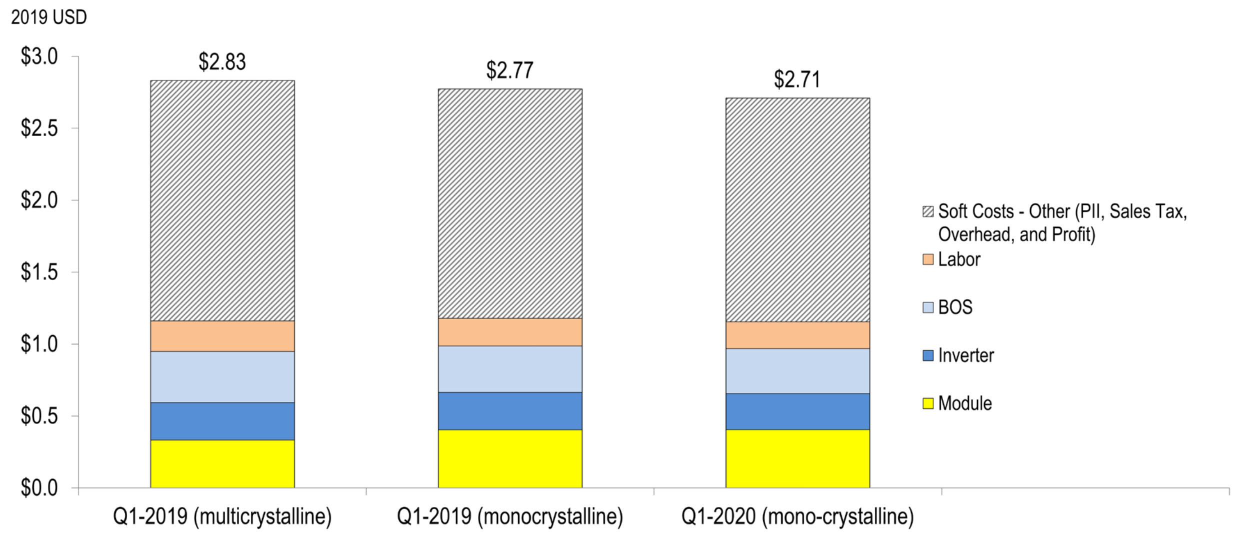

Figure 18. Q1 2019 cost for a residential multicrystalline PV system and Q1 2019 and Q1 2020 costs for a residential monocrystalline PV system

As shown in Figure 18, in Q1 2019 there was a \$0.06/W system price premium from using multicrystalline modules over monocrystalline modules for residential PV systems. The total system cost reductions achieved by increasing efficiency with monocrystalline modules outweighed the premium in monocrystalline module price. Residential PV systems using monocrystalline modules achieved a \$0.06/W (2%) reduction in price from Q1 2019 to Q1 2020.

3.8 Residential PV LCOE Historical Trends

Assumptions for the residential PV LCOE benchmarks from 2010 to 2020 are summarized in Table 4. In addition to a 64% reduction in installed cost from 2010 to 2020, O&M costs declined 49%, annual degradation declined 30%, equity discount rate declined 32%, debt interest rate declined 27%, and debt fraction increased 57%.

Table 4. Residential PV: LCOE Assumptions, 2010–2020 (2019 USD/W_{DC})

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Benchmark Report											
Installed cost ($/W)	7.53	6.62	4.67	4.09	3.60	3.36	3.16	2.94	2.78	2.77	2.71
Inverter loading ratio	1.10	1.11	1.12	1.13	1.13	1.14	1.15	1.15	1.15	1.15	1.15
Ongoing NREL Benchmarking											
Annual degradation (%)	1.00	0.95	0.90	0.85	0.80	0.75	0.75	0.75	0.70	0.70	0.70
O&M expenses ($/kW-yr)	56	49	42	36	31	26	25	25	22	27	29
Preinverter derate (%)	90.0	90.1	90.2	90.3	90.4	90.5	90.5	90.5	90.5	90.5	90.5
Inverter efficiency (%)	94.0	94.8	95.6	96.4	97.2	98.0	98.0	98.0	98.0	98.0	98.0
Inflation rate (%)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Market Case											
Equity discount rate (real) (%)	9.0	8.6	8.3	7.9	7.6	7.3	6.9	6.9	6.9	6.1	6.1
Debt interest rate (%)	5.5	5.4	5.3	5.2	5.0	4.9	4.8	4.8	4.8	4.0	4.0
Debt fraction (%)	34.2	35.2	36.1	37.1	38.1	39.0	40.0	40.0	40.0	53.7	53.7
Steady-State Financing (No ITC)											
Equity discount rate (real) (%)	—	—	—	—	—	—	—	—	—	—	6.1
Debt interest rate (%)	—	—	—	—	—	—	—	——	—	—	5.0
Debt fraction (%)	—	—	—	—	—	—	—	—	—	—	71.8

All 2010–2018 data are from Fu, Feldman, and Margolis (2018), and they are adjusted for inflation. Residential PV system LCOE assumes:

(1) System lifetime of 30 years

(2) Federal tax rate of 21%

(3) State tax rate of 6%

(4) Modified Accelerated Cost Recovery System (MACRS) depreciation schedule

(5) No state or local subsidies

(6) A working capital and debt service reserve account for six months of operating costs and debt payments (earning an interest rate of 1.75%)

7) Three-month construction loan, with an interest rate of 4% and a fee of 1% of the cost of the system

(8) Module tilt angle of 25 degrees, and an azimuth of 180 degrees

(9) Debt with a term of 18 years

(10) $1.1 million of upfront financial transaction costs for a $100 million TPO transaction of a pool of residential projects

(11) 2019 and 2020 financial assumptions from Feldman, Bolinger, and Schwabe (2020).

Using these assumptions, we calculate the residential PV LCOE—with and without the 30% federal ITC—for a high solar resource (capacity factor [CF]: 21.6%), medium solar resource (CF: 17.6%), and low solar resource (CF: 16.4%) (Figure 19).[18] From 2010 to 2020, residential PV LCOE declined 74% (1% between 2019 and 2020), resulting in an unsubsidized LCOE of $0.11–$0.14/kWh ($0.07–$0.09/kWh when including the federal ITC). This reduction is 93% toward achieving SETO's 2020 residential PV LCOE goal from the residential PV system price when the goal was announced in 2010.[19] We also calculate PV LCOE without the ITC using steady-state financing assumptions. Under these assumptions, unsubsidized residential PV LCOE ranges from $0.10–$0.14/kWh in Q1 2020.

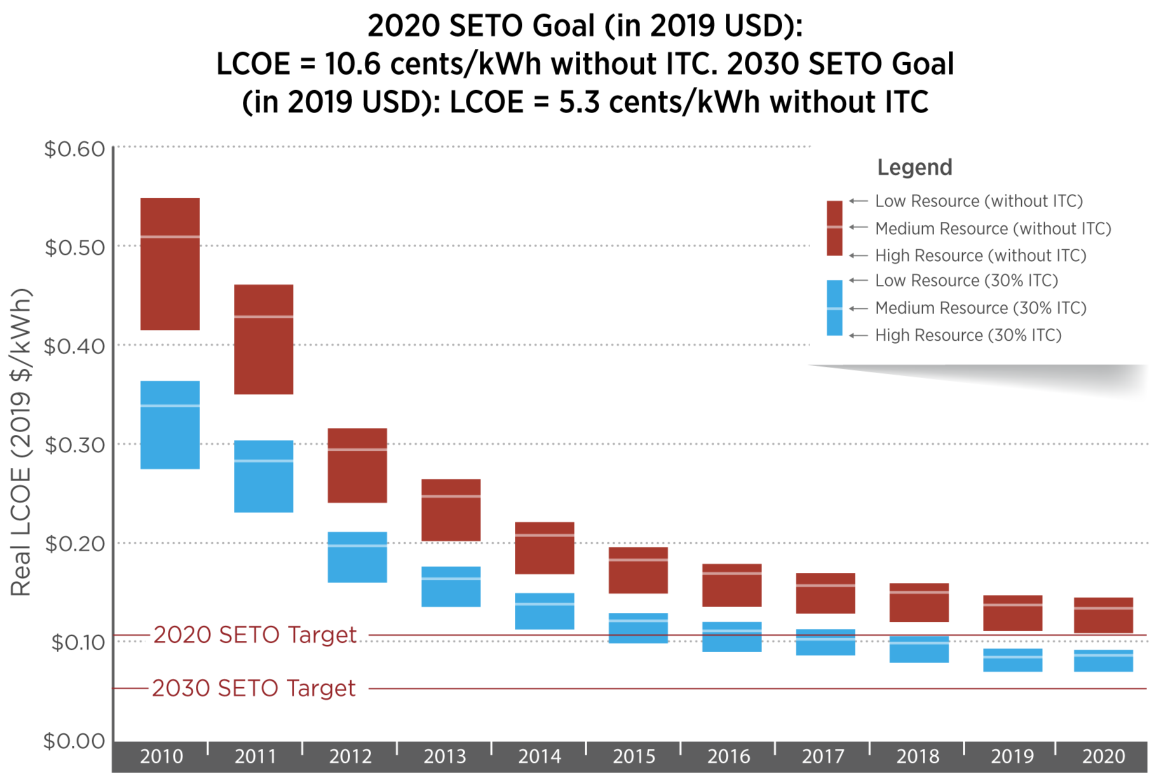

Figure 19. LCOE for residential PV systems, by region, with and without ITC, 2010–2020

We updated our methods and model this year; 2019 and 2020 LCOEs are higher than they would have been using previous models. Appendix A provides a detailed discussion of the changes made to the models between the previous version (Fu, Feldman, and Margolis 2018) and this year's version. LCOE is calculated for each scenario under a range of CFs, but all other values remain the same.

[18] CFs are calculated based on Phoenix, AZ (high solar resource), Kansas City, MO (medium solar resource), and New York, NY (low solar resource).

[19] In 2019 USD, the 2020 SETO target is $0.106/kWh, and the residential LCOE in a medium resource area (without the ITC) is $0.509/kWh in 2010 and $0.135/kWh in 2020; see Appendix B. Progress toward the SETO target is calculated as follows: (0.509 – 0.135)/(0.509 – 0.106) = 93%.

4 Commercial PV Model

This section describes our commercial PV model's structure, inputs, and assumptions (Section 4.1) and output (4.2) as well as trends in historical PV price (4.3) and LCOE (4.4).

4.1 Commercial Model Structure, Inputs, and Assumptions

We model both a 200-kW, 1,000-volt DC (V_{DC}), commercial-scale flat-roof system using a ballasted racking solution on a membrane roof,[20] and a 500-kW, 1,000-V_{DC} commercial-scale fixed-tilt ground-mount system using driven-pile foundations; the ground-mount system is larger because U.S. ground-mount systems are larger than rooftop systems on average. Owing to the adoption of the 2017 and 2020 NEC in many states, three-phase string inverter, power optimizer, and microinverter options are each modeled individually for the commercial rooftop model, and the "mixed" case applies their market shares (45%, 39%, and 16%, respectively) as weightings. Because the 2017 NEC only requires rapid shutdown at the module level for rooftop applications, the commercial ground-mount system only models three-phase string inverters. Both models use monocrystalline 19.5%-efficient modules from a Tier 1 supplier.

We also model a range of system sizes, from 100 kW to 2 MW. Figure 20 presents a schematic of our commercial-scale system cost model. Table 5 presents the detailed modeling inputs and assumptions. We separate our cost estimate into EPC and project-development functions. Although some firms engage in both activities in an integrated manner, and potentially achieve lower cost and pricing by reducing the total margin across functions, we believe the distinction can help separate and highlight the specific cost trends and drivers associated with each function.

[20] A penetrating PV mounting system can have higher energy yield (in kilowatt-hours per kilowatt) than a ballasted racking solution owing to wider tilt-angle range allowance. However, we do not model this system type, because its market share has declined owing to the additional flashing and sealing work required, roof warranty issues, and the difficulty of replacing such systems.

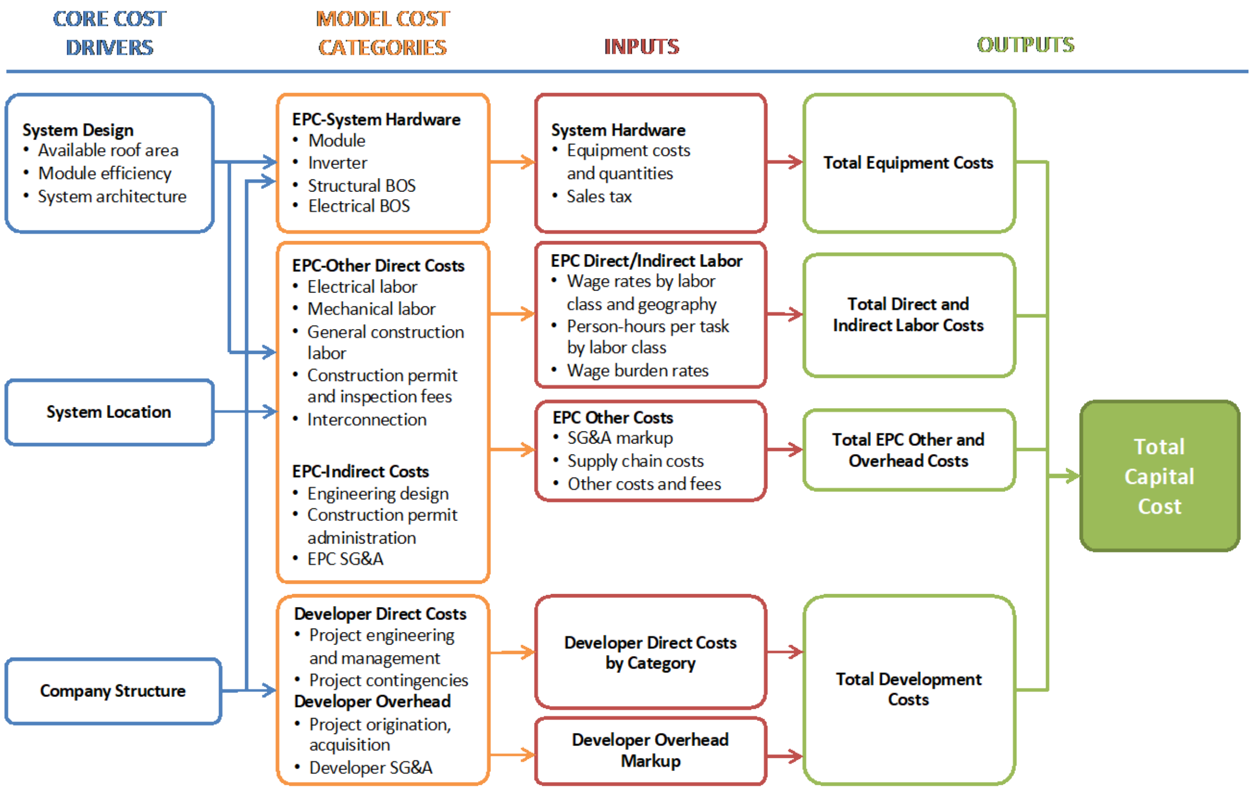

Figure 20. Commercial PV: Model structure

SG&A = selling, general, and administrative

Table 5. Commercial PV: Modeling Inputs and Assumptions

Category	Modeled Value	Description	Sources
System size	200 kW (rooftop) and 500 kW (ground-mount); range (100 kW–2 MW)	Average installed size per system	Barbose and Darghouth 2019
Module efficiency	19.5%	Average monocrystalline module efficiency	CA NEM 2020
Module price	$0.41/W$_{DC}$	Ex-factory gate (first buyer) ASP, Tier 1 monocrystalline modules	Wood Mackenzie and SEIA 2020
Inverter price	Three-phase string inverter: $0.07/W$_{DC}$ DC power optimizer three-phase string inverter: $0.12/W$_{DC}$ (rooftop only) Microinverter: $0.29/W$_{DC}$ (rooftop only)	Ex-factory gate prices (first buyer) ASP, Tier 1 inverters	Wood Mackenzie 2020; Wood Mackenzie and SEIA 2020

Category	Modeled Value	Description	Sources
Structural components (racking)	\$0.11–\$0.17/W_{DC}; assumes national average wind and snow loading[a]; varies by racking type (ground-mount versus rooftop ballasted)	Ex-factory gate prices; flat-roof ballasted racking system or fixed-tilt ground-mount racking system	MEPS 2019; model assumptions; NREL 2019
Electrical components	\$0.13–\$0.24/W_{DC}	Conductors, conduit and fittings, transition boxes, switchgear, panel boards, and other parts	Model assumptions; NREL 2020; RSMeans 2017
EPC overhead (percentage of equipment costs)	13%	Costs and fees associated with EPC overhead, inventory, shipping, and handling	NREL 2020
Sales tax	National average: 5%	Sales tax on equipment costs	RSMeans 2017
Direct installation labor	Electrician: \$27.47 per hour Laborer: \$18.17 per hour	Modeled labor rate assumes national average nonunionized labor rates	BLS 2019; NREL 2020
Burden rates (percentage of direct labor)	Total nationwide average: 18%	Workers compensation, federal and state unemployment insurance, FICA, builders' risk, public liability	RSMeans 2017
PII	\$0.11/W_{DC}	For construction permits fee, interconnection study fees for existing substation, testing, and commissioning	NREL 2020
Developer overhead	\$0.30–\$0.36/W Varies by system size (30% developer overhead)	Includes overhead expenses such as payroll, facilities, travel, legal fees, administrative, business development, finance, and other corporate functions	Model assumptions; NREL 2020
Contingency	4%	Estimated as markup on EPC cost; value represents actual cost overruns above estimated cost	NREL 2020

Category	Modeled Value	Description	Sources
Profit	7%	Applies a fixed percentage margin to all costs, including hardware, installation labor, EPC overhead, and developer overhead	NREL 2020

[a] Racking companies currently meet the national standard, so there is not as much differentiation by state in the market within rooftop systems. The ground-mount racking system requires more material, equipment, and labor compared than the ballasted racking system. However, installation of ground-mount PV systems at utility scale helps reduce the BOS cost of these systems owing to economies of scale.

4.2 Commercial Model Output

Figure 21 presents the U.S. national benchmarks from our commercial PV models. We model different system sizes because of the wide scope of the commercial sector, which comprises a diverse customer base occupying a variety of building and property sizes. Economies of scale—driven by hardware, labor, and related markups—are evident here. As system sizes increase, the per-watt cost to build systems decreases. As shown in Figure 21 and Figure 22, commercial rooftop applications have lower costs than commercial ground-mount systems for several smaller system sizes. However, the difference in price decreases as system size increases, and ground-mount systems have lower costs for system sizes of 1 and 2 MW. Compared with rooftop systems, ground-mount applications have higher material, equipment, and labor costs associated with pile-driven mounting. As PV system size increases, the per-watt cost of pile-driven mounting is significantly reduced through economies of scale. Ground-mount commercial PV systems also benefit from lower inverter costs owing to the rapid shutdown requirements for commercial rooftop systems.

Figure 23 and Figure 24 show sensitivity analyses for the 200-kW rooftop system and 500-kW ground-mount system, with cost categories that vary by location and hardware specification. For the rooftop system, inverter type has the largest impact on installed system cost. For the ground-mount system, material location factor and equipment location factor have the largest impacts.

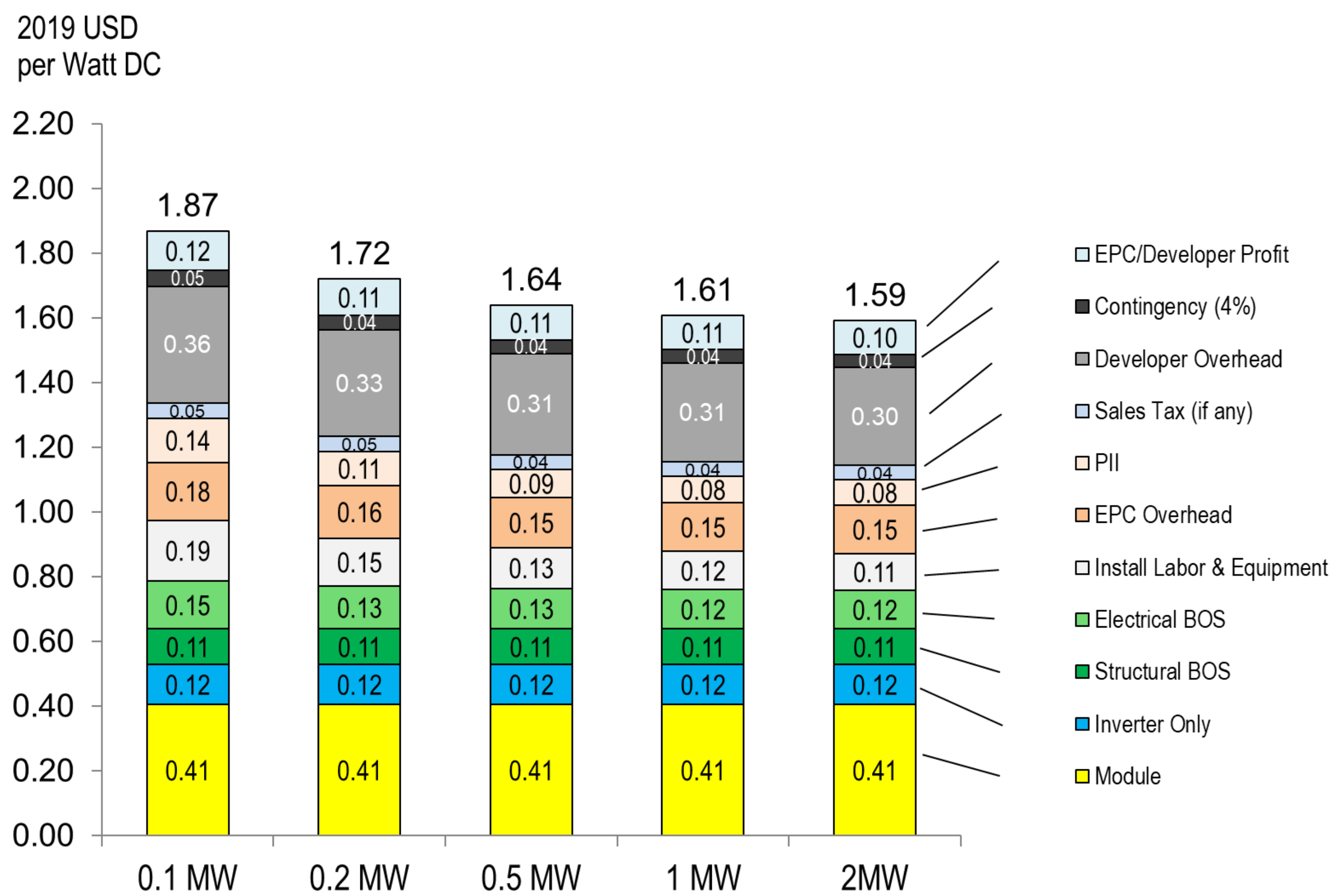

Figure 21. Q1 2020 U.S. benchmark: Commercial rooftop PV system cost (2019 USD/W_{DC})

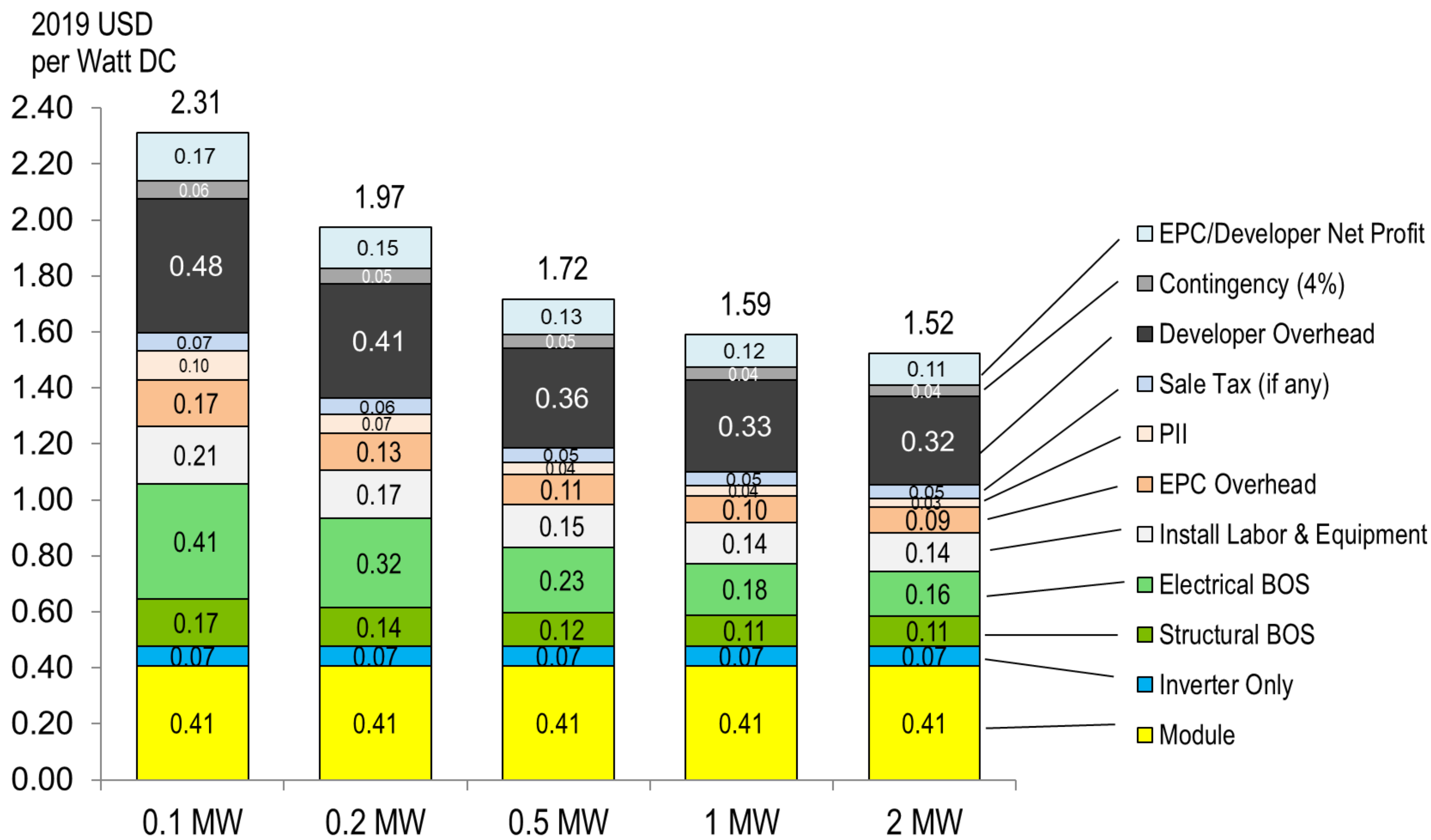

Figure 22. Q1 2020 U.S. benchmark: Commercial ground-mount PV system cost (2019 USD/W_{DC})

