Agenda

Introductions & Panel Member Priorities (30 minutes)

State of the Sector (10 minutes)

Pathways Presentation – E3 (15 minutes)

Work Plan Development Discussion (50 minutes)

Scope Development Discussion (40 minutes)

Timeline (10 minutes)

Next Steps (15 minutes)
Introductions & Panel Member Priorities
State of the Sector
Carbon neutral economy, mandating at least an 85% reduction in emissions below 1990 levels

40% reduction in emissions by 2030

100% zero-carbon electricity by 2040

70% renewable electricity by 2030

9,000 MW of offshore wind by 2035

6,000 MW of distributed solar by 2025

3,000 MW of energy storage by 2030

185 TBtu on-site energy savings by 2025
Alignment with the CLCPA

- 93 MW of Energy Storage Currently Operating (+ 1,400 MW of Pumped Hydro Storage, which does not count towards the Goal)
- 841 MW of energy storage Under Contract/Construction
- Needs to be contracted and constructed by 2030
- ~11.5 GW of land-based renewables
- ~4.1 GW of offshore wind
- ~3.3 GW of distributed energy resources
- ~4.1 GW of land-based renewables
- ~1.8 GW of offshore wind
- ~2.4 GW of distributed energy resources
- Currently generating renewable electricity for NYS
- 2,066 MW of energy storage needs to be contracted and constructed by 2030

Estimated 2030 NYS Load (GWh) - 151,678
Accelerated Renewable Energy Growth and Community Benefit Act

Three Major Components:

- Office of Renewable Energy Siting
- Clean Energy Resources Development and Incentives (Build-Ready) Program
- State Power Grid Study and Program

The Act will:

- advance renewable energy, drive statewide economic growth, and create jobs
- streamline the process for environmentally responsible and cost-effective siting of large-scale renewable energy projects across the State
- establish tools for achieving the State mandate to obtain 70 percent of the State’s electricity from renewable sources by 2030 and other nation-leading goals of the Climate Leadership and Community Protection Act
Clean Energy Standard Expansion

- **Alignment with the CLCPA**
  - Adopts 70 by 30 Goal on the path to 100 by 40
  - Narrows definition of Renewable Energy (per CLCPA)

- **Procurement Targets**
  - Tier 1 Land Based Renewables (Annual Procurements of ~4,500 GWh 2021 – 2026)
  - Offshore Wind (Annual Procurements of ~4,500 GWh from 2020 – 2023)

- **Tier 4 Proposal – Renewables in Zone J, including Canadian Hydropower**

- **Competitive Tier 2 Petition – For Existing Renewables**

- **Repowering Proposal**
Pathways Presentation – E3
**Electricity Demand**

+ **Electrification of buildings and transportation drives significant increase in annual electric load**
  - Analysis within range found in the literature, which project annual load increases ranging 20%–100% by midcentury
  - Range primarily reflects extent and timing of end-use electrification, with some studies assuming lower electrification and larger role for renewable gas and/or renewable transportation fuels

+ **NYS shifts from summer peak to winter peak around 2040, driven primarily by electrification of heating in buildings and EV battery charging**
  - Flexibility in electric vehicles and building loads can significantly reduce peak demands and the need for new generation capacity
  - Flexible loads can also serve a similar role to battery storage, shifting demand to times of high renewables output
Opportunities to Decarbonize the Electricity Sector

+ Energy efficiency and managed electrification will be critical to mitigating load growth and “peak heat” impacts
+ To decarbonize electricity supply, New York has access to a diverse portfolio of renewable resources
+ Battery storage and demand-side flexibility can play a key role in intraday balancing
+ A number of firm, zero-carbon resources can help solve interday balancing challenges, e.g. multi-day periods of low renewable output

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<td>• In-state hydro • Hydro imports • Solar PV (utility-scale and distributed) • Wind (onshore &amp; offshore)</td>
</tr>
<tr>
<td>Energy Storage</td>
<td>• Battery storage (&gt;1hr) • Pumped storage (&gt;12hr)</td>
</tr>
<tr>
<td>Customer Technologies</td>
<td>• Energy efficiency • Flexible loads</td>
</tr>
</tbody>
</table>
New York State has significant potential renewable energy resources and zero-carbon technology options, as well as access to adjoining states, provinces, and regional transmission systems, which offer additional options for energy supply.

Significant in-state renewable development will require careful siting considerations.