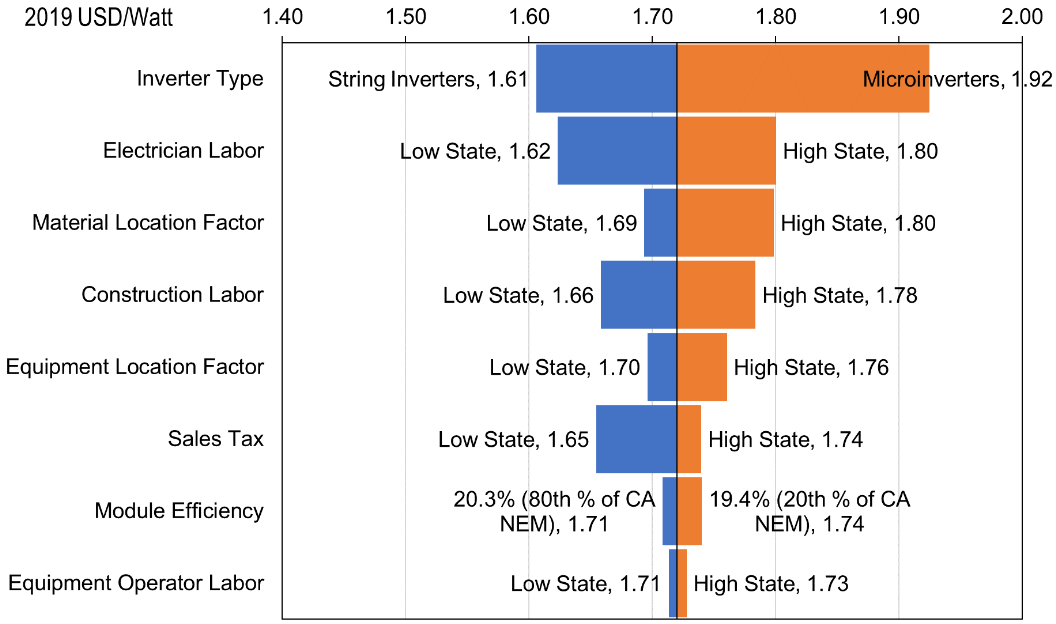

Figure 23. Sensitivity analysis for the Q1 2020 benchmark: 200-kW rooftop commercial PV system cost (2019 USD/W$_{DC}$)

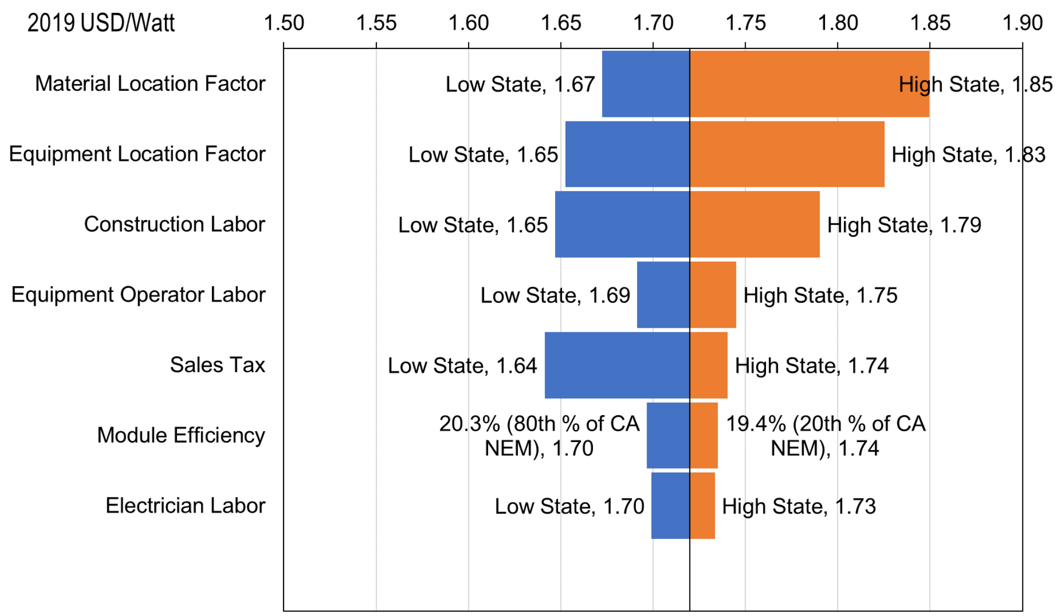

Figure 24. Sensitivity analysis for the Q1 2020 benchmark: 500-kW commercial ground-mount PV system cost (2019 USD/W$_{DC}$)

4.3 Commercial Rooftop PV Price Benchmark Historical Trends

The current version of our commercial cost model makes a few significant changes from the version used in our Q1 2018 benchmark report (Fu, Feldman, and Margolis 2018). To better distinguish the historical cost trends from the changes to our cost models, we also calculate Q1 2019 and Q1 2020 PV benchmarks using the Q1 2018 version. Appendix A provides a detailed discussion of the changes made to the models between the previous report (Fu, Feldman, and Margolis 2018) and this year's report. Figure 25 summarizes the reduction in commercial PV system cost benchmarks between 2010 and 2020. The "Additional Costs from Model Updates" category represents the difference between modeled results calculated using the current model versus the previous model. Using the previous cost model, the Q1 2019 and Q1 2020 benchmarks are calculated to be $1.71/W_{DC}$ and $1.64/W_{DC}$, respectively. Figure 25 shows a 69% reduction in commercial PV system cost benchmarks between 2010 and 2020.[21] Approximately 78% of that reduction can be attributed to total hardware costs (module, inverter, and hardware BOS), and module prices dropped 85% over that period. The final 22% is attributable to labor and soft costs, including PII, sales tax, overhead, and net profit. From 2019 to 2020, there was a 2.4% reduction in the commercial rooftop PV system cost benchmark, largely driven by reductions in inverter and BOS hardware costs.

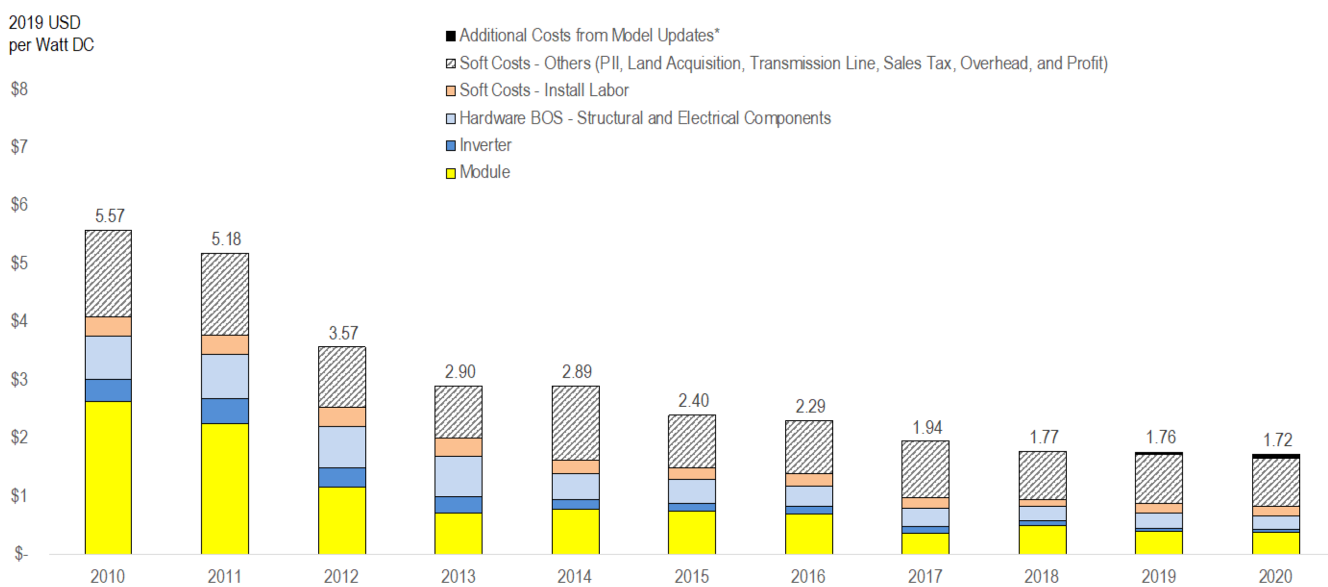

Figure 25. NREL commercial rooftop PV system cost benchmark summary (inflation-adjusted), 2010–2020

* The current version of our cost model makes a few significant changes from the version used in our Q1 2018 benchmark report (Fu, Feldman, and Margolis 2018) and incorporates costs that had previously not been benchmarked in as much detail. To better distinguish the historical cost trends from the changes to our cost models, we calculate Q1 2019 and Q1 2020 PV benchmarks using the Q1 2018 version of the commercial rooftop PV model. The "Additional Costs from Model Updates" category represents the difference between modeled results. Using the previous costs model, the Q1 2019 and Q1 2020 benchmarks are calculated to be $1.71/W_{DC}$ and $1.64/W_{DC}$, respectively.

[21] Each year's PV system cost benchmark corresponds to the NREL benchmark calculated in Q4 of the previous year or Q1 of the current year (e.g., 2010 = Q4 2009; 2017 = Q1 2017).

Comparing Multicrystalline and Monocrystalline PV Systems

For the same reasons described in Section 3.7.1, we compare commercial rooftop system pricing using monocrystalline and multicrystalline PV modules. Figure 26 compares Q1 2019 system pricing between commercial rooftop systems using the different module types, and it shows the change in price of a commercial rooftop PV system using monocrystalline PV modules between Q1 2019 and Q1 2020.

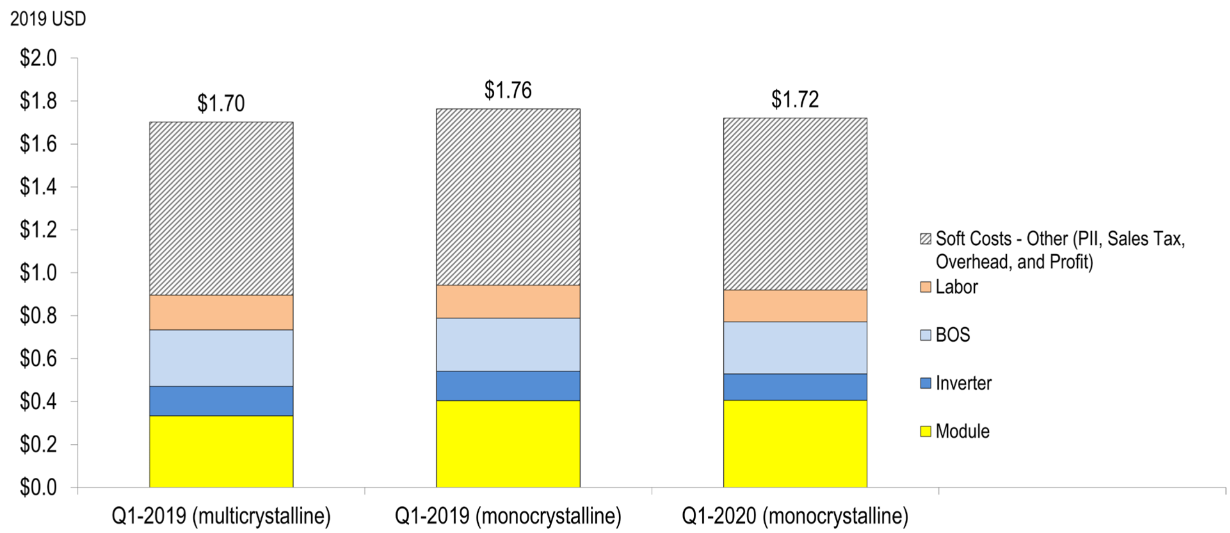

Figure 26. Q1 2019 cost for a commercial rooftop multicrystalline PV system and Q1 2019 and Q1 2020 costs for a commercial rooftop monocrystalline PV system

As shown in Figure 26, in Q1 2019 there was a $0.06/W system price premium for using monocrystalline PV modules over multicrystalline PV modules in commercial rooftop PV systems. The system cost reductions achieved by increased monocrystalline module efficiency were counterbalanced by the higher module price. Commercial rooftop PV systems using monocrystalline modules achieved a $0.04/W (2.4%) reduction in price from Q1 2019 to Q1 2020.

4.4 Commercial PV LCOE Historical Trends

Assumptions for the commercial PV LCOE benchmarks from 2010 to 2020 are summarized in Table 6. In addition to the 69% reduction in installed cost for commercial rooftop PV from 2010 to 2020, O&M costs declined 46%, annual degradation declined 30%, equity discount rate declined 32%, debt interest rate declined 27%, and debt fraction increased 57%.

Table 6. Commercial PV: LCOE Assumptions, 2010–2020 (2019 USD/W_{DC})

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Rooftop (200 kW)											
Installed cost ($/W)	5.57	5.18	3.57	2.90	2.89	2.40	2.29	1.94	1.77	1.76	1.72
Inverter loading ratio	1.10	1.11	1.12	1.13	1.13	1.14	1.15	1.15	1.15	1.15	1.15
Annual degradation (%)	1.00	0.95	0.90	0.85	0.80	0.75	0.75	0.75	0.70	0.70	0.70
O&M expenses ($/kW-yr)	35	32	29	26	23	20	19	19	18	19	19
Preinverter derate (%)	90.5	90.5	90.5	90.5	90.5	90.5	90.5	90.5	90.5	90.5	90.5
Inverter efficiency (%)	95.0	95.6	96.2	96.8	97.4	98.0	98.0	98.0	98.0	98.0	98.0
Ground-Mount (500 kW)											
Installed cost ($/W)	—	—	—	—	—	—	—	—	—	—	1.72
Inverter loading ratio	—	—	—	—	—	—	—	—	—	—	1.11
Annual degradation (%)	—	—	—	—	—	—	—	—	—	—	0.70
O&M expenses ($/kw-yr)	—	—	—	—	—	—	—	—	—	—	18.71
Preinverter derate (%)	—	—	—	—	—	—	—	—	—	—	90.5
Inverter efficiency (%)	—	—	—	—	—	—	—	—	—	—	98.0
Financing Assumptions											
Inflation rate (%)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Market Case											
Equity discount rate (real) (%)	9.0	8.6	8.3	7.9	7.6	7.3	6.9	6.9	6.9	6.1	6.1
Debt interest rate (%)	5.5	5.4	5.3	5.2	5.0	4.9	4.8	4.8	4.8	4.0	4.0
Debt fraction (%)	34.2	35.2	36.1	37.1	38.1	39.0	40.0	40.0	40.0	53.8	53.8
Steady-State financing											
Equity discount rate (real) (%)	—	—	—	—	—	—	—	—	—	—	6.1
Debt interest rate (%)	—	—	—	—	—	—	—	—	—	—	5.0
Debt fraction (%)	—	—	—	—	—	—	—	—	—	—	71.8

All 2010–2018 data are from Fu, Feldman, and Margolis (2018), and they are adjusted for inflation. Commercial PV system LCOE assumes:

(1) System lifetime of 30 years

(2) Federal tax rate of 21%

(3) Sate tax rate of 6%

(4) MACRS depreciation schedule

(5) No state or local subsidies

(6) A working capital and debt service reserve account for six months of operating costs and debt payments (earning an interest rate of 1.75%)

(7) Six-month construction loan, with an interest rate of 4% and a fee of 1% of the cost of the system

(8) Module tilt angle of 10 degrees and an azimuth of 180 degrees

(9) Debt with a term of 18 years

(10) $1.1 million of upfront financial transaction costs for a $100 million TPO transaction of a pool of commercial projects

(11) 2019 and 2020 financial assumptions from Feldman, Bolinger, and Schwabe (2020).

Using these assumptions, we calculate the commercial PV LCOE—with and without the 30% federal ITC—for a high solar resource (Phoenix, CF: 20.4%), medium solar resource (Kansas City, CF: 16.4%), and low solar resource (New York City, CF: 15.3%) (Figure 27). From 2010 to 2020, commercial rooftop PV LCOE declined 77% (3% between 2019 and 2020), resulting in an unsubsidized LCOE of $0.08–$0.10/kWh ($0.05–$0.07/kWh when including the federal ITC). This reduction is 97% toward achieving SETO's 2020 commercial PV LCOE goal from the commercial system price when the goal was announced in 2010.[22] Commercial ground-mount PV systems, which we began benchmarking this year, are calculated to have a 2020 unsubsidized LCOE of $0.07–$0.09/kWh ($0.05–$0.06/kWh when including the federal ITC). We also calculate PV LCOE without the ITC using steady-state financing assumptions. Under these assumptions, the commercial rooftop PV LCOE ranges from $0.07–$0.10/kWh, and the commercial ground-mount PV LCOE ranges from $0.07–$0.10/kWh in Q1 2020.

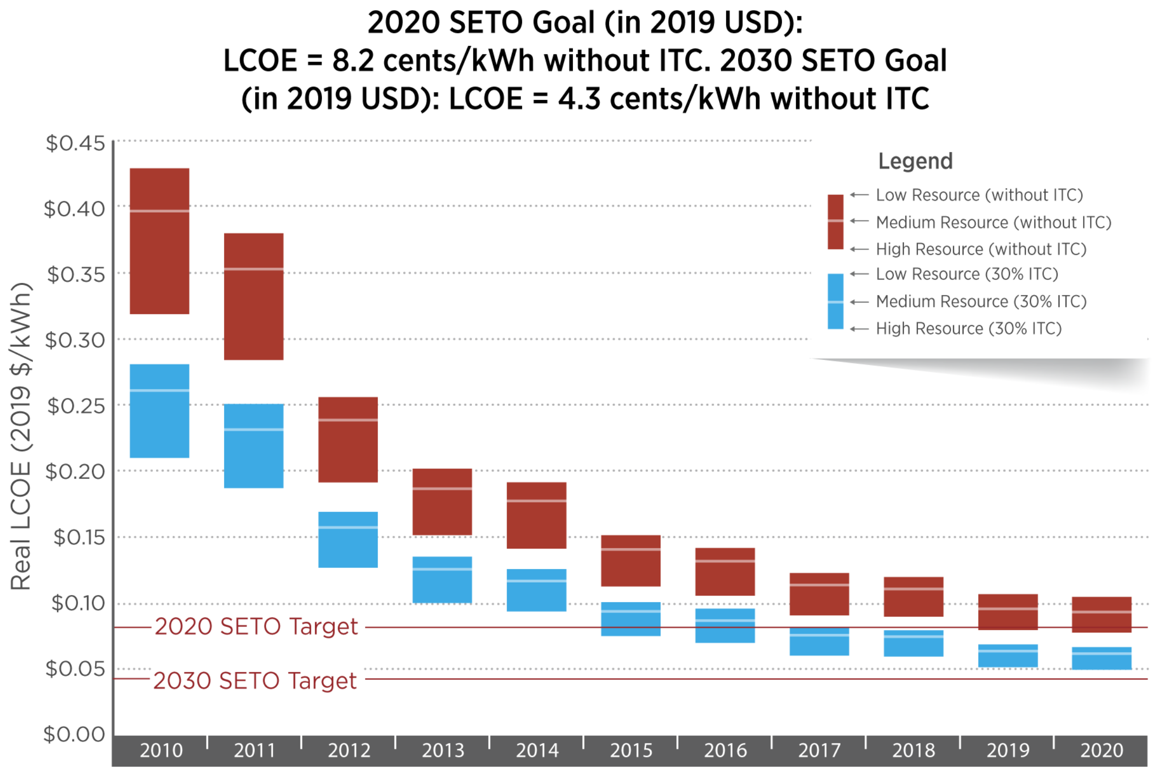

Figure 27. LCOE for commercial rooftop PV systems, by region, with and without ITC, 2010–2020

We updated our methods and model this year; 2019 and 2020 LCOEs are higher than they would have been using previous models. Appendix A provides a detailed discussion of the changes made to the models between the previous version (Fu, Feldman, and Margolis 2018) and this year's version. LCOE is calculated for each scenario under a range of CFs, but all other values remain the same.

[22] In 2019 USD, the 2020 SETO target is $0.082/kWh, and the commercial LCOE in Kansas City (without the ITC) is $0.397/kWh in 2010 and $0.093/kWh in 2020; see Appendix B. Progress toward the SETO target is calculated as follows: (0.397 – 0.093)/(0.397 – 0.082) = 97%.

5 Utility-Scale PV Model

This section describes our utility-scale PV model's structure, inputs, and assumptions (Section 5.1) and output (5.2) as well as trends in historical PV price (5.3) and LCOE (5.4).

5.1 Utility-Scale Model Structure, Inputs, and Assumptions

We model a baseline 100-MW, 1,500-V_{DC} utility-scale system using 72-cell, monocrystalline 19.5%-efficient modules from a Tier 1 supplier and three-phase central inverters. We model both fixed-tilt and one-axis tracking on ground-mounted racking systems using driven-pile foundations. In addition, we separate our cost estimates into EPC and project-development functions. Although some firms engage in both activities in an integrated manner, we believe the distinction can help separate and highlight the specific cost trends and drivers associated with each function. We also model a range of system sizes, from 5 MW to 100 MW. Figure 28 presents a schematic of our utility-scale system cost model, and Table 7 details its assumptions and inputs.

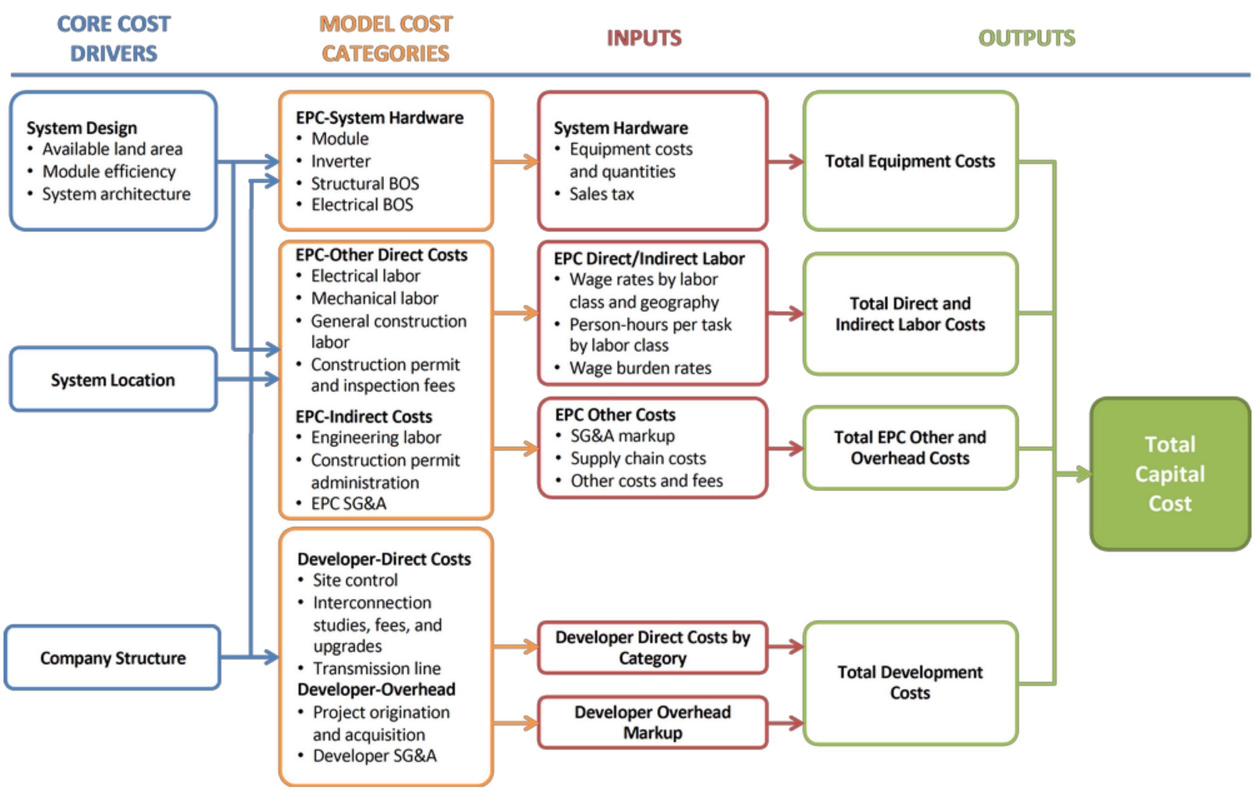

Figure 28. Utility-scale PV: Model structure

Table 7. Utility-Scale PV: Modeling Inputs and Assumptions

Category	Modeled Value	Description	Sources
System size	100 MW; range: 5 MW–100 MW	A large utility-scale system capacity	Model assumption
Module efficiency	19.5%	Average monocrystalline module efficiency	CA NEM 2020
Module price	$0.41/W_{DC}$	Ex-factory gate (first buyer) price, Tier 1 monocrystalline modules	Wood Mackenzie and SEIA 2020; NREL 2020
Inverter price	$0.05/W_{DC}$ (fixed-tilt) $0.05/W_{DC}$ (one-axis tracker)	Ex-factory gate (first buyer) price, Tier 1 inverters DC-to-AC ratio = 1.37 for fixed-tilt and 1.34 for one-axis tracker	Wood Mackenzie and SEIA 2020; Bolinger, Seel, and Robson 2019
Structural components (racking)	$0.12/W_{DC}$ for a 100-MW system	Fixed-tilt racking or one-axis tracking system	MEPS 2019; model assumptions; NREL 2020
Electrical components	$0.07–$0.13/W_{DC}$ Varies by system size	Model was upgraded to a 1,500-V_{DC} system that includes conductors, conduit and fittings, transition boxes, switchgear, panel boards, onsite transmission, and other electrical connections	Model assumptions; NREL 2020; RSMeans 2017
EPC overhead (percentage of equipment costs)	8.67%–13% for equipment and material (except for transmission line costs); 23%–69% for labor costs; varies by system size and labor activity	Costs associated with EPC SG&A, warehousing, shipping, and logistics	NREL 2020
Sales tax	National average: 5%	Sales tax on equipment costs	RSMeans 2017
Direct installation labor	Electrician: $27.47 per hour Laborer: $18.17 per hour	Modeled labor rate assumes national average nonunionized labor	BLS 2019; NREL 2020
Burden rates (percentage of direct labor)	Total nationwide average: 18%	Workers compensation, federal and state unemployment insurance, FICA, builders' risk, public liability	RSMeans 2017
PII	$0.03–$0.07/W_{DC}$ Varies by system size	For construction permits fee, interconnection, testing, and commissioning	NREL 2020

Category	Modeled Value	Description	Sources
Transmission line (gen-tie line)	$0.00–$0.02/W$_{DC}$ Varies by system size	System size < 10 MW uses 0 miles for gen-tie line System size > 200 MW uses five miles for gen-tie line System size = 10–200 MW uses linear interpolation	Model assumptions; NREL 2020
Developer overhead	2%–12% Varies by system size (100 MW uses 2%; 5 MW uses 12%)	Includes overhead expenses such as payroll, facilities, travel, legal fees, administrative, business development, finance, and other corporate functions	Model assumptions; NREL 2020
Contingency	3%	Estimated as markup on EPC cost	NREL 2020
Profit	5%–8% Varies by system size (100 MW uses 5%; 5 MW uses 8%)	Applies a percentage margin to all costs including hardware, installation labor, EPC overhead, and developer overhead	NREL 2020

Figure 29 shows the percentage of U.S. utility-scale PV systems using tracking systems for 2010–2019. Although the data include one-axis and dual-axis tracking systems in the same "tracking" category, there are many more one-axis trackers than dual-axis trackers (EIA 2020). Cumulative tracking system installation reached 65% in 2019, with 82% of new installations in 2019 having tracking. Based on these trends, we use fixed-tilt systems to calculate LCOE benchmarks from 2010 to 2015, and we use one-axis tracking systems for 2016 to 2020 (see Section 5.4).

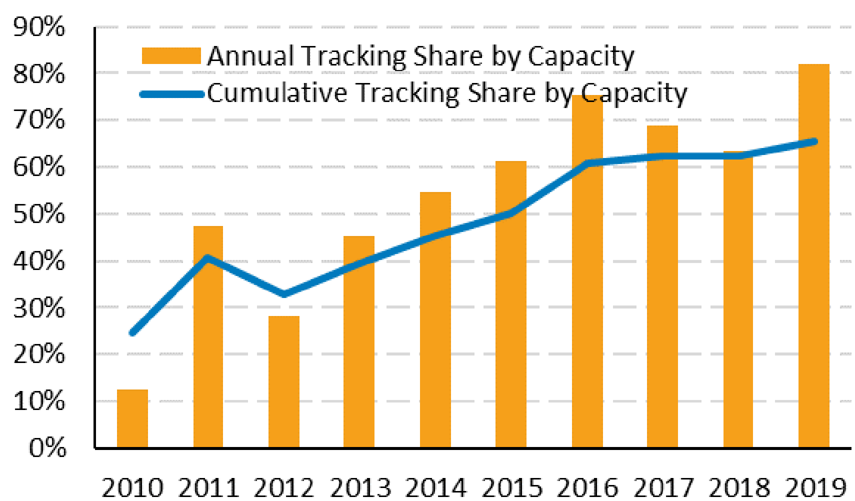

Figure 29. Percentage of U.S. utility-scale PV systems using tracking systems, 2010–2019

Source: EIA (2020)

5.2 Utility-Scale Model Output

Figure 30 shows the U.S. national benchmark (EPC + developer) for fixed-tilt and one-axis tracker systems, using nonunionized labor. Figure 31 shows a sensitivity analysis for the one-axis system benchmark, with cost categories that vary by location and hardware specification. Equipment location factor has the largest impact on installed system cost.

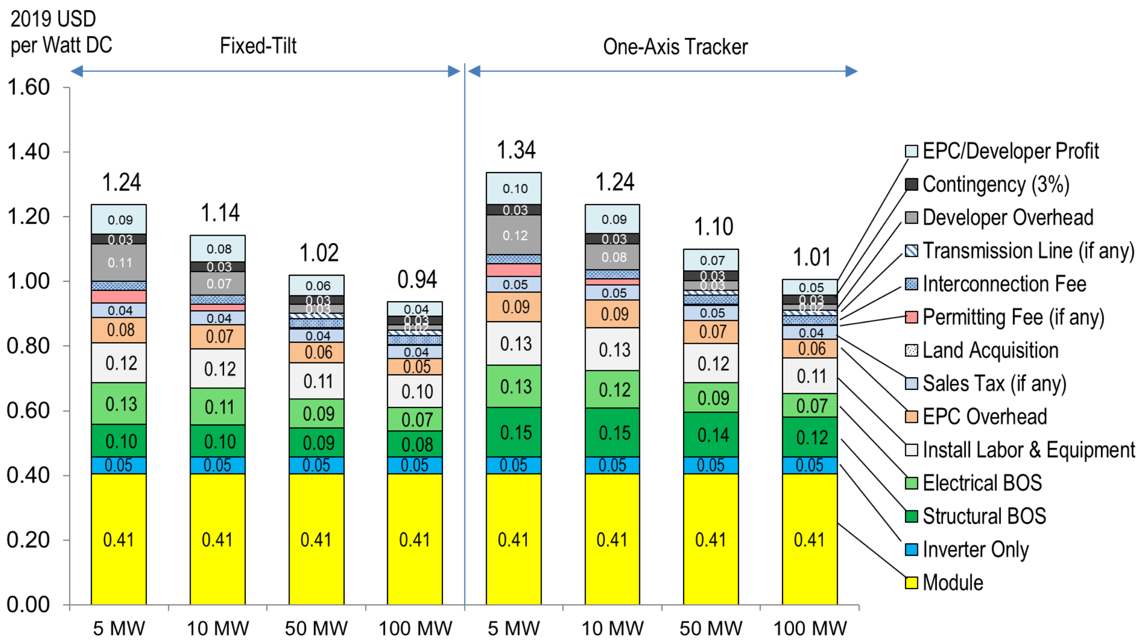

Figure 30. Q1 2020 U.S. benchmark: Utility-scale PV total cost (EPC + developer), 2019 USD/W_{DC}

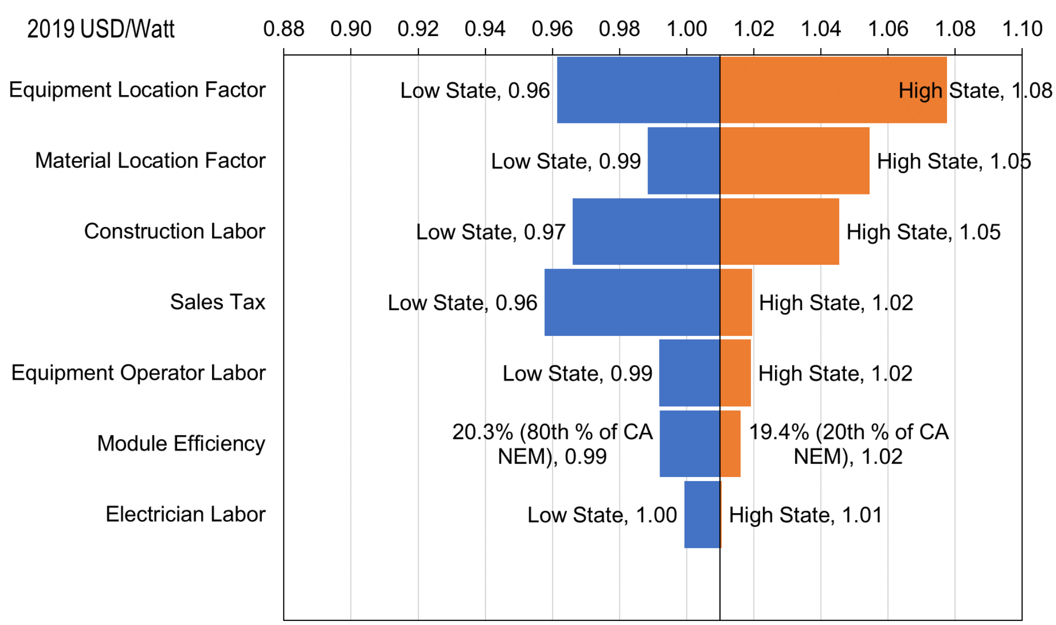

Figure 31. Sensitivity analysis for the Q1 2020 benchmark: 100-MW one-axis utility-scale PV system cost (2019 USD/W_{DC})

5.3 Utility-Scale PV Price Benchmark Historical Trends

Figure 32 shows the 80% (fixed-tilt) and 82% (one-axis tracking) reductions in utility-scale PV system cost benchmarks between 2010 and 2020.[23] Approximately 70% (fixed-tilt) and 64% (one-axis tracking) of those reductions can be attributed to total hardware costs, with module prices dropping 85% over that period. An additional 11% (fixed-tilt) to 12% (one-axis tracking) reduction can be attributed to labor, which dropped over that period. For previous editions of this report, we assumed a land acquisition cost of $0.03/W. Based on Wiser et al. (2020), which stated that most utility-scale PV projects do not own the land on which the PV system is placed, we have reclassified land costs from an upfront capital expenditure (land acquisition) to an operating expenditure (lease payments) for 2019 and 2020. Therefore, approximately 1% of the reduction in cost is attributed to the reclassification of land costs. The final 20% (fixed-tilt) and 25% (one-axis tracker) is attributable to other soft costs, including PII, sales tax, overhead, and net profit.

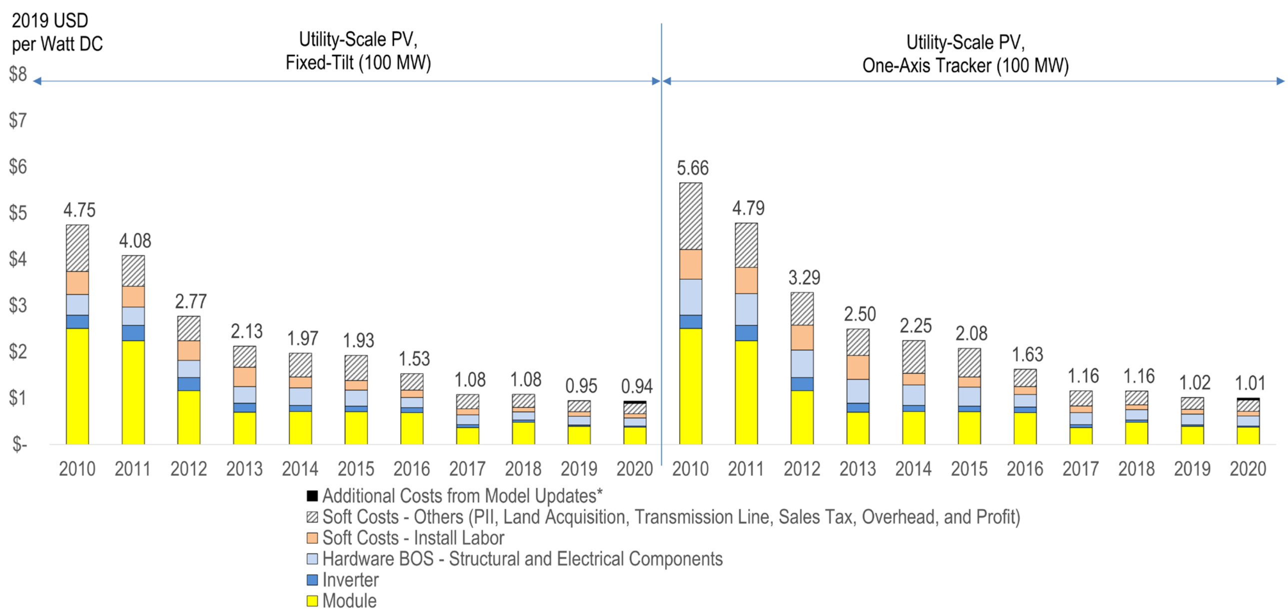

Figure 32. NREL utility-scale PV system cost benchmark summary (inflation-adjusted), 2010–2020

* The current version of our cost model makes a few significant changes from the version used in our Q1 2018 benchmark report (Fu, Feldman, and Margolis 2018) and incorporates costs that had previously not been benchmarked in as much detail. To better distinguish the historical cost trends from the changes to our cost models, we calculate Q1 2019 and Q1 2020 PV benchmarks using the Q1 2018 versions of the utility-scale PV model. The "Additional Costs from Model Updates" category represents the difference between modeled results. Using the previous costs model, the Q1 2019 and Q1 2020 benchmarks are calculated to be $0.94/W_{DC}$ and $0.89/W_{DC}$ (fixed-tilt) as well as $1.01/W_{DC}$ and $0.96/W_{DC}$ (one-axis), respectively.

From 2019 to 2020, overall there was a 1% reduction in the cost benchmarks for both utility-scale PV systems (fixed-tilt and one-axis tracking).

[23] Each year's PV system cost benchmark corresponds to the NREL benchmark calculted in Q4 of the previous year or Q1 of the current year (e.g., 2010 = Q4 2009; 2017 = Q1 2017).

Comparing Multicrystalline and Monocrystalline PV Systems

For the same reasons described in Section 3.7.1, we compare utility-scale PV system pricing using monocrystalline and multicrystalline PV modules. Figure 33 compares Q1 2019 system pricing between fixed-tilt and one-axis tracking utility-scale PV systems using the different module types, and it shows the change in price of fixed-tilt and one-axis tracking utility-scale PV systems using monocrystalline PV modules between Q1 2019 and Q1 2020.

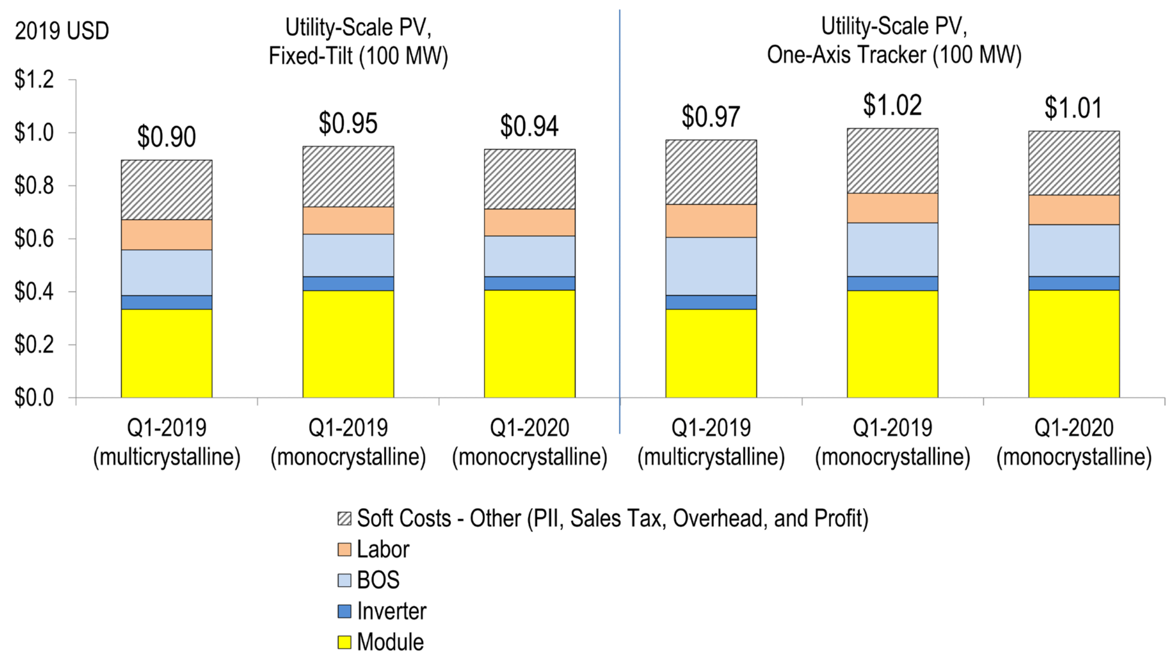

Figure 33. Q1 2019 costs for utility-scale multicrystalline PV systems and Q1 2019 and Q1 2020 costs for utility-scale monocrystalline PV systems

As shown in Figure 33, in Q1 2019 there was a $0.05/$W_{DC}$ system price premium for using monocrystalline PV modules over multicrystalline PV modules in utility-scale PV systems. The system cost reductions achieved by increased monocrystalline module efficiency were counterbalanced by the higher module price. The price of utility-scale PV systems using monocrystalline modules decreased by $0.01/$W_{DC}$ from Q1 2019 to Q1 2020.

5.4 Utility-Scale PV LCOE Historical Trends

Assumptions for the utility-scale PV LCOE benchmarks from 2010 to 2020 are summarized in Table 8. In addition to the 82% reduction in the installed cost of utility-scale (one-axis) systems from 2010 to 2020, O&M costs declined 40%, annual degradation declined 30%, equity discount rate declined 31%, debt interest rate declined 27%, and debt fraction increased 52%.

Using these assumptions, we calculate the utility-scale PV LCOE—with and without the 30% federal ITC—for a high solar resource (Phoenix, CF: 21.6% for fixed-tilt and 25.2% for one-axis), medium solar resource (Kansas City, CF: 17.3% for fixed-tilt and 19.6% for one-axis), and low solar resource (New York City, CF: 16.2% for fixed-tilt and 18.1% for one-axis) (Figure 34). We use fixed-tilt systems for LCOE benchmarks from 2010 to 2015 and then switch to one-axis tracking systems from 2016 to 2020 to reflect the market share change in Figure 29.

From 2010 to 2020, utility-scale PV LCOE declined 83% (0% between 2019 and 2020), resulting in an unsubsidized LCOE of \$0.04–\$0.05/kWh (\$0.025–\$0.035/kWh when including the federal ITC). This reduction signifies the achievement of SETO's 2020 utility-scale PV goal.[24] We also calculate PV LCOE without the ITC using steady-state financing assumptions. Under these assumptions, utility-scale (one-axis and fixed-tilt) PV LCOE ranges from \$0.04–\$0.05/kWh in Q1 2020.

[24] The 2020 utility-scale goal is not adjusted for inflation, because wholesale electricity prices were relatively flat, and in some cases declined, from 2010 to 2020. The goal is shown in Appendix B along with the detailed utility-scale LCOE values over time.

Table 8. One-Axis Tracker and Fixed-Tilt Utility-Scale PV: LCOE Assumptions, 2010–2020 (2019 USD/W_{DC})

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
One-Axis Tracker											
Installed cost ($/W)	5.66	4.79	3.29	2.50	2.25	2.08	1.63	1.16	1.16	1.02	1.01
Annual degradation (%)	1.00	0.95	0.90	0.85	0.80	0.75	0.75	0.75	0.70	0.70	0.70
O&M expenses ($/kW-yr)	29	28	26	25	24	22	22	21	15	17	17
Preinverter derate (%)	90.5	90.5	90.5	90.5	90.5	90.5	90.5	90.5	90.5	90.5	90.5
Inverter efficiency (%)	96.0	96.4	96.8	97.2	97.6	98.0	98.0	98.0	98.0	98.0	98.0
Inverter loading ratio	1.10	1.12	1.13	1.15	1.17	1.18	1.20	1.30	1.30	1.34	1.34
Fixed-Tilt											
Installed cost ($/W)	4.75	4.08	2.77	2.13	1.97	1.93	1.53	1.08	1.08	0.95	0.94
Annual degradation (%)	1.00	0.95	0.90	0.85	0.80	0.75	0.75	0.75	0.70	0.70	0.70
O&M expenses ($/kW-yr)	29	27	25	23	21	19	19	18	13	16	16
Preinverter derate (%)	90.5	90.5	90.5	90.5	90.5	90.5	90.5	90.5	90.5	90.5	90.5
Inverter efficiency (%)	96.0	96.4	96.8	97.2	97.6	98.0	98.0	98.0	98.0	98.0	98.0
Inverter loading ratio	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.30	1.36	1.37	1.37
Financing Assumptions											
Inflation rate (%)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Market Case											
Equity discount rate (real) (%)	7.4	7.2	7.0	6.9	6.7	6.5	6.3	6.3	6.3	5.1	5.1
Debt interest rate (%)	5.5	5.3	5.2	5.0	4.8	4.7	4.5	4.5	4.5	4.0	4.0
Debt fraction (%)	34.2	35.2	36.1	37.1	38.1	39.0	40.0	40.0	40.0	51.9	51.9
Steady-State Financing											
Equity discount rate (real) (%)	—	—	—	—	—	—	—	—	—	—	5.1
Debt interest rate (%)	—	—	—	—	—	—	—	—	—	—	5.0
Debt fraction (%)	—	—	—	—	—	—	—	—	—	—	71.8

All 2010–2018 data are from Fu, Feldman, and Margolis (2018), and they are adjusted for inflation. Utility-scale PV system LCOEs assume:

(1) System lifetime of 30 years

(2) Federal tax rate of 21%

(3) State tax rate of 6%

(4) MACRS depreciation schedule

(5) No state or local subsidies

(6) A working capital and debt service reserve account for six months of operating costs and debt payments (earning interest of 1.75%)

(7) Six-month construction loan with an interest rate of 4% and a fee of 1% of the cost of the system

(8) System size of 100 MW

(9) Debt with a term of 18 years

(10) $1.1 million of upfront financial transaction costs

(11) 2019 and 2020 financial assumptions from Feldman, Bolinger, and Schwabe (2020).

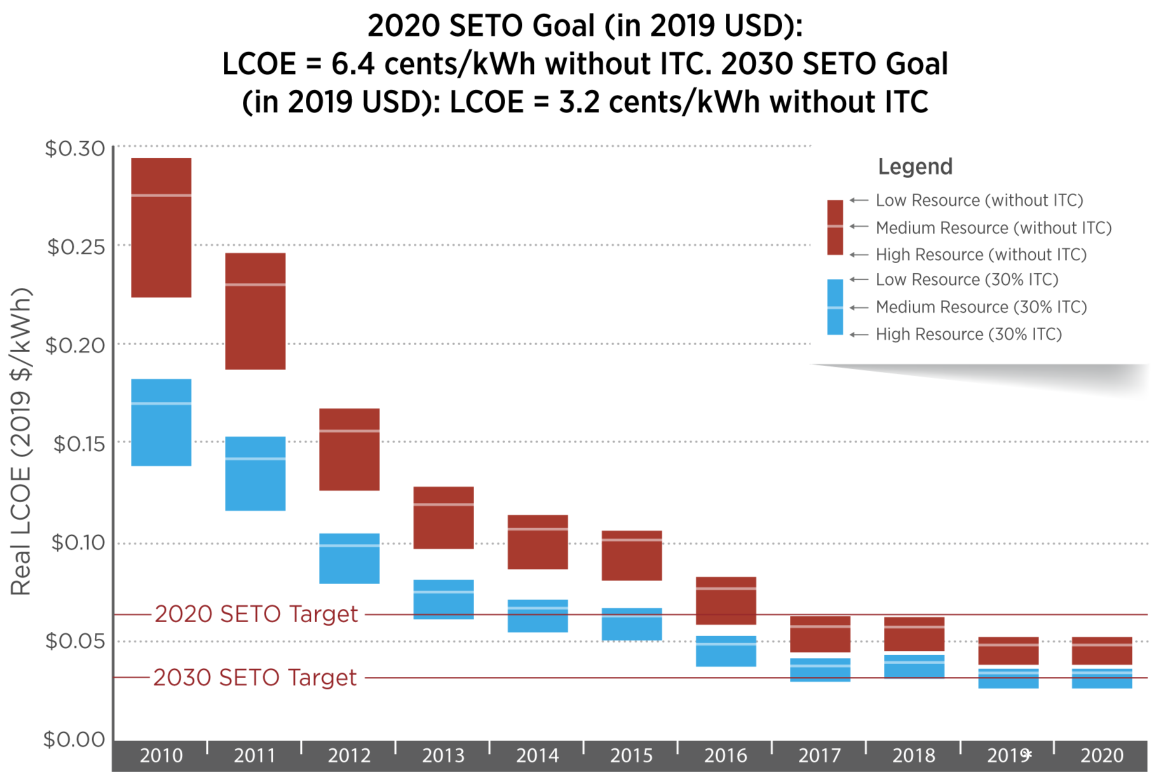

Figure 34. LCOE for utility-scale PV systems, by region, with and without ITC, 2010–2020 (fixed-tilt from 2010 to 2015, one-axis tracking from 2016 to 2020)

We updated our methods and model this year; 2019 and 2020 LCOEs are higher than they would have been using previous models. Appendix A provides a detailed discussion of the changes made to the models between the previous version (Fu, Feldman, and Margolis 2018) and this year's version. LCOE is calculated for each scenario under a range of CFs, but all other values remain the same.

6 Residential Storage and PV-plus-Storage Model

To analyze component costs and system prices for PV-plus-storage installed in Q1 2020, we adapt NREL's component- and system-level modeling approach for standalone PV. For this report, system configuration refers to four characteristics that determine a PV-plus-storage system's functionality:

- PV system capacity (kW)
- Battery energy capacity (kWh)
- Battery power capacity (kW)
- Whether the battery is DC- or AC-coupled.[25]

Customer preference for specific characteristics is based on several factors, including cost, load profile, and planned use of the system for load shifting (storing energy in one period for use in a later period). In general, customers who have loads with high peaks of short duration may desire a high-power (high-kW) battery capable of meeting the high peak. Customers who have flatter loads with lower peaks of longer duration may prefer a high-energy (high-kWh) battery capable of longer-duration energy discharge.