### Upstate NY
- **Zones A-F**
  - Land-based wind: 8.9 GW
  - Solar: 36.1 GW

### Downstate NY
- **Zones G-K**
  - Offshore wind: 15.5 GW
  - Solar: 9.8 GW

### Upstate Installed Capacity (GW)

<table>
<thead>
<tr>
<th>Technology</th>
<th>Existing</th>
<th>2030</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear</td>
<td>3.4</td>
<td>3.4</td>
<td>2.1</td>
</tr>
<tr>
<td>Fossil</td>
<td>7.3</td>
<td>7.3</td>
<td>-</td>
</tr>
<tr>
<td>CCS</td>
<td>-</td>
<td>-</td>
<td>0.7</td>
</tr>
<tr>
<td>Bioenergy</td>
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<tr>
<td>Hydro</td>
<td>4.4</td>
<td>5.0</td>
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</tr>
<tr>
<td>Land-Based Wind</td>
<td>2.2</td>
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<td>8.9</td>
</tr>
<tr>
<td>Offshore Wind</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Solar</td>
<td>1.3</td>
<td>7.2</td>
<td>36.1</td>
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### Downstate Installed Capacity (GW)

<table>
<thead>
<tr>
<th>Technology</th>
<th>Existing</th>
<th>2030</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear</td>
<td>2.1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Fossil</td>
<td>17.1</td>
<td>12.3</td>
<td>-</td>
</tr>
<tr>
<td>CCS</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Bioenergy</td>
<td>0.2</td>
<td>0.2</td>
<td>7.9</td>
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<tr>
<td>Hydro</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Land-Based Wind</td>
<td>-</td>
<td>-</td>
<td>0.1</td>
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<tr>
<td>Offshore Wind</td>
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<td>6.2</td>
<td>15.5</td>
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<tr>
<td>Solar</td>
<td>1.5</td>
<td>3.4</td>
<td>9.8</td>
</tr>
<tr>
<td>Storage</td>
<td>0.5</td>
<td>2.0</td>
<td>5.8</td>
</tr>
</tbody>
</table>

**Total**
- Existing: 21.3
- 2030: 24.1
- 2050: 39.2
- Load (TWh): 91.9, 88.7, 138.4
Battery storage deployment will play an important role, even after accounting for declining effective load carrying capability and end-use load flexibility.

Transmission investments will be needed to enable the delivery of 100% zero-emission electricity.

Forthcoming Power Grid Study will explore transmission needs in greater detail.

*Total 5.1 GW includes existing pumped storage capacity
As the share of intermittent resources like wind and solar grows substantially, some studies suggest that complementing with firm, zero-emission resources, such as bioenergy, synthesized fuels such as hydrogen, hydropower, carbon capture and sequestration, and nuclear generation could provide a number of benefits\textsuperscript{1,2,3}

The need for dispatchable resources is most pronounced during winter periods of high demand for electrified heating and transportation and lower wind and solar output.


Work Plan Development
Advisory Panel Work Product

> Develop sector-specific strategies to achieve 53–56% reduction in GHG emissions from 2016 level by 2030 (100% by 2050)

> Present a list of recommendations for emissions reducing policies, programs or actions, for consideration by the Climate Action Council for inclusion in the Scoping Plan.

  • Recommendations should identify the estimated scale of impact, knowable costs to achieve, ease of deployment or commercial availability, potential co-benefits to emissions reduction, advancement of climate justice outcomes, and impacts to businesses.
  
  • Recommendations may be informed by quantitative analysis or qualitative assessment.

> Produce sector-based recommendations.

  • The Panels should not rely on economy-wide policies to achieve emission reduction goals but can recommend that the Council consider economy-wide policies if needed to advance certain sector-specific policies.
  
  • Cross-sector recommendations should be advanced only after consultation with the appropriate Panels (e.g. beneficial electrification and/or fossil fuel transitions with Transportation and Energy Efficiency/Housing, or renewables siting with Land Use & Local Governments)
Each Advisory Panel shall:

> Meet at least once per month and provide regular updates to the Council on the advancement of its work.
  • Present (oral or written) progress reports at Council meetings and solicit feedback.
  • Provide final recommendations in accordance with the Scoping Plan development schedule.

> Consult with the Climate Justice and Just Transition Working Groups to inform its recommendations for the Climate Action Council.