A PV array, a battery, and a battery-based inverter are the fundamental components of every PV-plus-storage system. Additional component requirements are determined by whether the system is DC- or AC-coupled[26]: a DC-coupled system often requires a charge controller to step down the PV output voltage to a level that is safe for the battery, whereas an AC-coupled system requires a grid-tied inverter to feed PV output directly to the customer's load or the grid.[27] For a detailed discussion of the differences and considerations related to DC- versus AC-coupled system configurations, see Ardani et al. (2017).

Based on our industry interviews, increasing numbers of end users are willing to pay a premium for larger, more-resilient PV-plus-storage systems with enhanced back-up power capabilities, owing to the increased occurrence of superstorms and natural disasters. This decision may not always be driven by economics, given the higher costs of PV-plus-storage systems today; however, consumer-adoption motivations extend beyond economics to concerns about security, safety, and resiliency (EuPD Research and Greentech Media 2016).

When considering PV-plus-storage for enhanced back-up power, optimal system configurations and technology choices are determined by the system application. We model a larger, more-resilient PV-plus-storage system (7-kW PV plus 5-kW/20-kWh storage) designed for daily PV self-consumption and enhanced back-up capabilities. The average U.S. home uses about 30 kWh of electricity each day, with large variations based on location and season. Assuming an average household could cut its electricity use by two thirds in an emergency, it would need to meet

[25] NREL's modeled DC-coupled system includes a single dual-function inverter that is tied to both the PV array and the battery. In our AC-coupled system, to charge a battery, PV power is first converted (DC to AC) through a grid-tied inverter and then converted (AC to DC) through a battery-based inverter.
[26] Our discussion is simplified to explain the basic technical differences between AC- and DC-coupled systems. However, the decision to use AC- or DC-coupling might also be driven by non-technical factors such as policy, contractual obligations, and economics.
[27] Some Li-ion battery packs have built-in safety controls, such as those integrated in a battery management system, but some do not. For consistency, our model assumes there is a dedicated charge controller.

10 kWh of demand each day. At this rate, our more-resilient system could provide back-up electricity for an average of 35 hours without PV recharging. In contrast, our less-resilient battery system (3-kW/6-kWh storage) could only provide back-up electricity for an average of 10 hours without PV recharging.[28] If 30% of the PV system's average output were available to charge the battery each day, the more-resilient battery system could provide back-up electricity for about four days, compared with about one day for the less-resilient battery system.[29] The higher power of the more-resilient battery system (5 kW)—compared with the less-resilient battery system (3 kW)—would also enable the more-resilient battery system to meet higher peak electricity demands during a grid outage (e.g., to run a refrigerator).

Sections 6.1 and 6.2 present the residential storage and PV-plus-storage cost models, Section 6.3 shows the model outputs, Section 6.4 compares PV-plus-storage benchmark trends over time, and Section 6.5 benchmarks the levelized cost for a residential PV-plus-storage system.

6.1 Residential Li-Ion Standalone Storage Cost Model

The residential storage market is predominantly composed of fully integrated storage kits, which include Li-ion battery packs, inverters, field wiring, disconnect, and casing. Although this equipment is sold as one product, we model these components separately to compare costs across storage kit sizes and configurations. Table 9 presents the detailed modeling inputs and assumptions for the residential standalone storage costs.

Table 9. Residential Storage-Only Modeling Inputs and Assumptions

Category	Modeled Value	Description
System size	3-kW/6-kWh storage	Less-resilient system
	5-kW/20-kWh storage	More-resilient system
Battery pack cost	$253/kWh	Battery pack only
Battery-based inverter cost	$174/kWh	6-kW, 48-V bidirectional inverter (less resilient)
		8-kW, 48-V bidirectional inverter (more resilient)
Electrical BOS cost	• $1,830 (DC-coupled) • $1,520 (AC-coupled) Assumes higher electrical BOS costs for DC-coupled systems that are due to the need for a charge controller	Revenue-grade meter, communications device, AC main panel, DC disconnect, maximum power point tracking, charge controller, subpanel (breaker box) for critical load, conduit, wiring, DC cable

[28] These calculations assume 80% depth of discharge for the batteries and 90% inverter efficiency. Even in these simplified scenarios, the actual amount of time that the system could provide back-up electricity would depend on the battery's charge level and the time of day at the time of the outage as well as the home's load profile.
[29] This is based on 2016 results using NREL's PVWatts for a 5.6-kW PV system located in Denver (5.6 kW was the calculated system size for a 22-module PV system in 2016, based on average module efficiency). This modeled system generates 8,179 kWh per year (average, 22.4 kWh per day). Thus, we assume this same 5.6-kW PV array will generate an average of 6.7 kWh per day when only 30% of the total PV resource is available owing to severe weather conditions. Since 2016, our residential PV benchmark has increased in capacity, but battery storage capacity has remained flat. The storage capacities benchmarked here conform with what we observed in the marketplace.

Category	Modeled Value	Description
Supply-chain costs	5% of cost of equipment	Includes costs of inventory, shipping, and handling of equipment
Sales tax	5.1% (national average)	Sales tax on the equipment
Installation labor cost	Electrician: $27.47 per hour Laborer: $18.17 per hour AC systems require more hours of work to integrate with an existing inverter and monitoring system	Assumes national average pricing
Engineering fee	$99	Engineering design and professional engineer-stamped calculations and drawings
PII	$297 permit fee $594–$951 in labor	20–32 hours (DC-coupled/AC-coupled) of commissioning and interconnection labor, and permit fee
Sales and marketing (customer acquisition)	$0.61/$W_{DC}$	20 hours more time for DC system, and 32 hours more for AC system, per closed sale, associated with selling a storage systems versus selling a PV system
Overhead (general and administrative)	$0.28/$W_{DC}$	Rent, building, equipment, staff expenses not directly tied to PII, customer acquisition, or direct installation labor
Profit (%)	17%	Fixed percentage margin applied to all direct costs including hardware, installation labor, direct sales and marketing, design, installation, and permitting fees

As demonstrated in Figure 35, the kit for a 3-kW/6-kWh storage system costs approximately $4,200–$4,600, with a total installed cost of $11,823 (DC-coupled) to $12,287 (AC-coupled). The kit for a 5-kW/20-kWh storage system costs approximately $10,400–$10,800, with a total installed cost of $21,471 (DC-coupled) to $22,041 (AC-coupled).[30]

[30] We assume all batteries are installed inside the home. Installation of batteries outside would require additional BOS hardware, such as a concrete pad and associated container. Such additional BOS hardware would add to the benchmarked price of our modeled systems.

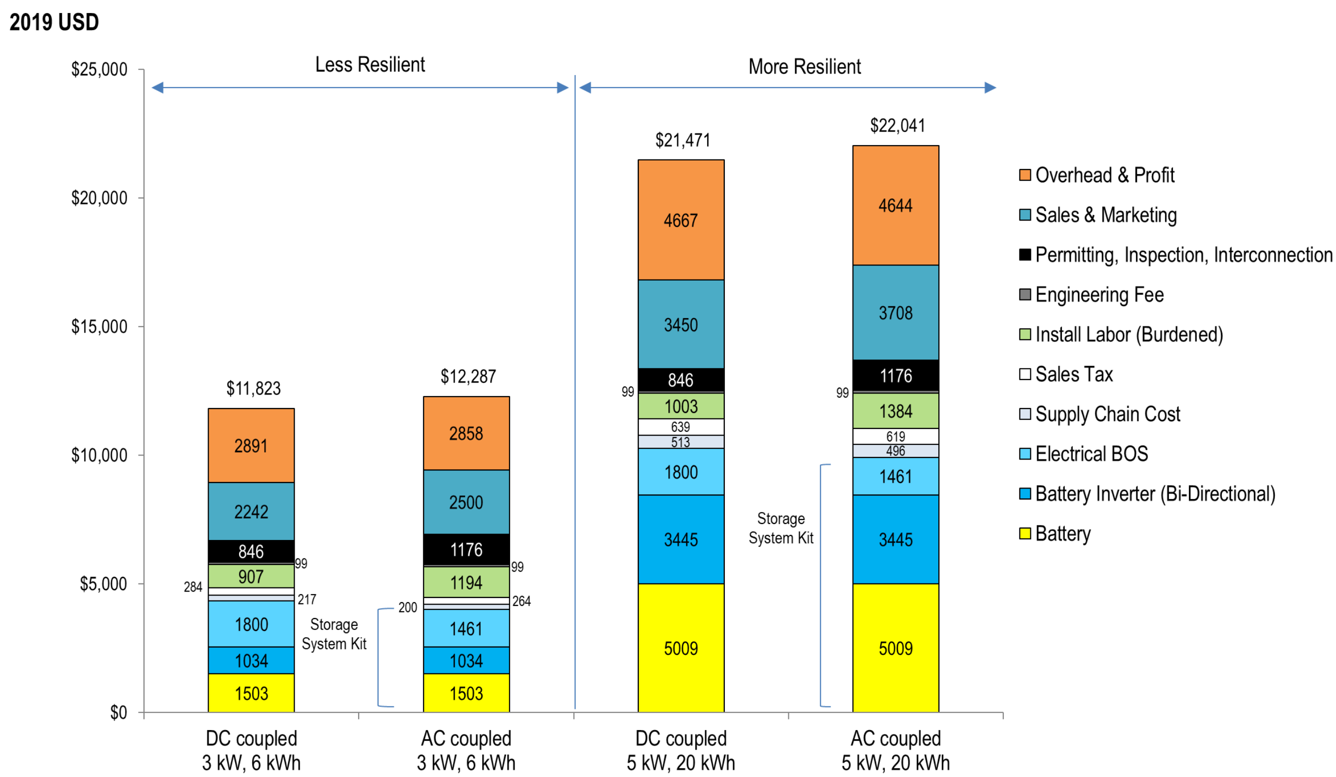

Figure 35. Installed cost of residential storage only

6.2 Residential PV-plus-Storage System Cost Model

We model a 7-kW PV system coupled with a 3-kW/6-kWh or 5-kW/20-kWh storage system, using the same PV assumptions we used with our standalone PV system. Figure 36 provides a schematic of typical DC- and AC-coupled PV systems with battery back-up. Table 3, Table 9, and Table 10 present modeling inputs and assumptions.

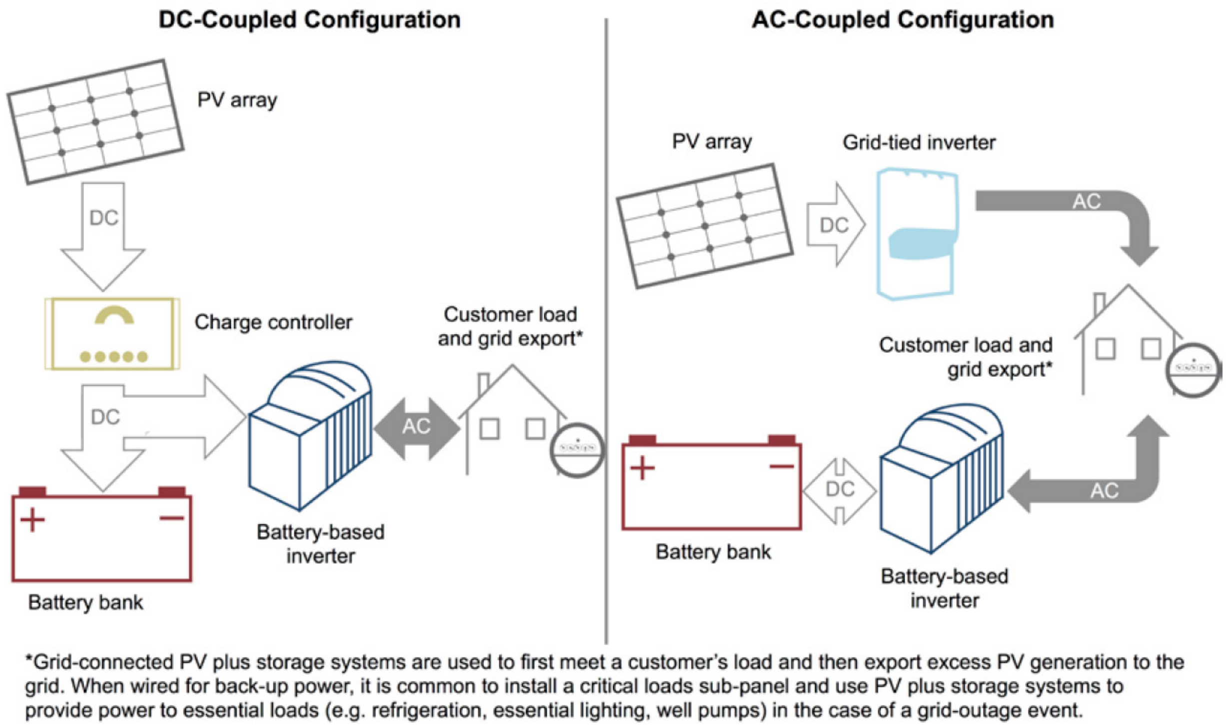

Figure 36. Modeled DC- and AC-coupled system configurations

Figure is simplified for illustrative purposes.

Table 10. Changes to Residential PV and Storage Models When PV and Storage Are Combined

Category	Modeled Value	Description
Electrical BOS	90% of the combined BOS costs for PV and battery standalone systems	Duplicative parts are removed.
Installation labor	90% of the combined BOS costs for PV and battery standalone systems	Duplicative work is removed.
Sales and marketing	20 hours more time for DC system, and 32 hours more for AC system, per closed sale, associated with selling a PV system with storage	Additional explanation, calculations, and a lower close rate, and the AC system requires more customer site assessment.

6.3 Residential Model Output

Figure 37 compares cost and price components for a standalone PV system as well as PV-plus-storage systems with less-resilient (3-kW/6-kWh) and more-resilient (5-kW/20-kWh) battery systems. With DC-coupling, the price of the more-resilient system is $35,591, which is $9,438 (36%) more than the price of the DC-coupled less-resilient system. With AC-coupling, the price of the more-resilient battery system is $37,909, which is $9,538 (34%) more than the price of the DC-coupled less-resilient battery system. The premium is due to the more-resilient systems' higher battery, inverter, BOS, and labor costs plus indirect costs (profit, sales tax, and supply-chain costs).

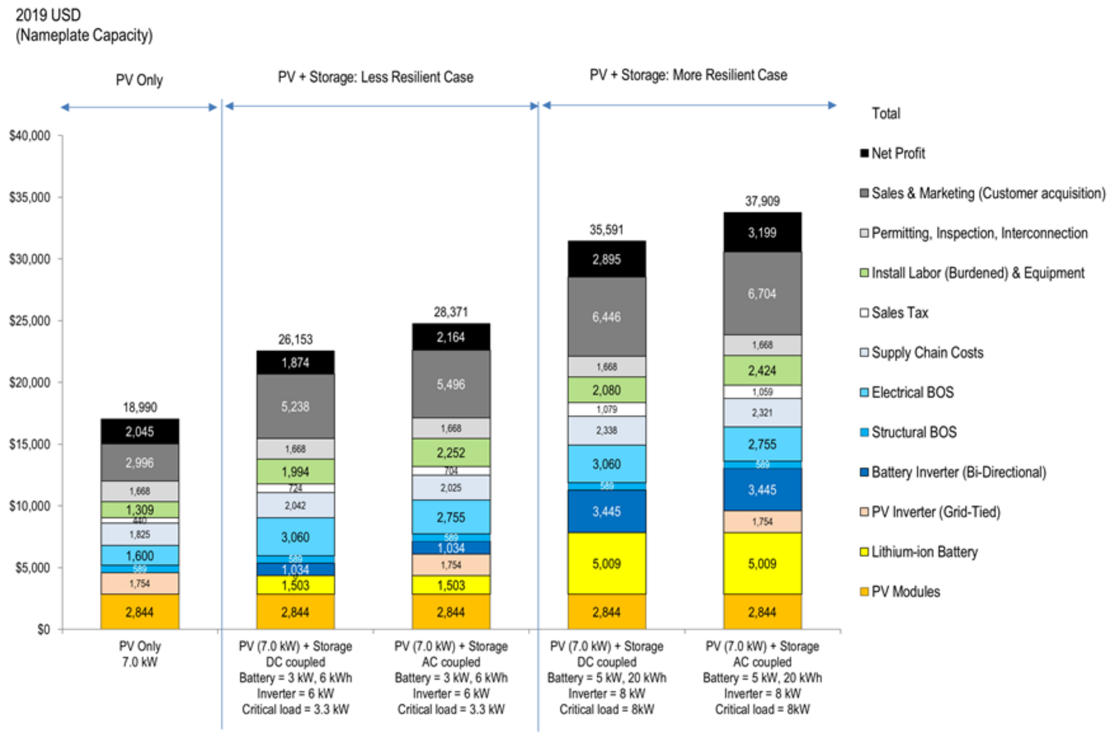

Figure 37. Modeled total installed cost and price components for residential PV-plus-storage systems, less-resilient versus more-resilient battery case (2019 USD)

6.4 Residential PV-plus-Storage Price Benchmark Historical Trends

Figure 38 shows the 11% and 25% reductions in residential PV-plus-storage benchmarks between 2016 (Ardani et al. 2017) and 2020, for the AC-coupled less-resilient and more-resilient cases, respectively.[31] The reduction is due to a 26% reduction in PV module costs, 38% and 44% reduction in costs associated with the storage system kit (including a bidirectional inverter), a 16% reduction in hardware BOS, and a 34% and 65% reduction in labor costs. These cost reductions are partially offset by 18% and 10% increases in other soft costs (including PII, sales tax, overhead, and net profit). Other soft costs increased between 2016 and 2020 because of a change in methodology and because the rated capacity of the 22-module system increased from 5.6 kW to 7.0 kW between 2016 and 2020. From 2019 to 2020, the residential PV-plus-storage system cost benchmarks decreased by 5%, mostly owing to lower storage system kit prices.

[31] Each year's PV system cost benchmark corresponds to the NREL benchmark calculated in Q1 of the current year (e.g., 2016 = Q1 2016). Figure 38 only shows AC-coupled system costs to more easily demonstrate the historical trends; the cost of DC-coupled systems follows the same historical trends.

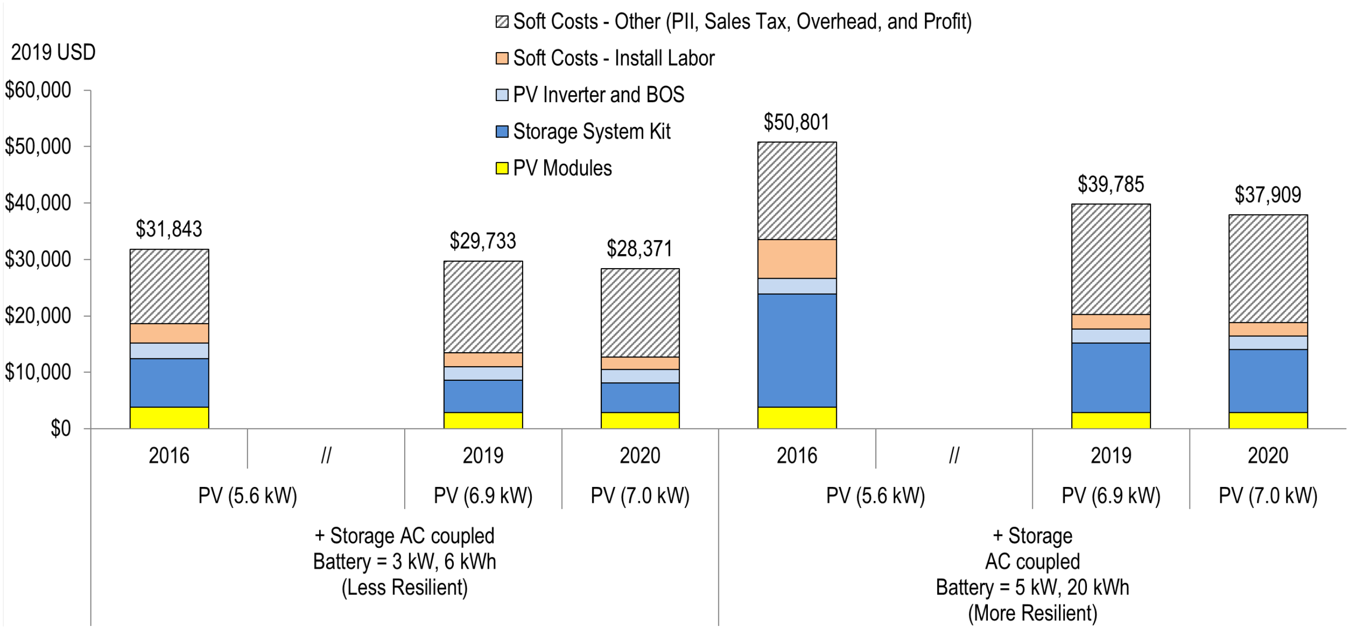

Figure 38. Residential PV-plus-storage system cost benchmark summary, 2016, 2019, and 2020

The 2016 benchmarks differ from those originally published, because values are adjusted for inflation.

6.5 Residential Levelized Cost of Solar-plus-Storage

For this year's benchmark report, we derive a formula for the levelized cost of solar-plus-storage (LCOSS) to contextualize our upfront PV-plus-storage system benchmarks and better represent the total cost of operating a PV-plus-storage system, on a per-kWh basis. BNEF (2019c) and Lazard (2018) performed similar LCOSS calculations. None of these LCOSS calculations, including the one in this report, attempts to value the electricity generated by these systems or the different ways they may operate. Storage value calculations for residential applications require integrating storage dispatch into building load, retail rates, and requirements. In addition, residential storage systems perform various functions—such as shifting load, reducing peak demand, and providing emergency power—depending on location, regulations, and customer preferences; our analysis represents the load-shifting use case. For a detailed discussion of residential storage value, see Fitzgerald et al. (2015), DiOrio et al. (2015), and Darghouth et al. (2019). Similar to LCOE, LCOSS does not focus on value but rather can help track improvements to all costs associated with residential PV-plus-storage systems over time (as opposed to just upfront costs), and the metric can provide limited comparisons with other dispatchable electricity generation technologies (e.g., PV-plus-generator systems). Table 11 lists our model inputs and assumptions for calculating residential LCOSS.

Table 11. Residential LCOSS Inputs and Assumptions

Model Component	Model Input	Description
System size	7-kW PV plus 3-kW/6-kWh storage system	
Initial investment	$28,371	2020 residential PV-plus-storage benchmark, AC-coupled
First follow-on investments (inverter, battery replacements)	$240 in year 10	20% of the batteries are replaced after 10 years due to battery capacity dropping 20%. We assume costs for battery and bidirectional inverters drop 20% in the next 10 years.
Second follow-on investments (inverter, battery replacements)	$180 in year 20	20% of the batteries are replaced after 20 years due to battery capacity dropping 20%. We assume costs for battery and bidirectional inverters drop 40% in the next 20 years.
Real discount rate	3.1%	Consistent with LCOE formula
Tax rate	25.7%	21% federal, 6% state
Residual value	$0	
Initial annual PV system production	High resource: 1,892 MWh/MW Medium resource: 1,546 MWh/MW Low resource: 1,440 MWh/MW	
Percentage of generated solar electricity fed to battery	High resource: 25% Medium resource: 31% Low resource: 33%	Assumes a 75% discharge per day for a 2-hour, 3-kW battery
Roundtrip energy losses from PV/battery/grid	10%	
Roundtrip energy losses from grid/battery/grid	8%	
Charging cost	$0	Battery charged solely by PV due to ITC considerations
O&M ($/kW/yr)	$39	Assumes storage O&M adds $10/kW-yr to PV costs
Annual PV degradation	0.70%	
Annual electricity purchased from grid	0	
System lifetime	30 years	
Inflation	2.5%	

We use these inputs to calculate LCOSS as follows:

Equation 1. LCOSS formula

$$LCOSS = \frac{E + \frac{F^n}{(1+R)^n} - \sum_{n-1}^{N} \frac{(D+DF)^n}{(1+Rn)^n} \times (T) + \sum_{n-1}^{N} \frac{(O+C+I)^n}{(1+Rn)^n} \times (1-T) - \frac{Rv^n}{(1+R)^n} \times (1-T) + \sum_{n-1}^{N} \frac{(P)^n}{(1+Rn)^n} \times (1-T)}{\left(\sum_{n-1}^{N} \frac{P \times (1-Dr)^n}{(1+R)^n} \times (1-B) + \sum_{n-1}^{N} \frac{P \times (1-Dr)^n}{(1+R)^n} \times (B) \times (1-Lp) + \sum_{n-1}^{N} \frac{G}{(1+R)^n} \times (1-Lg) \right) \times (1-\mathrm{T})}$$

E = Initial equity investment of solar and storage
I = Debt interest payments
P = Debt principal payments
C = Charging cost
F = Follow-on investments (inverter, battery replacements)
D = Depreciation of solar and storage (which may include depreciation from follow-on investments)
R = Real discount rate
Rn = Nominal discount rate
T = Tax rate
O = O&M
Dr = Degradation of PV
Rv = Residual value
P = Initial annual system production
B = Percentage of generated solar electricity fed to battery
Lp = Roundtrip energy losses from PV-storage-grid
Lg = Roundtrip energy losses from grid-storage-grid
G = Annual electricity purchased from grid.[32]

[32] If the ITC is claimed, we assume the initial investment is reduced by 30% and depreciation is reduced by 15%. We assume projects can qualify as starting construction before 2020, allowing them to claim a 30% ITC, instead of the 26% ITC for projects starting construction in 2020.

Figure 39 shows the LCOSS for a residential AC-coupled PV (7 kW) plus storage (3 kW/6 kWh, 2-hour duration) system, as well as the LCOE of a 7-kW standalone PV system. LCOSS is calculated to be $201/MWh without the federal ITC and $124/MWh with the 30% ITC for the PV-plus-storage system, with a medium resource for PV electricity production.[33] The PV-plus-storage LCOSS is $74/MWh higher than the standalone-PV LCOE without the ITC, and $47/MWh higher with a 30% ITC.

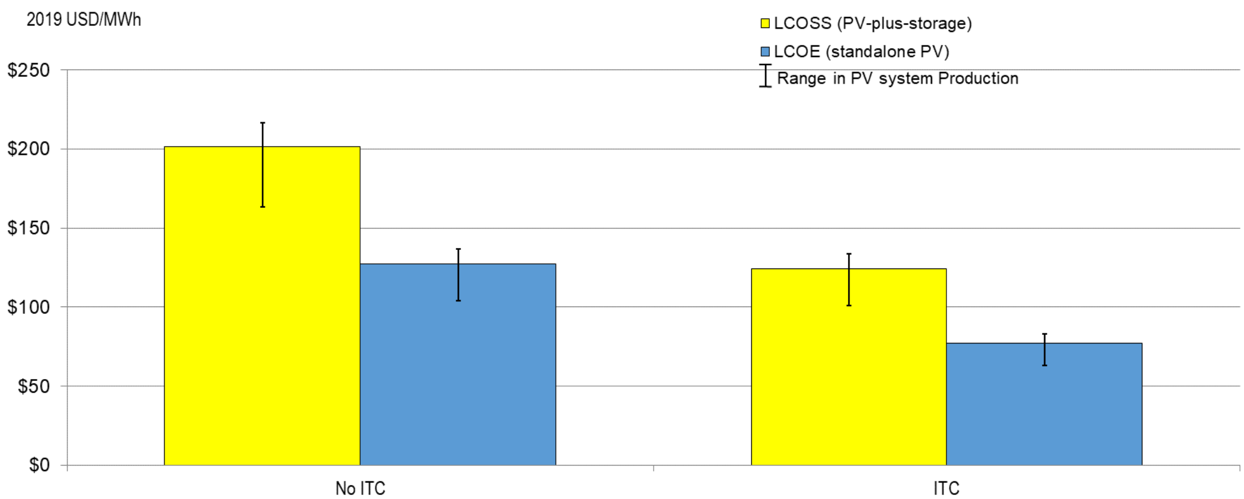

Figure 39. U.S. residential LCOSS for an AC-coupled PV (7 kW) plus storage (3 kW/6 kWh, 2-hour duration) system and LCOE for a 7-kW standalone PV system, Q1 2020

LCOSS is calculated for each scenario with a medium CF (representing Kansas City); LCOSS and LCOE ranges based on high and low CF assumptions; all other values remain the same.

[33] We do not change the inputs and assumptions between the ITC and non-ITC cases, despite the fact that the inputs in the LCOSS calculation assume the owner of the PV-plus-storage system is operating the plant in such a way that they can claim the ITC on the storage equipment. In reality, an owner would likely operate a PV-plus-storage system differently without the ITC.

7 Commercial Storage and PV-plus-Storage Model

To analyze component costs and system prices for commercial PV-plus-storage installed in Q1 2020, we adapt NREL's component- and system-level modeling approach for standalone PV in the same manner as we did for the residential PV-plus-storage system. This is the first year in which we analyzed commercial PV-plus-storage, and therefore we have no historical analysis from which to compare.

Customer preference for specific characteristics is based on several factors, including cost, load profile, and planned use of the system for load shifting (storing energy in one period for use in a later period). In general, customers who have loads with high peaks of short duration may desire a high-power (high-kW) battery capable of meeting the high peak. Customers who have flatter loads with lower peaks of longer duration may prefer a high-energy (high-kWh) battery capable of longer-duration energy discharge.

Sections 7.1 and 7.2 present the commercial storage and PV-plus-storage cost models, Section 7.3 shows the model outputs, and Section 7.4 benchmarks the LCOSS for a commercial PV-plus-storage system

7.1 Commercial Li-Ion Standalone Storage Cost Model

To reduce installation costs, some battery manufacturers may combine Li-ion battery cells, a battery management system, and the battery inverter in one compact unit (Sonnen Batterie 2018) as an AC battery. However, in this report, we focus on traditional DC batteries typically configured with the components shown in Figure 40 and Figure 41.

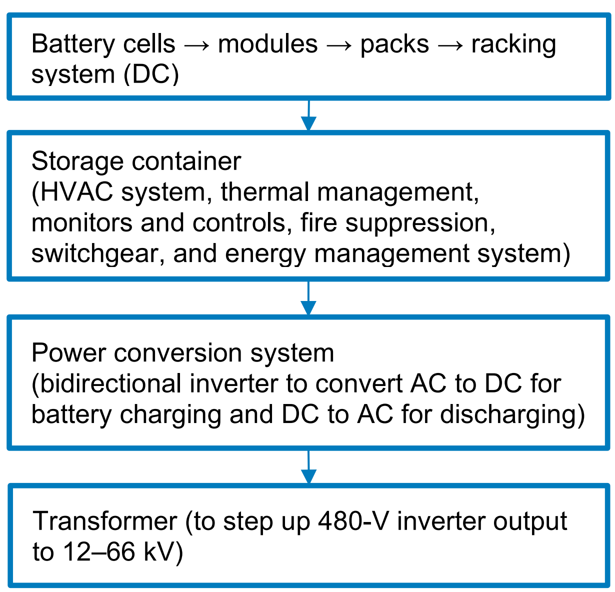

Figure 40. Traditional commercial and utility-scale Li-ion battery energy storage components

HVAC = heating, ventilating, and air conditioning

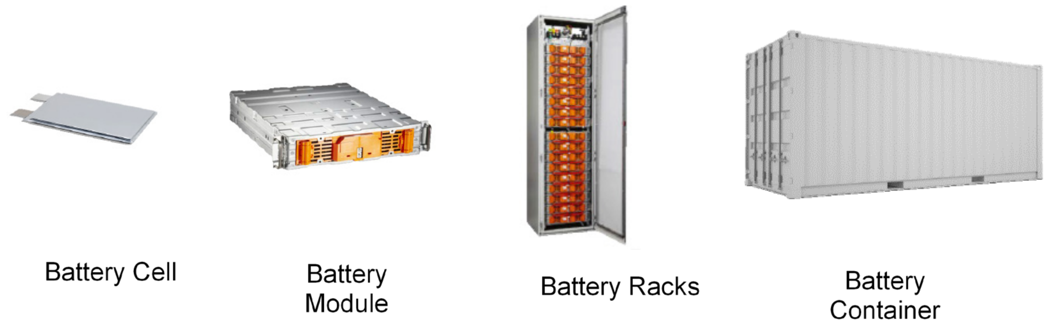

Figure 41. Battery system components

Source: 2018 North American Generator Forum/Energy Systems Integration Group Workshop

Table 12 lists our model inputs and assumptions for a commercial energy storage system. We determine the battery size (600 kW_{DC})[34] using an inverter loading ratio of 1.3 and a PV/storage size ratio of 1.67, based on Denholm, Eichman, and Margolis (2017).

Table 12. Commercial Li-ion Energy Storage System: Model Inputs and Assumptions

Model Component	Modeled Value	Description	Sources
Battery total size	600 kW_{DC}	Baseline case to match a 1-MW PV system	NREL 2020
Battery size per container	2.4 MWh per 40-ft container	1 container	NREL 2020
Li-ion battery price	0.5 hours: \$242/kWh 1 hour: \$223/kWh 2 hours: \$198/kWh 4 hours: \$194/kWh	Ex-factory gate (first buyer) prices	BNEF 2019b
Duration	0.5–4.0 hours	Duration determines energy (MWh)	NREL 2020
Battery central inverter price	\$0.06/W	Ex-factory gate (first buyer) prices	Wood Mackenzie 2019
Electrical BOS	\$0.19/W	Includes conduit, wiring, DC cable, energy management system, switchgear, transformer, and monitor and controls for each container. Costs impacted by the number of containers, transformers, and row spacing	NREL 2020
Structural BOS	\$0.10/W	Includes foundation, battery containers, and inverter house. Costs impactedby the number of containers, inverters, transformers, and the spacing between containers	NREL 2020

[34] For a 1 MW PV system with an inverter loading ratio of 1.3 and PV/storage size ratio of 1.67, maximum deliverable power at point of interconnection is 1.37 MW_{AC} (1-MW/1.3 + 1 MW/1.67) for AC coupled systems and 770 kW_{AC} (1 MW/1.3) for DC coupled systems.

Model Component	Modeled Value	Description	Sources
Installation labor	Electrician: $27.47 per hour Laborer: $18.17 per hour	National average modeled labor rate assumes nonunionized labor	BLS 2019
Sales tax	5% (national average)	Sales tax on the equipment	RSMeans 2017
EPC overhead and profit	8.67% for equipment and material; 23%–69% for labor costs; varies by system size, labor activity, and location	Costs associated with EPC SG&A, warehousing, shipping, and logistics	NREL 2020
Developer cost: developer overhead	6% of total installation cost	Includes overhead expenses such as payroll, facilities, travel, legal fees, administrative, business development, finance, and other corporate functions	NREL 2020
Developer cost: PII	$0.06/W	Construction permits fee, interconnection study, interconnection inspection, and interconnection fee	NREL 2020
Developer cost: contingency	4%	Estimated as markup on the total EPC cost	NREL 2020
Developer cost: EPC/developer net profit	5%	Applies a percentage margin to all costs including hardware, installation labor, EPC overhead, and developer overhead	NREL 2020

We use these inputs to calculate energy storage cost via the following equation[35]:

$$Energy\ storage\ installation\ cost\ \left(\frac{\$}{kWh}\right) =$$

$$Battery\ cost\ \left(\frac{\$}{kWh}\right) + \frac{Other\ cost\ components\ (\$)\ such\ as\ battery\ inverter\ and\ labor}{Storage\ system\ size\ (kW) \times Duration\ (hours)}$$

Figure 42 and Table 13 show the resulting $/kWh costs for 600-kW Li-ion energy storage systems, which vary from $469/kWh (4-hour duration) to $2,167/kWh (0.5-hour duration). The battery cost accounts for 41% of total system cost in the 4-hour system, but only 11% in the 0.5-hour system. At the same time, non-battery cost categories account for an increasing proportion of the system cost as duration declines.

[35] This equation is only for the energy storage installation cost calculation. For levelized cost of storage (LCOS), the equation would be different. LCOS is not covered in this report.

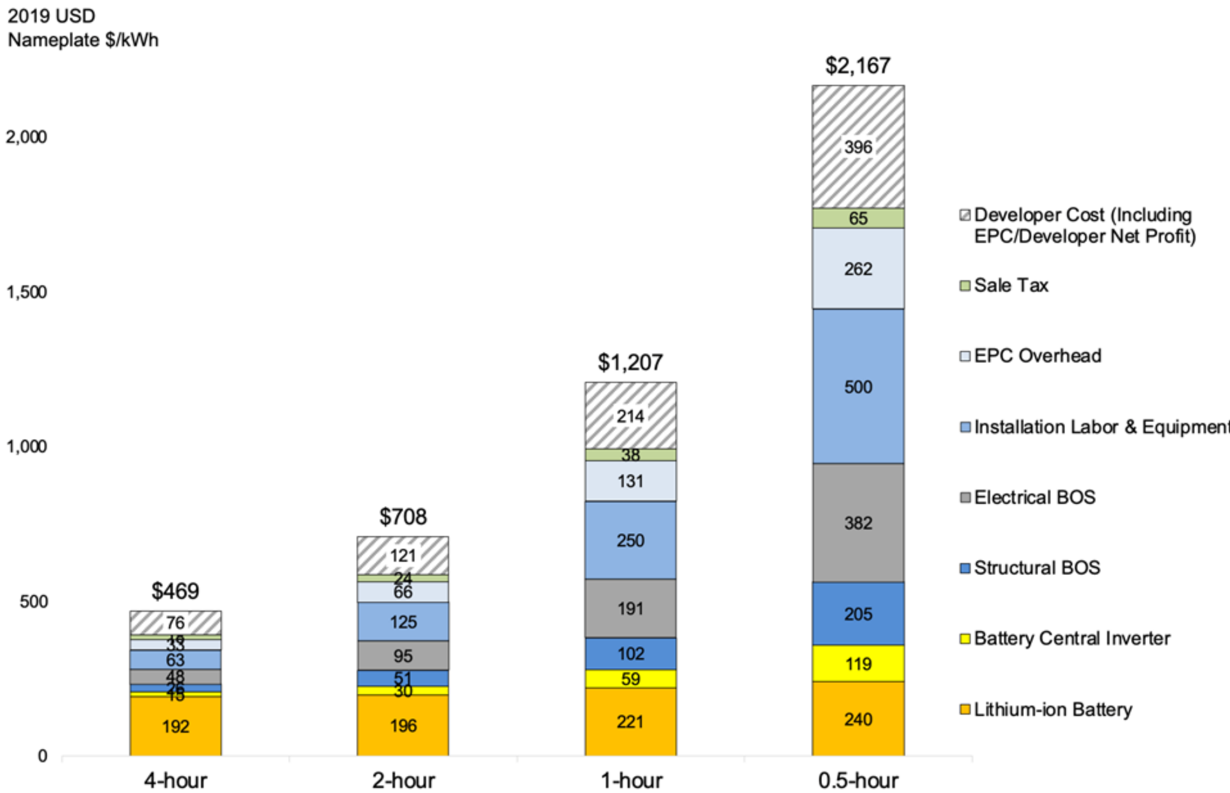

Figure 42. U.S. commercial Li-ion battery standalone storage costs for durations of 0.5–4.0 hours ($600\ kW_{DC}$), Q1 2020

Table 13. Detailed Cost Breakdown for a 600-kW U.S. Commercial Li-ion Standalone Storage System with Durations of 0.5–4 hours

	600-kW, 4-hour Duration, 2,400-kWh			600-kW, 2-hour Duration, 1,200-kWh			600-kW, 1-hour Duration, 600-kWh			600-kW, 0.5-hour Duration, 300-kWh		
Model Component	**Total Cost ($)**	**$/kWh**	**$/W**	**Total Cost ($)**	**$/kWh**	**$/W**	**Total Cost ($)**	**$/kWh**	**$/W**	**Total Cost ($)**	**$/kWh**	**$/W**
Li-ion battery	465,600	192	0.78	237,600	196	0.40	133,800	221	0.22	72,600	240	0.12
Battery central inverter	36,000	15	0.06	36,000	30	0.06	36,000	59	0.06	36,000	119	0.06
Structural BOS	62,012	26	0.10	62,012	51	0.10	62,012	102	0.10	62,012	205	0.10
Electrical BOS	115,618	48	0.19	115,618	95	0.19	115,618	191	0.19	115,618	382	0.19
Installation labor & equipment	151,596	63	0.25	151,596	125	0.25	151,596	250	0.25	151,596	500	0.25
EPC overhead	79,475	33	0.13	79,475	66	0.13	79,475	131	0.13	79,475	262	0.13
Sales tax	42,432	18	0.07	29,208	24	0.05	23,188	38	0.04	19,638	65	0.03
∑ EPC cost	**952,734**	**393**	**1.59**	**711,510**	**587**	**1.19**	**601,689**	**993**	**1.00**	**536,940**	**1,772**	**0.89**
Permitting fee	7,507	3	0.01	7,507	6	0.01	7,507	12	0.01	7,507	25	0.01
Interconnection fee	27,846	11	0.05	27,846	23	0.05	27,846	46	0.05	27,846	92	0.05
Contingency	38,455	16	0.06	28,806	24	0.05	24,414	40	0.04	21,824	72	0.04
Developer overhead	57,683	24	0.10	43,209	36	0.07	36,620	60	0.06	32,735	108	0.05
EPC/developer profit	52,836	22	0.09	39,569	33	0.07	33,529	55	0.06	29,967	99	0.05
∑ Developer cost	**184,327**	**76**	**0.31**	**146,937**	**121**	**0.24**	**129,915**	**214**	**0.22**	**119,879**	**396**	**0.20**
∑ Total energy storage system cost	**1,137,060**	**469**	**1.90**	**858,447**	**708**	**1.43**	**731,604**	**1,207**	**1.22**	**656,818**	**2,167**	**1.09**

7.2 Commercial PV-plus-Storage System Cost Model

We model a 1-MW commercial fixed-tilt ground-mount PV plus 600-kW storage system, with 0.5 hours (300 kWh), 1 hour (600 kWh), 2 hours (1.2 MWh), and 4 hours (2.4 MWh) of storage, using the same PV assumptions we used with our standalone PV system. Figure 43 provides a schematic of typical DC- and AC-coupled PV systems with battery back-up. Table 5, Table 12, and Table 14 present modeling inputs and assumptions.

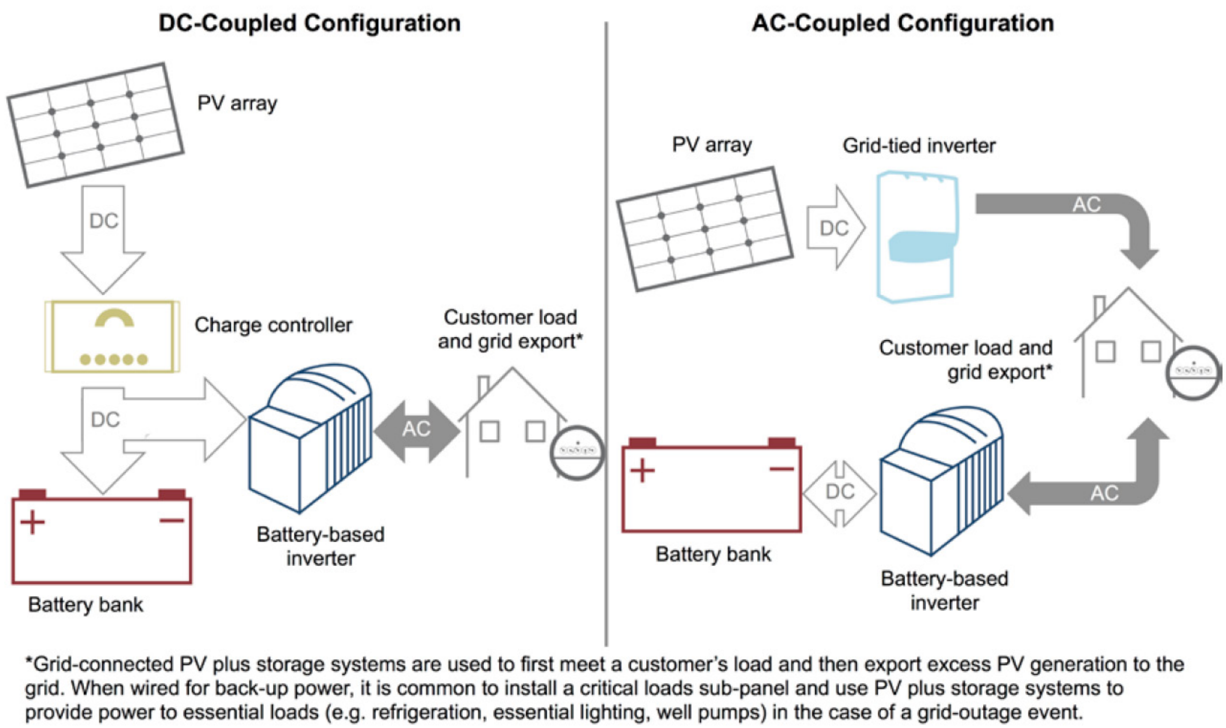

Figure 43. Modeled DC- and AC-coupled system configurations

Figure is simplified for illustrative purposes.

Table 14. Changes to Commercial PV and Storage Models When PV and Storage Are Combined

Category	Modeled Value	Description
Electrical BOS	90% of the combined BOS costs for PV and battery standalone systems	Duplicative parts are removed
Installation labor	90% of the combined BOS costs for PV and battery standalone systems	Duplicative work is removed
Sales and marketing	20 hours more time for DC system, and 32 hours more for AC system, per closed sale, associated with selling a PV system with storage	Additional explanation, calculations, and a lower close rate; also, the AC system requires more customer site assessment

7.3 Commercial Model Output

Figure 44 summarizes our model results for several system types and configurations:

- Standalone 1-MW commercial fixed-tilt ground-mount PV system ($1.59 million)

- Standalone 600-kW/2.4-MWh, 4-hour-duration energy storage system ($1.13 million)
- Colocated DC-coupled PV (1-MW) plus storage (600 kW/2.4 MWh, 4-hour duration) system ($2.13 million)
- Colocated AC-coupled PV (1-MW) plus storage (600 kW/2.4 MWh, 4-hour duration) system ($2.07 million)
- PV (1-MW) plus storage (600 kW/2.4 MWh, 4-hour duration) system with PV and storage components sited in different locations ($2.72 million).

Table 15 shows detailed costs for the three PV-plus-storage configurations. Colocating the PV and storage subsystems produces cost savings by reducing costs related to site preparation, permitting, interconnection, installation labor, hardware (via sharing of hardware such as switchgears, transformers, and controls), overhead, and profit. The cost of the colocated AC-coupled system is 24% lower than the cost of the system with PV and storage sited separately.

Using DC-coupling rather than AC-coupling results in a 2.8% higher total cost, which is the net result of cost differences between DC-coupling and AC-coupling in the categories of solar inverter, structural BOS, electrical BOS, labor, EPC and developer overhead, sales tax, contingency, and profit. For an actual project, however, cost savings may not be the only factor in choosing DC- or AC-coupling. Additional factors—such as retrofit considerations, system performance (including energy loss due to clipping), design flexibility, and O&M—should be considered.

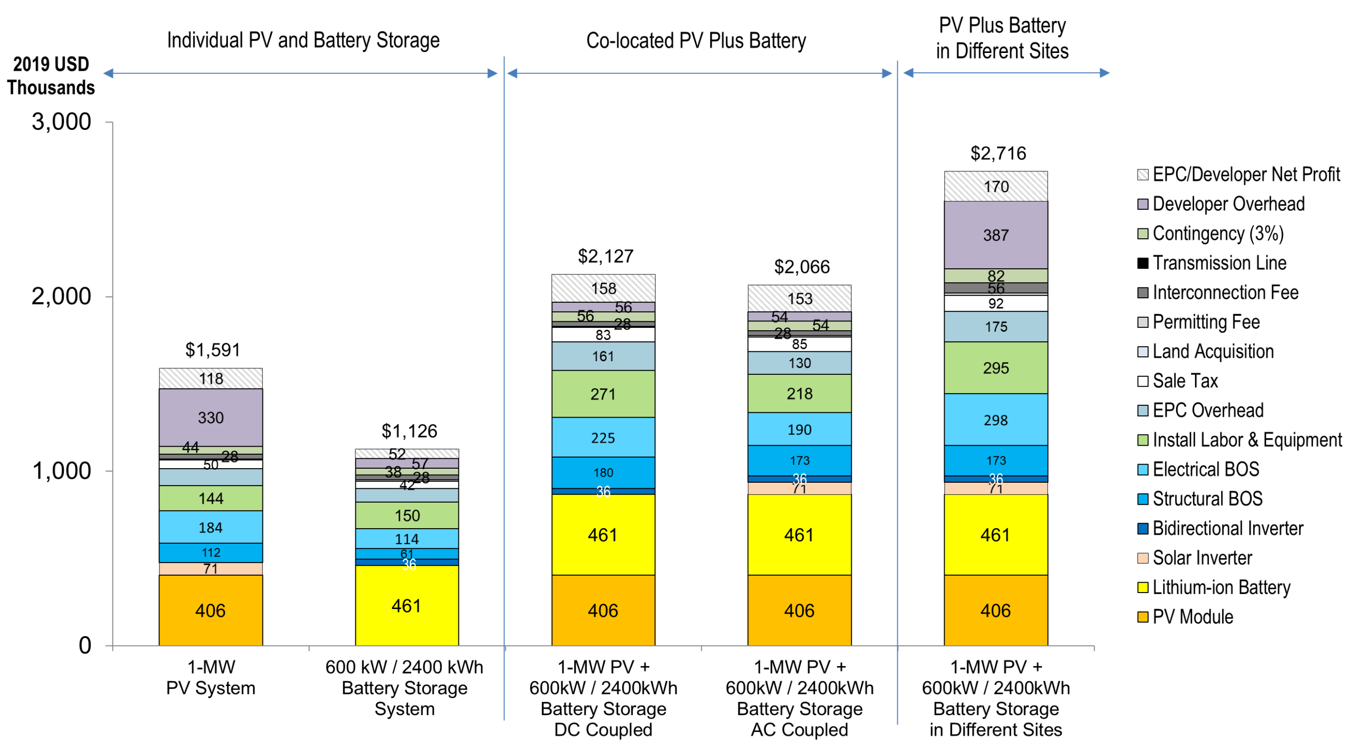

Figure 44. Cost benchmarks for commercial PV-plus-storage systems (4-hour duration) in different sites and the same site (DC-coupled and AC-coupled cases), Q1 2020

Table 15. Detailed Cost Breakdown for Commercial Li-ion PV-Plus-Storage Systems

Model Component	Total Cost 1-MW PV Plus 600-kW/2.4-MWh Battery, DC-Coupled, Colocated	1-MW PV Plus 600-kW/2.4-MWh Battery, AC-Coupled, Colocated	1-MW PV Plus 600-kW/2.4-MWh Battery, in Different Sites
PV module	$405,877	$405,877	$405,877
Li-ion battery	$460,917	$460,917	$460,917
Solar inverter	—	$71,347	$71,347
Bidirectional inverter	$35,638	$35,638	$35,638
Structural BOS	$179,759	$173,284	$173,285
Electrical BOS	$225,088	$190,036	$298,378
Installation labor & equipment	$271,097	$217,553	$294,560
EPC overhead	$161,386	$129,511	$175,354
Sales tax	$82,924	$84,816	$91,688
∑ **EPC cost**	$1,822,686	$1,768,978	$2,007,044
Land acquisition	0	0	0
Permitting fee	$7,507	$7,657	$15,014
Interconnection fee	$27,846	$28,403	$55,691
Transmission line	0	0	0
Contingency	$55,741	$54,151	$82,038
Developer overhead	$55,741	$54,151	$386,876
EPC/developer profit	$157,562	$153,067	$170,144
∑ **Developer cost**	$304,396	$297,429	$709,407
∑ **Total energy storage system cost**	$2,127,082	$2,066,408	$2,716,451

7.4 Commercial Levelized Cost of Solar-plus-Storage

For this year's benchmark report, we calculate the LCOSS for our commercial PV-plus-storage system, with the same formula and caveats as we use for our residential PV-plus-storage system (see Section 6.5). Table 16 lists our model inputs and assumptions for the commercial PV-plus-storage system.

Table 16. Commercial LCOSS Inputs and Assumptions

Model Component	Model Input	Description
System size	1-MW fixed-tilt ground-mount PV plus 600-kW/2.4-MWh storage system	
Initial investment	$2,066,408	2020 commercial PV-plus-storage benchmark, AC-coupled
First follow-on investments (inverter, battery replacements)	$73,747 in year 10	20% of the batteries are replaced after 10 years due to battery capacity dropping 20%. We assume costs for battery and bidirectional inverters drop 20% in the next 10 years.
Second follow-on investments (inverter, battery replacements)	$55,310 in year 20	20% of the batteries are replaced after 20 years due to battery capacity dropping 20%. We assume costs for battery and bidirectional inverters drop 40% in the next 20 years.
Real discount rate	3.1%	Consistent with LCOE formula
Tax rate	25.7%	21% federal, 6% state
Residual value	$0	
Initial annual system production	High resource area: 1,894 MWh/MW Medium resource area: 1,541 MWh/MW Low resource area: 1,438 MWh/MW	
Percentage of generated solar electricity fed to battery	High resource area: 35% Medium resource area: 43% Low resource area: 46%	Assumes a 75% discharge per day for a 4-hour, 600-kW battery
Roundtrip energy losses from PV/battery/grid	10%	
Roundtrip energy losses from grid/battery/grid	8%	
Charging cost	$0	Battery is charged solely by PV due to ITC considerations
O&M ($/kW/yr)	$29	Assumes storage O&M adds $10/kW-yr to PV costs
Annual PV degradation	0.70%	
Annual electricity purchased from grid	0	
System lifetime	30 years	
Inflation	2.5%	

We use these inputs to calculate LCOSS via Equation 1. Figure 45 shows the resulting LCOSS for a commercial AC-coupled fixed-tilt ground-mount PV (1 MW) plus storage (600 kW/2.4 MWh, 4-hour duration) system, as well as the LCOE of a 1-MW fixed-tilt ground-mount standalone PV system. LCOSS is calculated to be $113/MWh without the federal ITC and $73/MWh with the 30% ITC for commercial PV-plus-storage, with a medium resource for PV electricity production. The PV-plus-storage LCOSS is $37/MWh higher than the standalone-PV LCOE without the ITC, and $27/MWh higher with a 30% ITC.

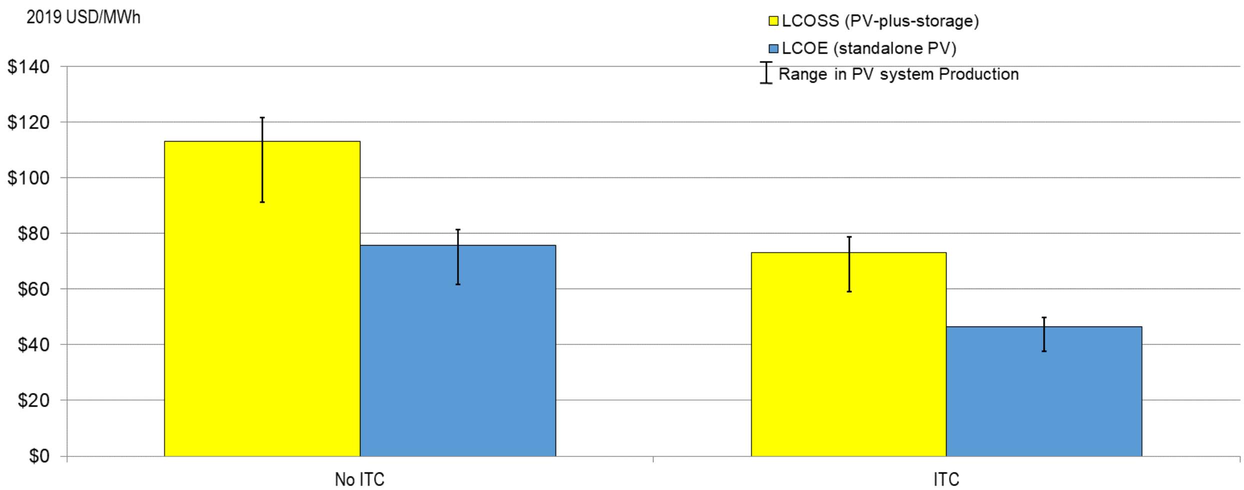

Figure 45. U.S. commercial LCOSS for an AC-coupled PV (1 MW) plus storage (600 kW/2.4 MWh, 4-hour duration) system and LCOE for a 1-MW standalone PV system, Q1 2020

LCOSS is calculated for each scenario with a medium CF (representing Kansas City); LCOSS and LCOE ranges based on high and low CF assumptions; all other values remain the same.

8 Utility-Scale Storage and PV-plus-Storage Model

Figure 46 shows the detailed bottom-up cost structure of our standalone utility-scale storage model, which uses a structure similar to our previously developed PV cost model (Fu et al. 2015, 2016, 2017; Fu, Feldman, and Margolis 2018; Fu, Remo, and Margolis 2018). Total system upfront capital costs are broken into EPC costs and developer costs. EPC non-hardware, or "soft," costs are driven by labor rates and labor productivities. We adapt engineering-design and cost-estimating models from RSMeans (2017) to determine the EPC hardware costs (including module/battery racking, mounting, wiring, containerization, and foundation) and related EPC soft costs (including related labor and equipment hours required in any given U.S. location).

Sections 8.1 and 8.2 present the utility-scale storage and PV-plus-storage cost models, Section 8.3 shows the model outputs, Section 8.4 compares PV-plus-storage benchmark trends over time, and Section 8.5 benchmarks the LCOSS for a utility-scale PV-plus-storage system.

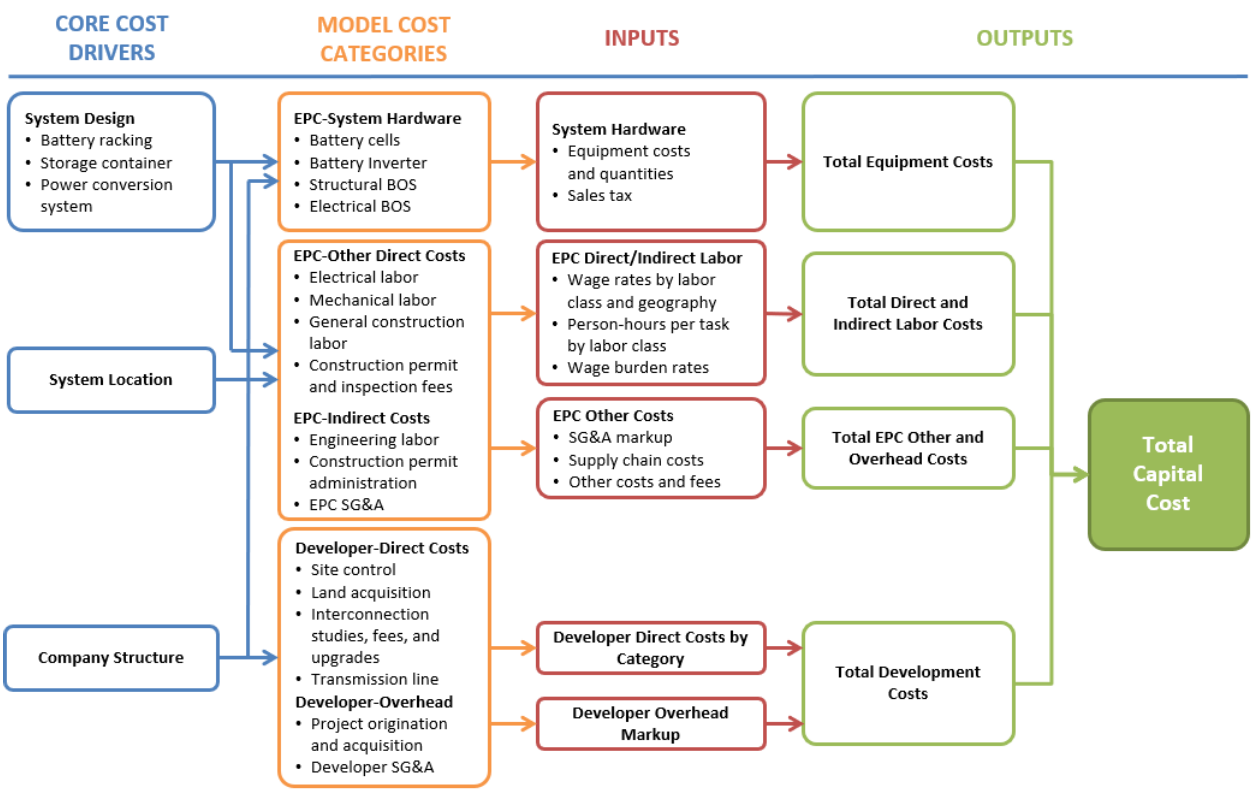

Figure 46. Structure of the bottom-up cost model for utility-scale standalone storage systems

8.1 Utility-Scale Li-Ion Standalone Storage Cost Model

The major storage components we model for utility-scale standalone storage systems are the same as those summarized in Figure 40 and Figure 41 for the commercial standalone storage model. Table 17 lists our model inputs and assumptions for such a utility-scale energy storage system. We determine the battery size (60 MW_{DC})[36] using an inverter loading ratio of 1.3 and a PV/storage size ratio of 1.67, based on Denholm, Eichman, and Margolis (2017).

Table 17. Utility-Scale Li-ion Energy Storage System: Model Inputs and Assumptions

Model Component	Modeled Value	Description	Source
Battery total size	60 MW_{DC}	Baseline case to match a 100-MW PV system	NREL 2020
Battery size per container	2.5 MWh per 40-ft container	Assumption to compute the number of containers	NREL 2020
Li-ion battery price	0.5 hours: $242/kWh 1 hour: $223/kWh 2 hours: $198/kWh 4 hours: $194/kWh	Ex-factory gate (first buyer) prices	BNEF 2019b
Duration	0.5–4.0 hours	Duration determines energy (MWh)	NREL 2020
Battery central inverter price	$0.06/W	Ex-factory gate (first buyer) prices	Wood Mackenzie 2019
Inverter size	2.5 MW per inverter	Used to determine the number of battery inverters	NREL 2020
Electrical BOS	$0.07–$0.14/W	Includes conduit, wiring, DC cable, energy management system, switchgear, transformer, and monitor and controls for each container. Determined by the number of containers, transformers, and row spacing.	NREL 2020
Structural BOS	$0.01–$0.05/W	Includes foundation, battery containers, and inverter house. Determined by the number of containers, inverters, transformers, and the spacing between containers.	NREL 2020
Installation labor	Electrician: $27.47 per hour Laborer: $18.17 per hour	National average modeled labor rate assumes nonunionized labor	BLS 2019
Sales tax	5% (national average)	Sales tax on the equipment	RSMeans 2017
EPC overhead and profit	8.67% for equipment and material; 23%–69% for labor costs; varies by system size, and labor activity	Costs associated with EPC SG&A, warehousing, shipping, and logistics	NREL 2020

[36] For a 100-MW PV system with an inverter loading ratio of 1.3 and PV/storage size ratio of 1.67, maximum deliverable power at point of interconnection is 137 MW_{AC} (100 MW/1.3 + 100 MW/1.67) for AC coupled systems and 77 MW_{AC} (100 MW/1.3) for DC coupled systems.

Model Component	Modeled Value	Description	Source
Developer cost: developer overhead	3% of total installation cost	Includes overhead expenses such as payroll, facilities, travel, legal fees, administrative, business development, finance, and other corporate functions	NREL 2020
Developer cost: PII	$0.03/W	Construction permits fee, interconnection study, interconnection inspection, and interconnection fee	NREL (2020
Developer cost: contingency	3%	Estimated as markup on the total EPC cost	NREL 2020)
Developer cost: EPC/developer net profit	5%	Applies a percentage margin to all costs including hardware, installation labor, EPC overhead, and developer overhead	NREL 2020

We use these inputs to calculate energy storage cost via the following equation[37]:

$$Energy\ storage\ installation\ cost\ \left(\frac{\$}{kWh}\right) =$$

$$Battery\ cost\ \left(\frac{\$}{kWh}\right) + \frac{Other\ cost\ components\ (\$)\ such\ as\ battery\ inverter\ and\ labor}{Storage\ system\ size\ (kW) \times Duration\ (hours)}$$

Figure 47 and Table 18 show the resulting costs for 60-MW Li-ion energy storage systems, which vary from $341/kWh (4-hour duration) to $845/kWh (0.5-hour duration). While the per-energy-unit battery cost increases as system duration decreases, the total battery cost—and the proportion of the cost attributed to the battery—decrease as system duration decreases. For example, the battery cost accounts for 56% of total system cost in the 4-hour system, but only 28% in the 0.5-hour system. At the same time, non-battery cost categories account for an increasing proportion of the system cost as duration declines.

[37] This equation is only for the energy storage installation cost calculation. For LCOS, the equation would be different. LCOS is not covered in this report.

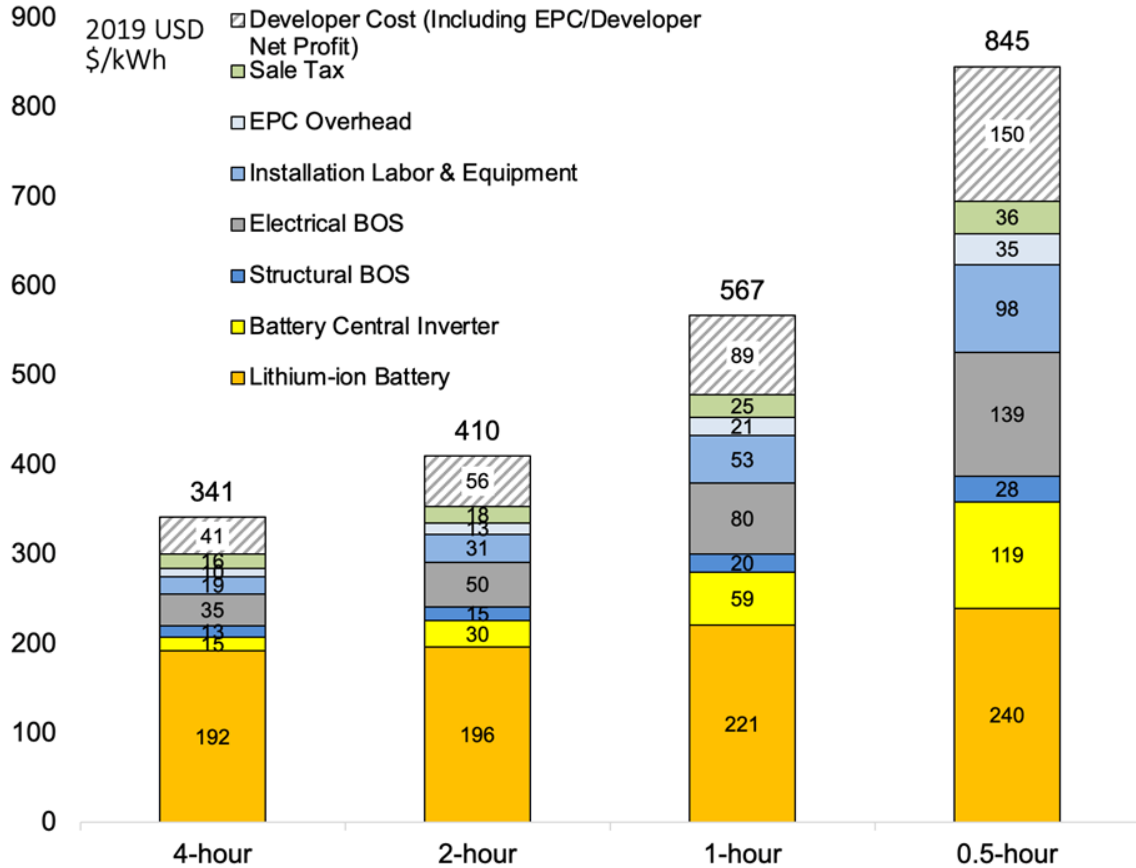

Figure 47. U.S. utility-scale Li-ion battery standalone storage costs for durations of 0.5–4.0 hours ($60\ MW_{DC}$), Q1 2020

Table 18. Detailed Cost Breakdown for a 60-MW U.S. Utility-Scale Li-ion Standalone Storage System with Durations of 0.5–4 hours

	60-MW, 4-hour Duration, 240-MWh			60-MW, 2-hour Duration, 120-MWh			60-MW, 1-hour Duration, 60-MWh			60-MW, 0.5-hour Duration, 30-MWh		
Model Component	**Total Cost ($)**	**$/kWh**	**$/W**	**Total Cost ($)**	**$/kWh**	**$/W**	**Total Cost ($)**	**$/kWh**	**$/W**	**Total Cost ($)**	**$/kWh**	**$/W**
Li-ion battery	46,560,000	192	0.78	23,760,000	196	0.40	13,380,000	221	0.22	7,260,000	240	0.12
Battery central inverter	3,600,000	15	0.06	3,600,000	30	0.06	3,600,000	59	0.06	3,600,000	119	0.06
Structural BOS	3,173,302	13	0.05	1,853,216	15	0.03	1,193,174	20	0.02	863,152	28	0.01
Electrical BOS	8,599,517	35	0.14	6,087,485	50	0.10	4,831,469	80	0.08	4,203,461	139	0.07
Installation labor & equipment	4,694,348	19	0.08	3,706,099	31	0.06	3,211,975	53	0.05	2,964,913	98	0.05
EPC overhead	2,354,557	10	0.04	1,623,195	13	0.03	1,257,513	21	0.02	1,074,673	35	0.02
Sales tax	3,807,403	16	0.06	2,236,341	18	0.04	1,509,970	25	0.03	1,092,844	36	0.02
∑ **EPC cost**	**72,789,126**	300	**1.21**	**42,866,336**	354	**0.71**	**28,984,101**	478	**0.48**	**21,059,043**	695	**0.35**
Land acquisition	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
Permitting fee	295,289	1	0.00	295,289	2	0.00	295,289	5	0.00	295,289	10	0.00
Interconnection fee	1,849,475	8	0.03	1,849,475	15	0.03	1,849,475	31	0.03	1,849,475	61	0.03
Contingency	2,265,878	9	0.04	1,359,264	11	0.02	938,331	15	0.02	698,347	23	0.01
Developer overhead	1,603,157	7	0.03	961,708	8	0.02	663,889	11	0.01	494,095	16	0.01
EPC/developer profit	3,940,146	16	0.07	2,366,604	20	0.04	1,636,554	27	0.03	1,219,812	40	0.02
∑ **Developer cost**	**9,953,946**	**41**	**0.17**	**6,832,340**	**56**	**0.11**	**5,383,539**	**89**	**0.09**	**4,557,019**	**150**	**0.08**
∑ **Total energy storage system cost**	**82,743,072**	**341**	**1.38**	**49,698,676**	**410**	**0.83**	**34,367,640**	**567**	**0.57**	**25,616,062**	**845**	**0.43**

8.2 Utility-Scale PV-plus-Storage System Cost Model

Here we combine our energy storage cost model with our PV system cost model in various configurations, including (1) colocated PV-plus-storage systems versus PV and storage systems located in different places and (2) DC-coupled versus AC-coupled battery configurations for the colocated PV-plus-storage systems. As shown in Table 19, colocation enables sharing of several hardware components by the PV and energy storage systems, which can reduce costs. Colocation can also reduce soft costs related to site preparation, land acquisition, installation labor, permitting, interconnection, and EPC/developer overhead and profit.

Table 19. Cost Factors for Siting PV and Storage Together versus Separately

Model Component	Colocated PV-plus-Storage	PV-plus-Storage at Different Sites
Site preparation[38]	Once	Twice
Land acquisition cost	Lower	Higher
Hardware sharing between PV and energy storage	Yes (step-up transformer, switchgear, monitor, and controls)	No
Installation labor cost	Lower (due to hardware sharing and single labor mobilization)	Higher
EPC/developer overhead and profit	Lower (due to lower labor cost, BOS, and total system cost)	Higher
Interconnection and permitting	Once	Twice

When PV and battery storage are colocated, the subsystems can be connected by either a DC-coupled or an AC-coupled configuration (Figure 48). A DC-coupled system needs only one bidirectional inverter, connects battery storage directly to the PV array, and enables the battery to charge and discharge from the grid. On the other hand, an AC-coupled system needs both a PV inverter and a bidirectional inverter, and there are multiple conversion steps between DC and AC to charge or discharge the battery. Also, the transmission line could be used for both PV and battery storage systems.

The advantages of the DC-coupled system include the following:

1. A DC-coupled system uses only a single bidirectional inverter (Table 20), thus reducing costs for the inverter, inverter wiring, and inverter housing.
2. Because of the extra conversion between DC and AC, an AC-coupled system may have lower roundtrip efficiency for battery charging than a DC-coupled system, which charges the battery directly. However, as power electronics are becoming more efficient, the actual efficiency difference is becoming smaller (Enphase 2019).
3. Because the battery is connected directly to the PV array, excess PV generation that would otherwise be clipped by an AC-coupled system at the inverter level can be sent directly to the battery, which could improve system economics (DiOrio and Hobbs 2018).

[38] Site preparation is a subcategory of labor cost, so it is not shown in the cost breakdown chart.

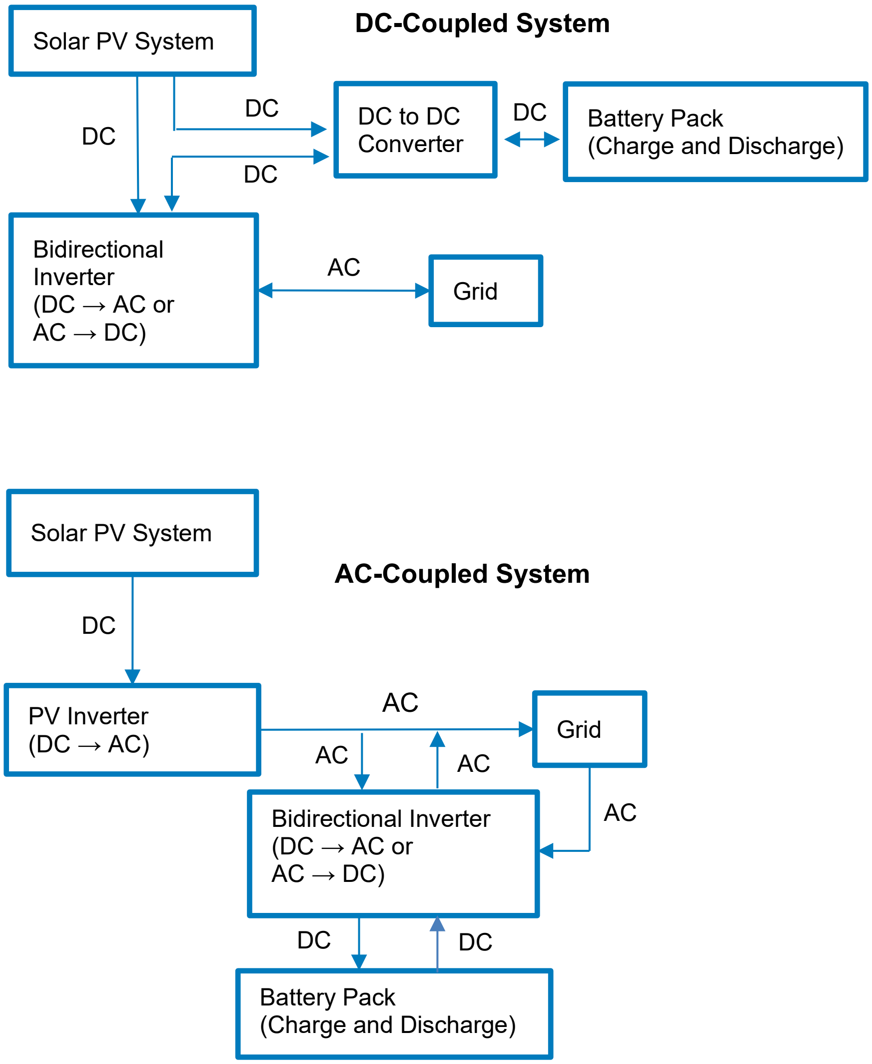

Figure 48. DC-coupled and AC-coupled PV-plus-storage system configurations

Table 20. Comparison of DC- and AC-Coupling for Utility-Scale PV-plus-Storage Systems

Model Component	DC-Coupled Configuration	AC-Coupled Configuration
Number of inverters	1 (bidirectional inverter for battery)	2 (bidirectional inverter for battery plus grid-tied inverter for PV), resulting in higher costs for the inverter, inverter wiring, and inverter housing
Battery rack size	Smaller (because battery is directly connected to PV),[a] resulting in more HVAC and fire-suppression systems required	Larger
Structural BOS	More (due to smaller battery rack size)	Less
Electrical BOS	Less (but needs additional DC-to-DC converters)	More (due to additional wiring for inverters)
Installation labor cost	More (due to smaller battery rack size and more skilled labor and labor hours required for DC work)	Less
EPC overhead	More (due to higher installation labor cost)	Less
Sales tax	Less	More (due to higher total hardware costs)
EPC/developer profit	Less	More (due to higher total EPC and developer costs)

[a] Because a PV system is not directly connected to a battery in an AC-coupled configuration, the battery racks are fewer and larger; this configuration is less costly than a DC-coupled system in which multiple distributed battery racks are deployed and managed. For example, using five smaller battery racks rather than one large rack requires five fire-suppression systems and five air conditioning systems.

The advantages of the AC-coupled system include the following:

1. Because the battery racks are not directly connected to the PV system in AC-coupled systems, these systems can use larger battery racks and thus reduce the number of HVAC and fire-suppression systems in the containers. This feature also reduces installation labor costs compared with DC-coupled systems.
2. For a retrofit (i.e., adding battery storage to an existing PV array), an AC-coupled battery may be more practical than a DC-coupled battery, because DC-coupled systems require installers to replace the existing PV inverter with a bidirectional inverter. Thus, the additional costs that are due to replacing the inverter and rewiring the system could make retrofit costs higher for a DC-coupled system than for an AC-coupled system (Ardani et al. 2017). In addition, AC-coupled systems enable the option of upgrading the PV and battery separately, because these systems are independent of one another.

3. Because AC-coupled systems have separate PV and battery systems, installers have more flexibility to adjust the battery location. For instance, DC-coupled systems require batteries to be installed next to the bidirectional inverter, and the resulting need for maintenance crews to enter the PV field can make maintenance more time consuming. Because AC-coupled systems can have batteries located outside the PV field, maintenance work can be quicker and easier.

8.3 Utility-Scale Model Output

Figure 49 (page 81) summarizes our model results for several system types and configurations:

- Standalone 100-MW PV system with one-axis tracking ($101 million)
- Standalone 60-MW/240-MWh, 4-hour-duration energy storage system ($83 million)
- Colocated DC-coupled PV (100-MW) plus storage (60-MW/240-MWh, 4-hour-duration) system ($173 million)
- Colocated AC-coupled PV (100-MW) plus storage (60-MW/240-MWh, 4-hour-duration) system ($171 million)
- PV (100-MW) plus storage (60-MW/240-MWh, 4-hour-duration) system with PV and storage components sited in different locations ($183 million).

Table 21 shows detailed costs for the three PV-plus-storage configurations. Colocating the PV and storage subsystems produces cost savings by reducing costs related to site preparation, land acquisition, permitting, interconnection, installation labor, hardware (via sharing of hardware such as switchgears, transformers, and controls), overhead, and profit. The cost of the colocated AC-coupled system is 7% lower than the cost of the system with PV and storage sited separately.

Using DC-coupling rather than AC-coupling results in a 1% higher total cost, which is the net result of cost differences between DC-coupling and AC-coupling in the categories of solar inverter, structural BOS, electrical BOS, labor, EPC and developer overhead, sales tax, contingency, and profit. For an actual project, however, cost savings may not be the only factor in choosing DC- or AC-coupling. Additional factors—such as retrofit considerations, system performance (including energy loss due to clipping), design flexibility, and O&M—should be considered.

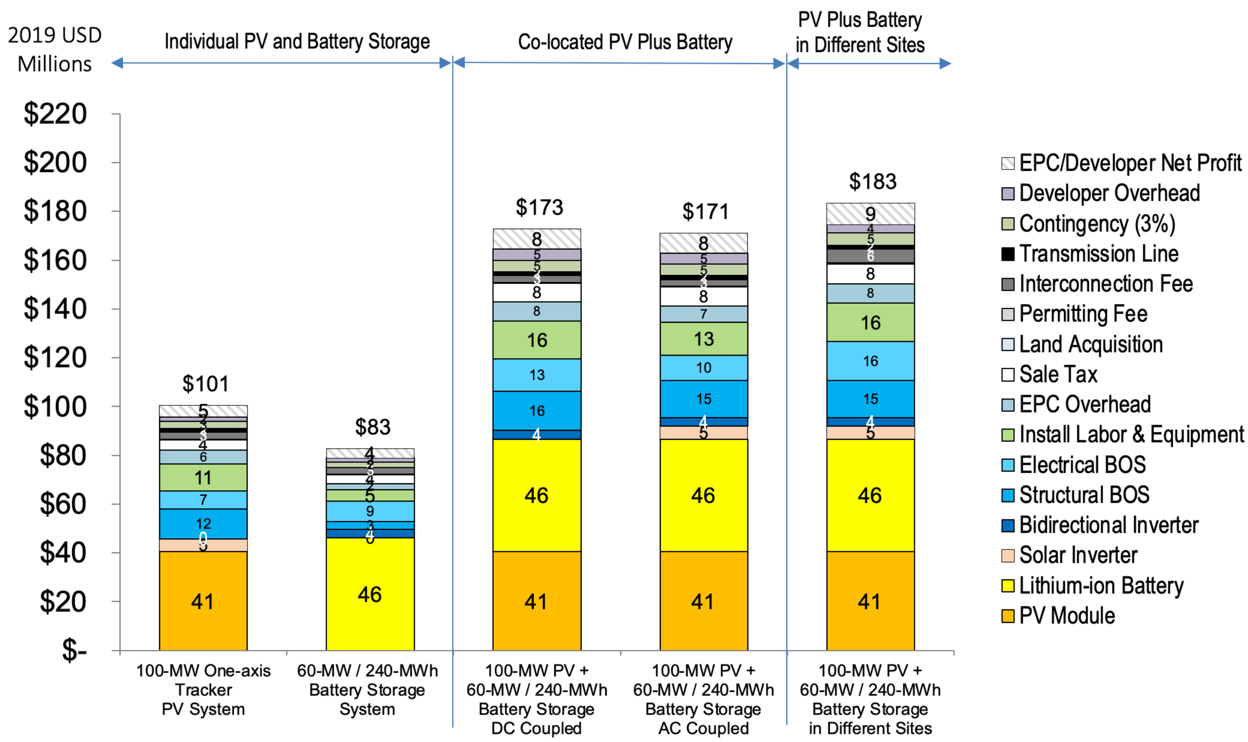

Figure 49. Cost benchmarks for PV-plus-storage systems (4-hour duration) in different sites and the same site (DC-coupled and AC-coupled cases), Q1 2020

Table 21. Detailed Cost Breakdown for Utility-Scale Li-ion PV-plus-Storage Systems

	Total Cost		
Model Component	**100-MW PV Plus 60-MW/240-MWh Battery, DC-Coupled, Colocated**	**100-MW PV Plus 60-MW/240-MWh Battery, AC-Coupled, Colocated**	**100-MW PV Plus 60-MW/240-MWh Battery, in Different Sites**
PV module	$40,587,666	$40,587,666	$40,587,666
Li-ion battery	$46,091,749	$46,091,749	$46,091,749
Solar inverter	—	$5,171,344	$5,171,344
Bidirectional inverter	$3,563,795	$3,563,795	$3,563,795
Structural BOS	$15,908,348	$15,289,203	$15,342,164
Electrical BOS	$13,384,607	$10,336,576	$15,855,408
Installation labor & equipment	$15,537,385.79	$13,417,123.80	$15,757,821
EPC overhead	$7,905,594	$6,826,782	$8,017,754
Sales tax	$7,645,117	$7,741,319	$8,097,671
∑ **EPC cost**	$150,624,262	$149,025,558	$158,485,372
Permitting fee	$198,395	$198,395	$396,790
Interconnection fee	$2,784,560	$2,784,560	$5,569,120
Transmission line	$1,669,331	$1,669,331	$1,669,331
Contingency	$4,658,296	$4,610,335	$4,980,515
Developer overhead	$4,658,296	$4,610,335	$3,523,821
EPC/developer profit	$8,229,657	$8,144,926	$8,688,259
∑ **Developer cost**	$22,198,536	$22,017,883	$24,827,837
∑ **Total system cost**	$172,822,798	$171,043,440	$183,313,209

8.4 Utility-Scale PV-plus-Storage Price Benchmark Historical Trends

Figure 50 shows 9% and 8% reductions in utility-scale PV-plus-storage benchmarks between 2018 (Fu, Remo, and Margolis 2018) and 2020 (this report), for DC-coupled and AC-coupled systems. For the DC-coupled system, approximately 28% of that reduction can be attributed to the Li-ion battery plus bidirectional inverter, while electrical and structural BOS decreased system cost by 13%; an additional 17% can be attributed to lower labor costs, and the final 42% is attributable to other soft costs, including PII, sales tax, overhead, and net profit. For the AC-coupled system, approximately 30% of the reduction can be attributed to the Li-ion battery plus bidirectional inverter, and 4% to electrical and structural BOS; an additional 16% can be attributed to lower labor costs, and the final 49% is attributable to other soft costs, including PII, sales tax, overhead, and net profit.

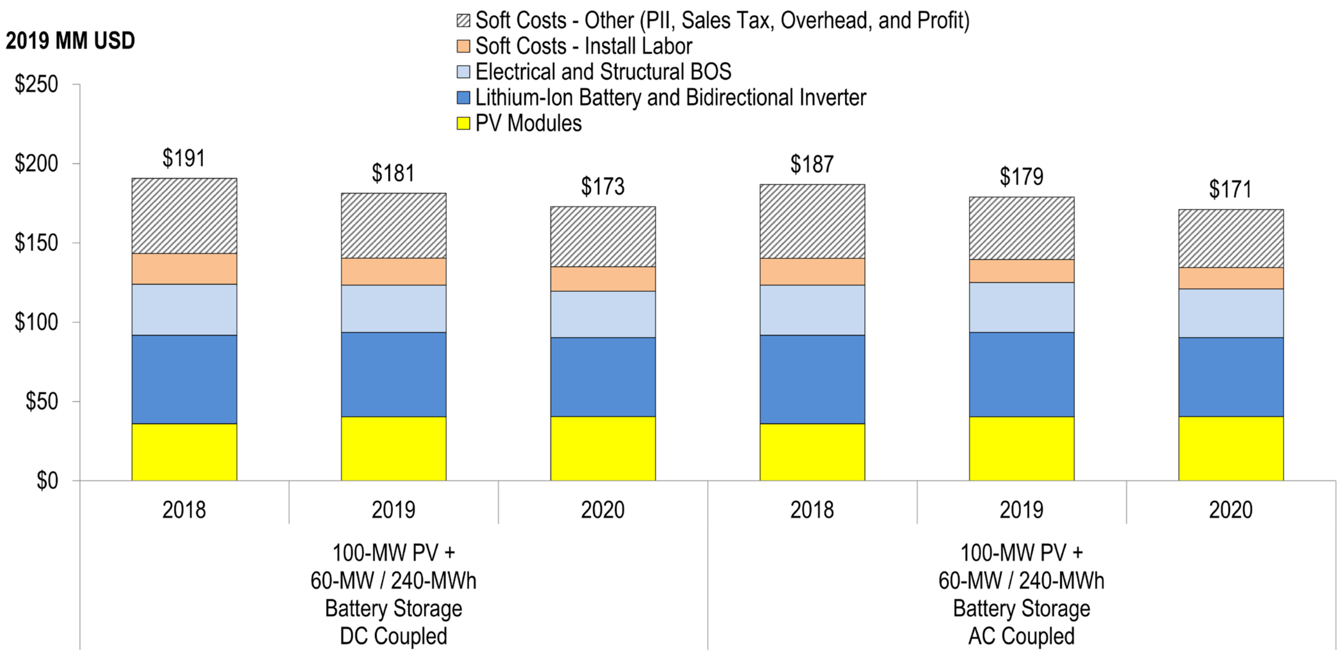

Figure 50. Utility-scale PV-plus-storage system cost benchmark summary 2018–2020, DC-coupled and AC-coupled

MM = million

8.5 Utility-Scale Levelized Cost of Solar-plus-Storage

For this year's benchmark report, we calculate the LCOSS for utility-scale PV-plus-storage, with the same formula and caveats as we use for our residential and commercial PV-plus-storage systems (see Section 6.5). BNEF (2019c) and Lazard (2018) have performed similar LCOSS calculations. None of these LCOSS calculations, including the ones in this report, attempts to value the electricity generated by these systems or the different ways they may operate. Storage value calculations require integrating storage dispatch into regional capacity expansion, load, or reliability models. For a detailed discussion of storage value, see Balducci et al. (2018), Denholm et al. (2019), Frew et al. (2018), and Schmidt et al. (2019). Similar to LCOE, LCOSS does not focus on value but rather can help track improvements to all costs of a utility-scale PV-plus-storage system over time (as opposed to just upfront costs), and the metric can provide limited comparisons with other dispatchable electricity generation technologies (e.g., natural gas). Table 22 lists our model inputs and assumptions for calculating utility-scale LCOSS.

Table 22. Utility-Scale LCOSS Inputs and Assumptions

Model Component	Model Input	Description
System size	100-MW PV plus 60-MW / 240-MWh battery storage, AC-coupled	
Initial investment	$171 million	2019 utility-scale PV-plus-storage benchmark, AC-coupled
First follow-on investments (inverter, battery replacements)	$7.4 million in year 10	20% of batteries replaced after 10 years due to battery capacity dropping 20%. We assume costs for battery and bidirectional inverters drop 20% in the next 10 years.
Second follow-on investments (inverter, battery replacements)	$5.5 million in year 20	20% of batteries replaced after 20 years due to battery capacity dropping 20%. We assume costs for battery and bidirectional inverters drop 40% in the next 20 years.
Real discount rate	2.7%	Consistent with LCOE formula
Tax rate	25.7%	21% federal, 6% state
Residual value	$0	
Initial annual system production	High resource area: 2,185 MWh/MW Medium resource area: 1,707 MWh/MW Low resource area: 1,572 MWh/MW	
Percentage of generated solar electricity fed to battery	High resource area: 30% Medium resource area: 39% Low resource area: 42%	Assumes a 75% discharge per day for a 4-hour, 60-MW battery
Roundtrip energy losses from PV/battery/grid	10%	
Roundtrip energy losses from grid/battery/grid	8%	
Charging cost	$0	Battery is charged solely by PV due to ITC considerations
O&M ($/kW/yr)	$27	Assumes storage O&M adds $10/kW-yr to PV costs
PV Degradation	0.70%	
Annual electricity purchased from grid	0	
System lifetime	30 years	
Inflation	2.5%	

We use these inputs to calculate LCOSS via Equation 1. Figure 51 shows the resulting LCOSS for a colocated AC-coupled PV (100 MW) plus storage (60 MW/240 MWh, 4-hour duration) system, as well as the LCOE of a 100-MW PV-standalone system, with one-axis tracking. LCOSS is calculated to be $83/MWh without the federal ITC and $57/MWh with the 30% ITC, with a medium resource for PV electricity production.[39] Based on these calculations, PV-plus-storage LCOSS is $40/MWh higher than standalone-PV LCOE without the ITC, and $28/MWh higher with a 30% ITC. Bolinger, Seel, and Robson (2019) reported a storage premium of $10–$15/MWh for PPAs with a 30% ITC, for systems that have a 4-hour battery sized to 50%–75% of the PV capacity.

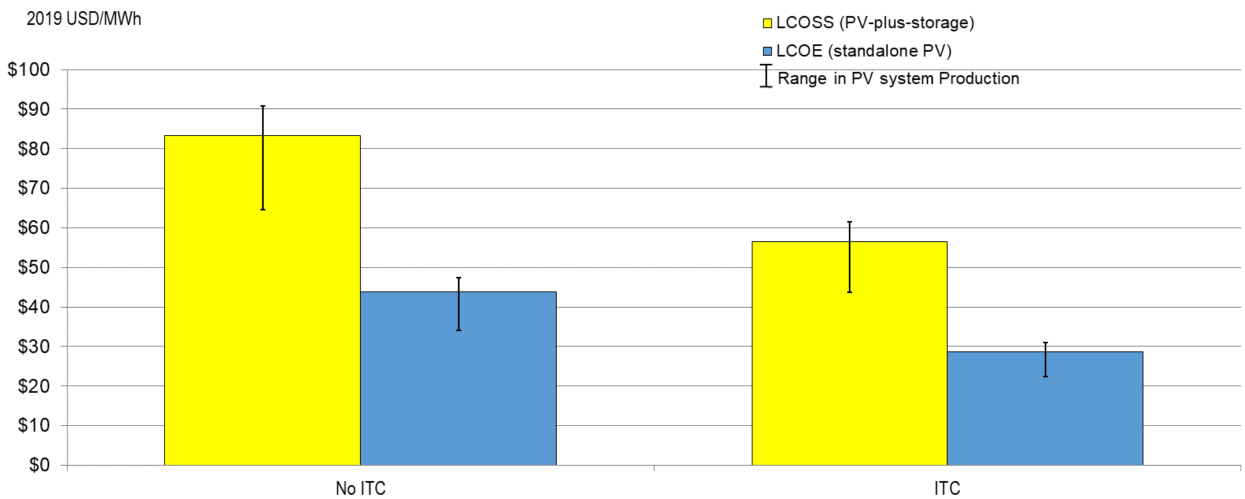

Figure 51. U.S. utility-scale LCOSS for an AC-coupled PV (100 MW) plus storage (60 MW/240 MWh, 4-hour duration) system and LCOE for a 100-MW PV standalone system, Q1 2020

LCOSS is calculated for each scenario with a medium CF (representing Kansas City);
LCOSS and LCOE ranges based on high and low CF assumptions; all other values remain the same.

[39] We do not change the inputs and assumptions between the ITC and non-ITC cases, despite the fact that the inputs in the LCOSS calculation assume the owner of the PV-plus-storage system is operating the plant such that they can claim the ITC on the storage equipment. In reality, an owner would likely operate a PV-plus-storage system differently without the ITC. Additionally, we assume projects can qualify as starting construction before 2020, allowing them to claim a 30% ITC, instead of the 26% ITC for projects starting construction in 2020.

9 Conclusions

NREL's bottom-up cost models can be used to assess the costs of PV and storage systems using various configurations. They can also estimate future potential cost-reduction opportunities for PV and PV-plus-storage systems, thus helping guide research and development aimed at advancing cost-effective system configurations. The data in this annual benchmark report inform the formulation of and track progress toward SETO's GPRA cost targets.

Based on our bottom-up modeling, the Q1 2020 cost benchmarks are:

- \$2.71/W_{DC} (or \$3.12/W_{AC}) for residential PV systems
- \$1.72/W_{DC} (or \$1.96/W_{AC}) for commercial rooftop PV systems
- \$1.72/W_{DC} (or \$1.91/W_{AC}) for commercial ground-mount PV systems
- \$0.94/W_{DC} (or \$1.28/W_{AC}) for fixed-tilt utility-scale PV systems
- \$1.01/W_{DC} (or \$1.35/W_{AC}) for one-axis-tracking utility-scale PV systems[40]
- \$26,153–\$28,371 for a 7-kW residential PV system with 3 kW/6 kWh of storage and \$35,591–\$37,909 for a 7-kW residential PV system with 5 kW/20 kWh of storage
- \$2.07 million–\$2.13 million for a 1-MW commercial ground-mount PV system colocated with 600 kW/2.4 MWh of storage
- \$171 million–\$173 million for a 100-MW PV system colocated with 60 MW/240 MWh of storage.

Overall, modeled installed costs of PV and storage systems continued to decline between Q1 2019 and Q1 2020. Figure 52 puts our Q1 2020 benchmark results in context with the results of previous NREL benchmarking analyses. When comparing the results across this period, note that:

1. Values are inflation-adjusted using the CPI (2019). Thus, historical values from our models are adjusted and presented as real USD instead of nominal USD.
2. Cost categories are aggregated for comparison purposes. "Soft Costs – Others" represents:
    A. PII
    B. Transmission line (if any)
    C. Sales tax
    D. EPC/developer overhead and profit.
3. The current versions of our cost models make a few significant changes from the versions used in our Q1 2018 benchmark report (Fu, Feldman, and Margolis 2018). To better distinguish the historical cost trends over time from the changes to our cost models, we also calculate Q1 2019 and Q1 2020 PV benchmarks using the Q1 2018 versions of the residential, commercial, and utility-scale PV models. Appendix A provides a detailed discussion of the changes made to the models between previous versions (Fu, Feldman, and Margolis 2018) and this year's versions.

[40] The dollar-per-watt total cost value is benchmarked as three significant figures, because the model inputs, such as module and inverter prices, use three significant figures.

4. Our Q1 2019 and Q1 2020 benchmarks use monocrystalline PV modules, whereas all historical benchmarks used multicrystalline PV modules. This switch reflects the overall trend occurring in the U.S. market.
5. For previous editions of this report, we assumed a land acquisition cost of \$0.03/W. Based on Wiser et al. (2020), which stated that most utility-scale PV projects do not own the land on which the PV system is placed, we have reclassified land costs from an upfront capital expenditure (land acquisition) to an operating expenditure (lease payments) for 2019 and 2020.

From 2010 to 2020, there was a 64%, 69%, and 82% reduction in the residential, commercial rooftop, and utility-scale (one-axis) PV system cost benchmark, respectively (Figure 52). The inflation-adjusted system cost differences between Q1 2019 and Q1 2020 are a \$0.06/W_{DC} reduction for residential PV, a \$0.04/W_{DC} reduction for commercial rooftop PV, and a \$0.01/W_{DC} reduction for utility-scale PV. Table 23 (page 89) shows the benchmarked values for all three sectors and drivers of cost decreases and increases.

BOS hardware cost reductions in Q1 2020 were counterbalanced by higher module costs, and soft costs remained relatively unchanged, year over year (Figure 18, Figure 26, Figure 33); this resulted in a steady percentage of soft costs as a percentage of total costs (Figure 53).[41] The historical increase in soft cost proportion for residential and commercial PV systems in Figure 53 indicates soft costs declined more slowly than did hardware costs over time; it does not indicate soft costs increased on an absolute basis.

Soft costs and hardware costs interact with each other. For instance, module efficiency improvements have reduced the number of modules required to construct a system of a given size, thus reducing hardware costs. This trend has also reduced soft costs from direct labor and related installation overhead.

Also, our bottom-up system cost models enable us to investigate regional variations, system configurations (e.g., MLPE versus non-MLPE, fixed-tilt versus one-axis tracker, and small versus large system size). In addition, we consider business structures (e.g., small installer versus national integrator, and EPC versus developer). Different scenarios result in different costs, so consistent comparisons can only be made when cost scenarios are aligned.

[41] Soft cost = total cost – hardware (module, inverter, structural and electrical BOS) cost.

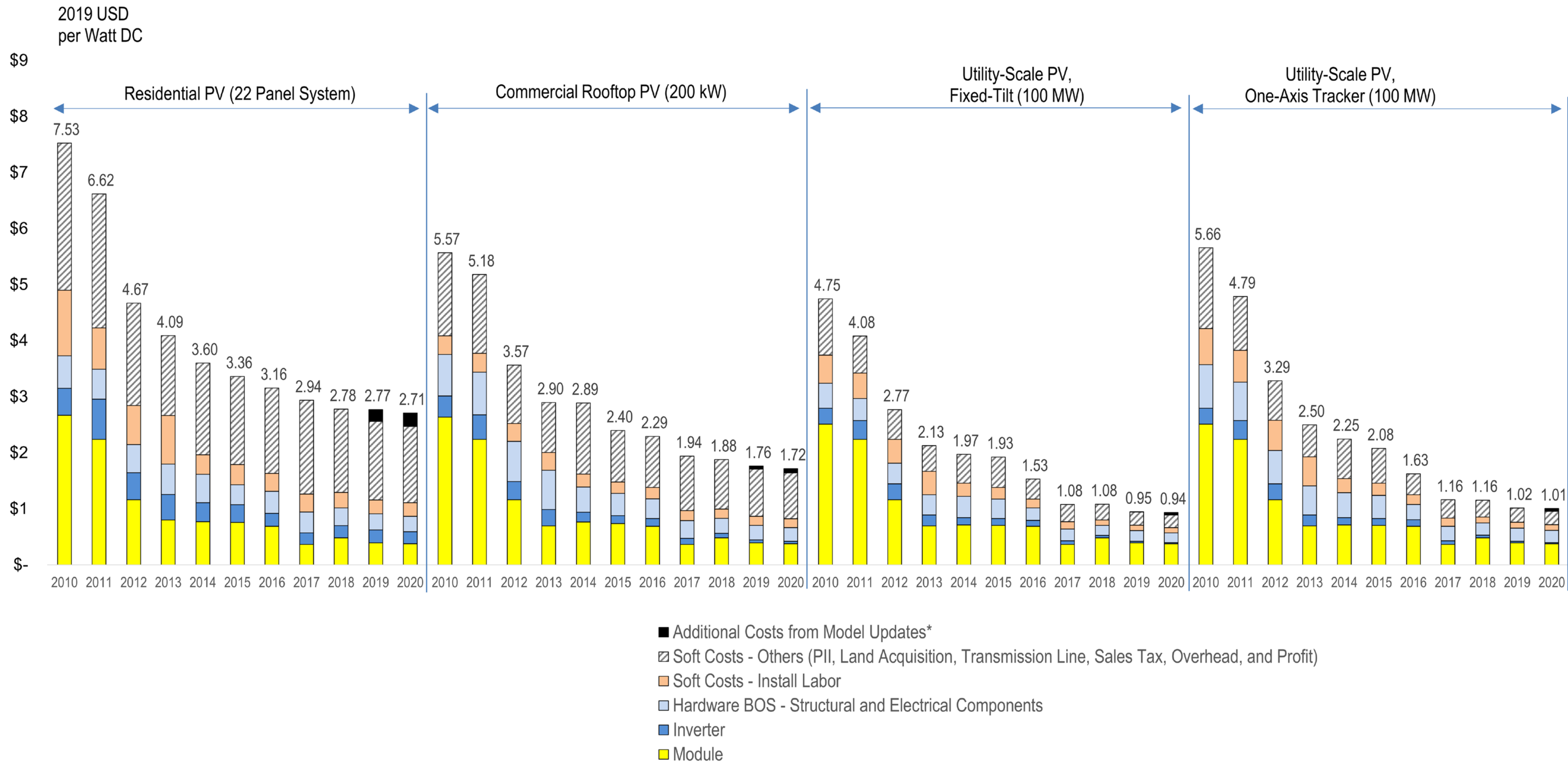

Figure 52. NREL PV system cost benchmark summary (inflation-adjusted), 2010–2020

* The current versions of our cost models make a few significant changes from the versions used in our Q1 2018 benchmark report (Fu, Feldman, and Margolis 2018) and incorporate costs that had previously not been benchmarked in as much detail. To better distinguish the historical cost trends from the changes to our cost models, we also calculate Q1 2019 and Q1 2020 PV benchmarks using the Q1 2018 versions of the residential, commercial, and utility-scale PV models. The "Additional Costs from Model Updates" category represents the difference between modeled results. Using the previous costs models, the Q1 2019 and Q1 2020 benchmarks are calculated to be: Q1 2019 = \$2.56/W_{DC} and Q1 2020 = \$2.47/W_{DC} (residential PV); Q1 2019 = \$1.71/W_{DC} and Q1 2020 = \$1.64/W_{DC} (commercial PV); Q1 2019 = \$0.94/W_{DC} and Q1 2020 = \$0.89/W_{DC} (utility-scale PV, fixed-tilt); Q1 2019 = \$1.01/W_{DC} and Q1 2020 = \$0.96/W_{DC} (utility-scale PV, one-axis tracker). Appendix A provides a detailed discussion of the changes made to the models between last year's versions (Fu, Feldman, and Margolis 2018) and this year's versions.

Table 23. Comparison of Q1 2019 and Q1 2020 PV System Cost Benchmarks

Sector	Residential PV	Commercial Rooftop PV	Utility-Scale PV, One-Axis Tracking
Q1 2019 benchmarks in 2019 USD/W_{DC}	\$2.77	\$1.76	\$1.02
Q1 2020 Benchmarks in 2019 USD/W_{DC}	\$2.71	\$1.72	\$1.01
Drivers of cost decrease	• Higher module efficiency (from 19.2% to 19.5%) • Decrease in BOS hardware and supply chain costs	• Higher module efficiency • Lower material & equipment costs in some categories	• Higher module efficiency • Lower material & equipment costs in some categories • Movement of land acquisition cost from upfront capital expenditures into O&M
Drivers of cost increase	• Higher labor wages • Higher module costs	• Higher labor wages • Higher module costs	• Higher labor wages • Higher steel prices • Higher module and inverter costs

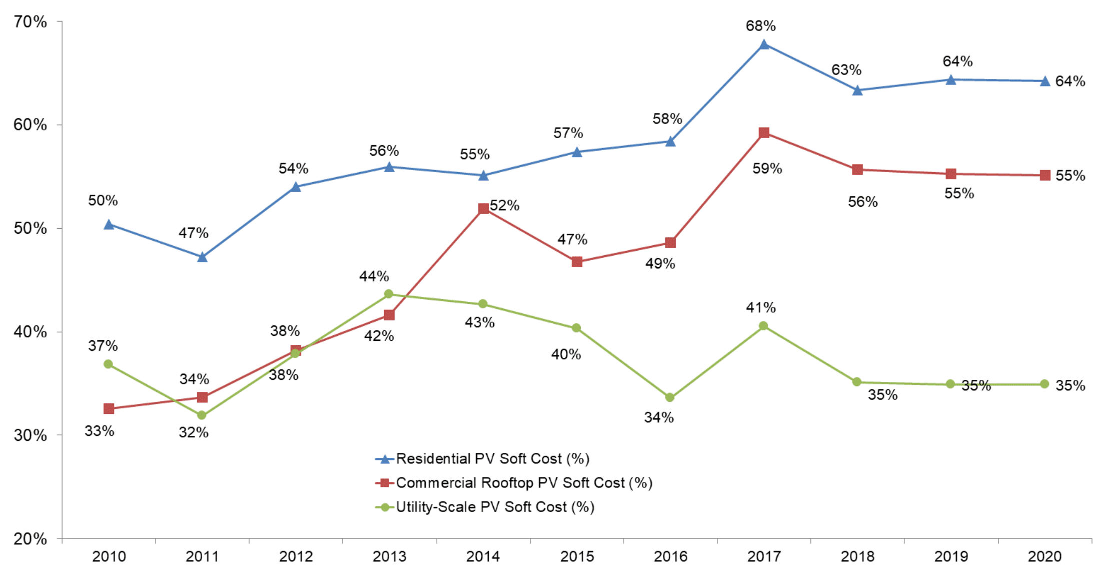

Figure 53. Modeled trend of soft cost as a proportion of total cost by sector, 2010–2020

Finally, the reduction in installed cost—along with improvements in operation, system design, and technology—have resulted in significant LCOE reductions (Figure 54). Compared with system prices when SETO's LCOE targets were announced in 2010, U.S. residential and commercial rooftop PV systems are 93% and 97% toward achieving the 2020 targets, respectively, and U.S. utility-scale PV systems achieved their 2020 SETO target three years early. In recognition of both the transformative PV progress to date and the potential for additional innovation, SETO extended its goals in 2016 to reduce the unsubsidized LCOE by 2030 to 3¢/kWh (utility-scale PV), 4¢/kWh (commercial PV), and 5¢/kWh (residential PV). Continued research and development, public and private partnerships, and business innovations are necessary to achieve SETO's 2030 LCOE targets.

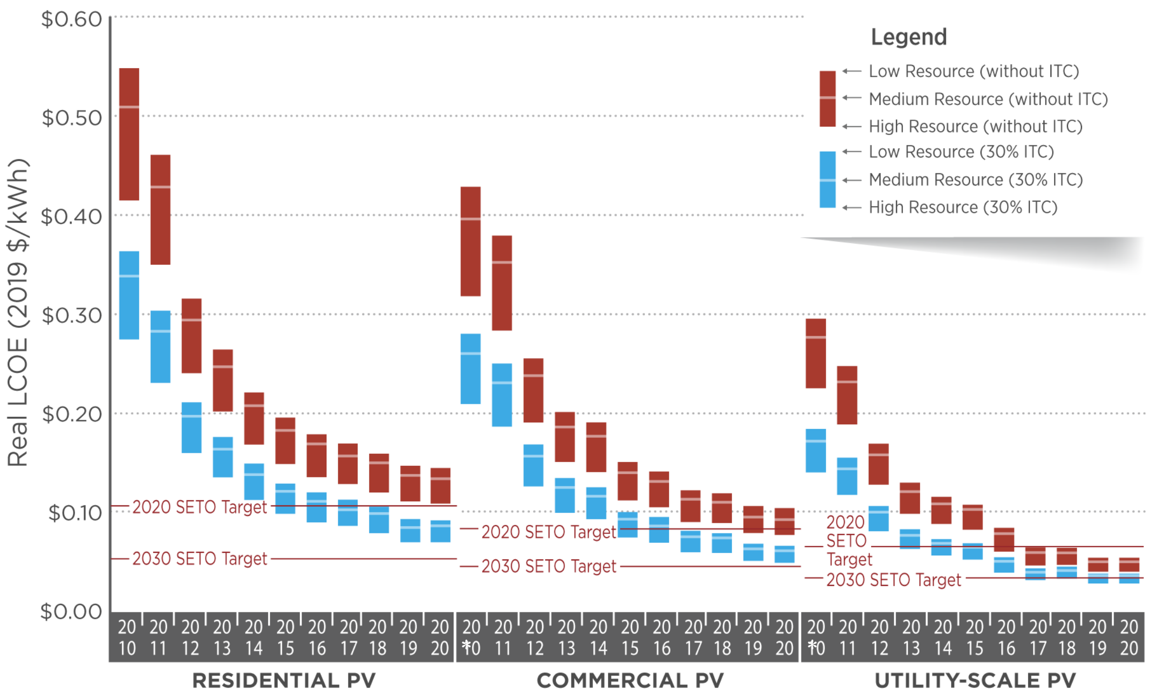

Figure 54. NREL PV LCOE benchmark summary (inflation-adjusted), 2010–2020

LCOE is calculated for each scenario under a low CF (New York City), medium CF (Kansas City), and high CF (Phoenix), but all other values remain the same. Appendix A provides a detailed discussion of the changes made to the models between last year's versions (Fu, Feldman, and Margolis 2018) and this year's versions.

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Appendix A. Changes in Methodology Between Q1 2018 and Q1 2020 Reports

Since 2010, NREL has performed PV system benchmark calculations. Each year we endeavor to improve the modeling to better characterize the U.S. market and the costs associated with installing (and operating, in the case of LCOE) residential, commercial, and utility-scale PV systems. This year, to better distinguish the historical cost trends from the changes to our cost models, we also calculate Q1 2019 and Q1 2020 PV benchmarks using the Q1 2018 versions of the residential, commercial, and utility-scale standalone PV models. This appendix summarizes the major changes we made in the models between the publication of the Q1 2018 and Q1 2020 reports.

Different Data Sources

We changed our data sources for several inputs to (1) create more consistency and transparency across years, and (2) incorporate sources that include data from a larger part of the U.S. market. Table A-1 summarizes the differences in data sources and the associated inputs in benchmarking PV system costs between this year's report and the 2018 report.

Table A-1. Comparison of Input Assumptions and Sources in the Q1 2018 Benchmark Report and the Q1 2020 Benchmark Report

Model Input	Q1 2018 Model: Sources	Q1 2020 Model: Sources
Inverter cost	PVinsights (2019, 2020) for string and central inverters; public corporate filings from Enphase (2019) and SolarEdge (2019) were used to calculate costs for microinverters and DC optimizers, respectively, using revenue per watt shipped. Q1 2019: \$0.12/W residential string inverters; \$0.24/W power optimizers plus string inverters; \$0.36/W microinverters; \$0.06/W commercial; \$0.04/W utility-scale. Q1 2020: \$0.10/W residential string inverters; \$0.23/W power optimizers plus string inverters; \$0.35/W microinverters; \$0.05/W commercial; \$0.03/W utility-scale.	Wood Mackenzie and SEIA (2020) for all inverter types; the switch to one data source provides more consistency across years and between sectors. Q1 2019: \$0.14/W residential string inverters; \$0.30/W residential power optimizers plus string inverters; \$0.34/W microinverters; \$0.09/W three-phase commercial; \$0.15/W three-phase commercial with power optimizers; \$0.06/W utility-scale. Q1 2020: \$0.15/W residential string inverters; \$0.30/W residential power optimizers plus string inverters; \$0.34/W microinverters; \$0.078/W three-phase commercial; \$0.14/W three-phase commercial with power optimizers; \$0.069/W utility-scale.
Module efficiency	California's NEM Interconnected Data Set, using average module power for the previous year's PV system in the residential sector for the residential PV model—311 watts-peak (W_p, 2018) and 319 W_p (2019)—divided by the average	California's NEM Interconnected Data Set, using capacity-weighted average module efficiency of 60-cell and 72-cell monocrystalline or multicrystalline modules for PV systems installed in that year. Monocrystalline: 19.2% (2019) and

Model Input	Q1 2018 Model: Sources	Q1 2020 Model: Sources
	module size for the entire data set (1.64 m^2 (2018) and 1.65 m^2 (2019)), giving an estimated module efficiency in residential PV systems of 19.0% (2018) and 19.4% (2019). Using average module power for the previous year's PV system in the commercial sector for the commercial PV model (330 W_p (2018) and 343 W_p (2019)), divided by the average module size for the entire data set (1.64 m^2 (2018) and 1.65 m^2 (2019)), giving an estimated module efficiency in commercial PV systems of 20.1% (2018) and 20.8% (2019).	19.5% (Q1 2020). Multicrystalline: 17.3% (2019) and 17.4% (Q1 2020).
Module price	Market-share-weighted-average monocrystalline and multicrystalline spot price from Wood Mackenzie and SEIA (2020) in the first quarter of the year. Q1 2019: $0.39/W. Q1 2020: $0.38/W.	U.S. monocrystalline silicon spot price from Wood Mackenzie and SEIA (2020) in the first quarter of the year. Q1 2019: $0.40/W. Q1 2020: $0.41/W.
Residential inverter market share	California's NEM Interconnection Data Set, using the percentage of market penetration of the previous year (by installed capacity), assuming all microinverters were represented by Enphase inverters, DC optimizers were represented by SolarEdge inverters, and the remainder were string inverters. Residential market share of string inverters, power optimizers, and microinverters: 2018 (61.8%, 16.8%, 21.4%); 2019 (59.2%, 18.8%, 22.0%).	Tracking the Sun data set; these data include a broader representation of the United States than just California. Residential market share of string inverters, power optimizers, and microinverters for latest year available: 2018 (used for both Q1 2019 and Q1 2020 benchmark): 14.6%, 49.8%, and 35.6%.
Residential business structure market share	Corporate filings from Sunrun (2020), Tesla (2020), and Vivint Solar (2020) to estimate national integrator Q1 2019 (33%) and Q1 2020 (30%) market share; Wood Mackenzie and SEIA (2020) to estimate the remainder, classified small installers.	TPO market share from Tracking the Sun data set to estimate national integrator market share, with the remainder classified as small installers; the TPO data include other national integrators besides Sunrun, Tesla, and Vivint. The 2018 (latest year available) TPO market share of 38% is used for both Q1 2019 and Q1 2020.

Different Methodology for Calculating Residential Overhead, Customer Acquisition, and PII

In this year's version of our benchmark analysis, we expand our modeling of customer acquisition, engineering, PII, and overhead. In addition to providing finer granularity to costs, we include costs borne by many installers throughout the United States. Table A-2 summarizes the current and previous methods.

Table A-2. Comparison of Methods for Calculating Q1 2018 Residential PV Soft Costs in the Q1 2018 Benchmark Report and the Q1 2020 Benchmark Report

Residential Soft Cost	Q1 2018 Model: Summary of Method (Value)	Q1 2020 Model: Summary of Method (Value)
PII	A permit fee of $200 and six hours of staff time ($0.05/W).	An itemized list of steps and associated labor and other costs needed to design the initial and final system plans, apply for and receive a permit and interconnection agreement, multiplied by the estimated percentage of national sales that use this step, divided by the average conversion from this step to an installed system (to account for the cost of lost sales) ($0.24/W). Many of these costs were not captured in previous editions.
Sales and marketing (customer acquisition)	Data from the 2013 report (Feldman et al. 2013), which calculated sales and marketing costs by estimating the headcount, salaries, benefits, and taxes of the sales, engineering, and marketing departments, as well as vehicle costs ($0.37/W).	An estimated breakdown of the necessary steps and associated labor and other costs of customer acquisition, including advertisement, lead generation, qualifications/first sales pitch, and final sales pitch. Each possible customer acquisition pathway is multiplied by the estimated percentage of national sales that use this step, divided by the average conversion from this step to an installed system (to account for the cost of lost sales) ($0.43/W).
Overhead (general and administrative)	Data from the 2013 report (Feldman et al. 2013), which calculated overhead costs by estimating the headcount, salaries, benefits, and taxes of the management, human resources, project management, administration, supply chain, information technology, and customer service departments, as well as rent and other office expenses, professional services, insurance, taxes, dues, and memberships ($0.34/W).	An update of previous cost categories, including the overhead of the larger staff associated with customer acquisition and PII; the model also assumes 10% is added to the base salary to account for training expenses ($0.27/W).

Incorporation of MLPE into the Commercial Rooftop PV Model

MLPE are growing to be a substantial part of the commercial PV rooftop market in the United States owing in part to the adoption by many states of the 2017 NEC, which requires rooftop PV systems to have module-level rapid shutdown. In past years, we only assumed string inverters for the commercial PV benchmark, only weighting the residential PV system benchmark by MLPE market share. This year, we also weight the commercial rooftop PV benchmark by MLPE market share (45% for three-phase string inverters, 39% for power optimizers, and 16% for microinverters).

Annual Updates of Installation Labor Rates

In previous year's models, we adjusted the 2012 labor rates by inflation, using the CPI "All Urban Consumers" series. For this year's model, we pull each year's labor rate directly from the Bureau of Labor Statistics.

Elimination of State Variations from the Cost of Doing Business

In previous year's models, we adjusted installation labor rates and supply chain costs for each state by the state's cost of doing business, as reported by Case (2012). For this year's report, we do not use a cost of doing business adjustment because all costs are use national averages.

Changes to Calculating Number of Modules in Commercial and Utility-Scale PV Models

Previous year's models calculated the number of modules in a system by dividing system size by 310.4 W, rounded to the nearest whole number. We update the model to calculate the number of modules by dividing system size by module efficiency and module area, and rounding any fraction up to the closest whole number.

Changes to the Cost Classification of Land Acquisition for Utility-Scale PV Models

For previous editions of this report, we assumed a land acquisition cost of $0.03/W. Based on Wiser et al. (2020), which stated that most utility-scale PV projects do not own the land on which the PV system is placed, we reclassify land costs from an upfront capital expenditure (land acquisition) to an operating expenditure (lease payments) for 2019 and 2020.

Switching from Weighting Costs by State PV Installation Levels

In previous year's models, our national average benchmarks were calculated by weighting the state averages of sales tax, labor rates, wind load, snow load, and material and equipment location factor by the amount of PV capacity installed in each state in the previous year for that sector (utility-scale, commercial, residential). We update the model to use national average labor rates and the average values of state sales tax, wind load, snow load, and material and equipment location factor.

Changes to Reported Dollar Year Calculation

In previous year's models, we adjusted values for inflation based on a partial year of CPI data. For example, in the Q1 2018 benchmark report (Fu, Feldman, and Margolis 2018), all values are quoted in $2018; however, the inflation adjustment is based on the average CPI Index of Q1 2018 (January through March 2018). Because the benchmark reports are produced before the end of the calendar year, indexing them in that year is not possible. To better correct for inflation, in this year's report, we quote values in previous year's dollars ($2019). In 2018, the CPI-All Urban

Consumers Index is 248.8 for the first three months and 251.1 for the whole year (and 255.7 for 2019).

The changes summarized in this appendix result in Q1 2019 and Q1 2020 benchmarks with different results than would have been calculated using the previous edition's models and assumptions. For example, the 2020 total residential PV installed-cost benchmark calculated using the Q1 2018 model is $\$2.47/W_{DC}$, whereas the same benchmark calculated using the Q1 2020 model is $\$2.71/W_{DC}$ (7% higher).

Table A-3 summarizes the impacts these changes have on each cost category in the residential, commercial, and utility-scale PV benchmarks for Q1 2020.

Table A-3. Comparison of Q1 2020 Benchmark Costs, per Category, Calculated Using Previous Report's Model (Q1 2018) and the Current Model (Q1 2020) in 2019 USD

	Residential PV (2020)			Commercial Rooftop PV (2020)			Utility-Scale, Fixed-Tilt (2020)			Utility-Scale, One-Axis (2020)		
	Q1 2018 Model	**Q1 2020 Model**	**% Change**	**Q1 2018 Model**	**Q1 2020 Model**	**% Change**	**Q1 2018 Model**	**Q1 2020 Model**	**% Change**	**Q1 2018 Model**	**Q1 2020 Model**	**% Change**
Module	$0.376	$0.406	5%	$0.376	$0.406	5%	$0.376	$0.406	5%	$0.376	$0.406	5%
Inverter	$0.217	$0.250	12%	$0.045	$0.123	169%	$0.022	$0.051	127%	$0.022	$0.052	127%
Structural BOS	$0.084	$0.084	-3%	$0.112	$0.110	-4%	$0.087	$0.080	-10%	$0.130	$0.122	-9%
Electrical BOS	$0.190	$0.228	17%	$0.133	$0.133	-3%	$0.088	$0.073	-19%	$0.088	$0.073	-19%
Supply chain costs	$0.254	$0.261	0%	—	—	—	—	—	—	—	—	—
Installation labor	$0.242	$0.187	-25%	$0.159	$0.148	-9%	$0.094	$0.102	5%	$0.102	$0.111	6%
PII	$0.050	$0.238	366%	$0.100	$0.106	3%	$0.033	$0.030	-13%	$0.033	$0.030	-13%
Transmission Line (if any)	—	—	—	—	—	—	$0.019	$0.017	-13%	$0.019	$0.017	-13%
Sales and marketing (customer acquisition)	$0.360	$0.428	15%	—	—	—	—	—	—	—	—	—
Overhead	$0.327	$0.274	-18%	$0.526	$0.492	-8%	$0.068	$0.068	-3%	$0.077	$0.076	-3%
Contingency	—	—	—	$0.040	$0.044	7%	$0.024	$0.026	3%	$0.026	$0.027	2%
Profit	$0.296	$0.292	-4%	$0.107	$0.113	2%	$0.042	$0.045	2%	$0.046	$0.048	2%
Sales tax	$0.077	$0.063	-21%	$0.045	$0.046	1%	$0.038	$0.041	4%	$0.041	$0.043	4%
Total price	$2.474	$2.710	7%	$1.642	$1.720	2%	$0.891	$0.937	2%	$0.959	$1.005	2%

Appendix B. PV System LCOE Benchmarks in 2019 USD

Table B-1. NREL LCOE Summary (2019 cents/kWh)

	Market Financing Rates											Steady-State Financing		
Reporting Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2020	2020 Goal	Goal 2030
Benchmark Date	Q4 2009	Q4 2010	Q4 2011	Q4 2012	Q4 2013	Q1 2015	Q1 2016	Q1 2017	Q12018	Q1 2019	Q1 2020	Q1 2020		
Residential (6.9 kW)														
High resource (CF 21.6%), no ITC	41.6	35.0	24.1	20.2	16.9	15.0	13.8	12.9	12.0	11.2	11.0	10.5	—	—
Medium resource (CF 17.6%), no ITC	50.9	42.8	29.5	24.7	20.8	18.4	16.9	15.8	14.8	13.7	13.5	12.8	10.6	5.3
Low resource (CF 16.4%), no ITC	54.7	46.0	31.7	26.6	22.3	19.7	18.1	17.0	15.9	14.7	14.5	13.8	—	—
High resource (CF 21.6%), ITC	27.6	23.2	16.1	13.5	11.3	9.9	9.1	8.6	8.0	7.1	7.1	—	—	—
Medium resource (CF 17.6%), ITC	33.9	28.4	19.8	16.5	13.8	12.1	11.2	10.5	9.8	8.7	8.7	—	—	—
Low resource (CF 16.4%), ITC	36.4	30.5	21.2	17.7	14.8	13.0	12.0	11.3	10.5	9.4	9.3	—	—	—
Commercial Rooftop (200 kW)														
High resource (CF 20.4%), no ITC	32.0	28.5	19.2	15.2	14.3	11.5	10.7	9.2	8.9	7.9	7.7	7.3	—	—
Medium resource (CF 16.4%), no ITC	39.7	35.4	23.9	18.8	17.8	14.2	13.3	11.5	11.0	9.5	9.3	9.0	8.2	4.3
Low resource (CF 15.3%), no ITC	42.8	38.1	25.7	20.3	19.2	15.3	14.3	12.4	11.9	10.6	10.3	9.7	—	—
High resource (CF 20.4%), ITC	21.1	18.8	12.8	10.1	9.5	7.6	7.1	6.2	5.9	5.1	4.9	—	—	—
Medium resource (CF 16.4%), ITC	26.2	23.3	15.9	12.6	11.8	9.5	8.8	7.7	7.4	6.3	6.1	—	—	—
Low resource (CF 15.3%), ITC	28.2	25.1	17.1	13.5	12.7	10.2	9.5	8.3	7.9	6.8	6.6	—	—	—

Commercial Ground-Mount (500 kW)														
High resource (CF 21.6%), no ITC	—	—	—	—	—	—	—	—	—	—	7.1	6.7	—	—
Medium resource (CF 17.6%), no ITC	—	—	—	—	—	—	—	—	—	—	8.7	8.2	—	—
Low resource (CF 16.4%), no ITC	—	—	—	—	—	—	—	—	—	—	9.3	8.8	—	—
High resource (CF 21.6%), ITC	—	—	—	—	—	—	—	—	—	—	4.5	—	—	—
Medium resource (CF 17.6%), ITC	—	—	—	—	—	—	—	—	—	—	5.6	—	—	—
Low resource (CF 16.4%), ITC	—	—	—	—	—	—	—	—	—	—	6.0	—	—	—
Utility-Scale (100 MW One-Axis Tracking)														
High resource (CF 25.2%), no ITC	22.5	18.6	12.7	9.6	8.5	7.6	6.0	4.6	4.4	3.7	3.7	3.6	—	—
Medium resource (CF 19.6%), no ITC	28.9	23.9	16.4	12.4	10.9	9.8	7.8	5.9	5.6	4.7	4.7	4.6	6.4	3.2
Low resource (CF 18.2%), no ITC	31.4	26.0	17.8	13.4	11.8	10.6	8.4	6.4	6.1	5.1	5.1	4.9	—	—
High resource (CF 25.2%), ITC	13.9	11.5	8.0	6.1	5.4	4.8	3.9	3.1	3.0	2.5	2.5	—	—	—
Medium resource (CF 19.6%), ITC	17.9	14.8	10.3	7.8	6.9	6.2	5.0	3.9	3.8	3.3	3.3	—	—	—
Low resource (CF 18.2%), ITC	19.4	16.1	11.1	8.5	7.5	6.7	5.4	4.3	4.2	3.5	3.5	—	—	—
Utility-Scale (100 MW Fixed-Tilt)														
High resource (CF 21.3%), no ITC	22.5	18.9	12.8	9.8	8.8	8.2	6.6	5.0	4.7	4.0	4.0	3.7	—	—
Medium resource (CF 17.3%), no ITC	27.7	23.2	15.7	12.0	10.8	10.1	8.1	6.1	5.8	4.9	4.9	4.6	—	—
Low resource (CF 16.2%), no ITC	29.6	24.8	16.9	12.9	11.5	10.8	8.7	6.5	6.2	5.2	5.2	4.9	—	—
High resource (CF 21.3%), ITC	14.0	11.7	8.1	6.2	5.6	5.2	4.2	3.3	3.0	2.5	2.5	—	—	—
Medium resource (CF 17.3%), ITC	17.2	14.4	9.9	7.6	6.8	6.4	5.2	4.0	3.7	3.1	3.1	—	—	—
Low resource (CF 16.2%), ITC	18.4	15.5	10.6	8.2	7.3	6.8	5.5	4.3	3.9	3.3	3.3	—	—	—

[a] 2020 residential and commercial SETO goals are adjusted for inflation using the CPI; the 2020 utility-scale goal was left unchanged, because wholesale prices were relatively flat, and in some cases declined, from 2010 to 2020.