> Seek public input to inform the development of recommendations to the Council for consideration.
  • Panels may seek input from selected expertise in a subject area, as determined necessary by the members.
  • Panels shall, during the next six months, hold at least one forum to receive broad-based public input.
  • Provide transparency by making meetings open to public viewing and/or publishing minutes of deliberations.

> Make available information regarding advisory panel public meetings and comment opportunities on the climate.ny.gov webpage.
Evaluate the costs and benefits of recommended strategies, informed by the Value of Carbon established in accordance with Section 75-0113 of the CLCPA.

Identify measures to reduce greenhouse gas emissions and co-pollutants in disadvantaged communities.

Include climate adaptation and resilience considerations.

Consider approaches taken by different states and nations.

Identify potential sources of funding necessary to implement the recommended policies.
Scope Development – Initial Thoughts

- Clean Energy Siting
- Transmission
- Electrification of Buildings and Transportation
- Natural Gas System
- Carbon Pricing
- Downstate Peakers
- Equity Issues
- Reliability of the Future Grid – Storage, Flexible/Dispatchable Resources
- Instate Renewables
- Downstate Renewables
- "Last" Clean Megawatts (Final X%)
- Resource Transition/Ramping Fossils Down
- Encouraging the Needed Investment
- Markets for the Future (Including Resource Adequacy)
- Affordability
- Jobs/Prevailing Wage
Important Deadlines:

- **October 2020**: Work Plan finalized
- **December 2020**: Briefing on priority policies/strategies
- **March 2021**: Final Recommendations to CAC
# Timeline of Advisory Panel Work

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<tr>
<td>Finalized Work Plan</td>
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<td>Final Recommendations to CAC</td>
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<td></td>
<td>Briefing for CAC and CJWG on priority policies/strategies</td>
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<tr>
<td>External Engagement</td>
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<tr>
<td>Seek written input on priority policies/strategies</td>
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<td></td>
<td></td>
<td>Open public forum on priority policies/strategies under consideration</td>
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<tr>
<td>Collaboration with outside experts</td>
<td></td>
<td></td>
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<tr>
<td>Meetings with CJWG and EJAP</td>
<td>Seek written input on priority policies/strategies</td>
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<tr>
<td>Briefings of Council</td>
<td>Present Work Plan</td>
<td>Seek input on priority policies/strategies and progress towards Recommendations</td>
<td></td>
<td>Seek input from Council on progress</td>
<td></td>
<td>Present Recommendations</td>
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</tbody>
</table>
Next Steps
Any topic adds, at this stage of meeting?

How do we want to calendar and organize meetings?

Desired information that Panel members would like to receive?

What thoughts on our public engagement session(s)? (Must have at least one)

Interaction with the Climate Justice Working Group and the Environmental Justice Advisory Panel

Briefings for Council

Schedule and methods for exchange and review of drafts

What cross-sectoral issues can we anticipate/identify now?

Other points?
Appendix
Full Power Generation Presentation – E3
New York State
Decarbonization Pathways Analysis

Power Generation Advisory Panel Discussion
September 16, 2020
NYSERDA engaged E3 to develop a strategic analysis of New York’s decarbonization opportunities. This ongoing analytic work, initiated prior to the passage of the CLCPA, has modeled existing policies and explored additional actions needed to reach the State’s 2030 and 2050 targets and provides a starting point to inform the work of the Climate Action Council.

E3 reviewed the literature on deep decarbonization and highly renewable energy systems and gained additional insights from discussions with leading subject matter experts.

Further work will be needed to fully incorporate GHG accounting requirements of the CLCPA and re-calibrate to DEC’s forthcoming rulemaking establishing the statewide GHG emission limits.
Scenario Development

+ **Reference Case** includes pre-CLCPA adopted policies & goals, including 50x30 Clean Energy Standard, 2025 and 2030 energy efficiency targets, zero-emission vehicle mandate

+ Range of **pathways** designed to achieve CLCPA GHG targets that include CLCPA electric sector provisions (e.g., 70x30, 100x40, offshore wind & solar)

+ **Two “Starting Point” Pathways:**
  
  - **High Technology Availability Pathway:** Emphasizes efficiency and electrification at “natural” end-of-life asset replacement schedule, while also utilizing advanced biofuels, carbon capture and storage (CCS), bioenergy with carbon capture and storage (BECCS), and a high natural and working lands (NWL) sink
  
  - **Limited Non-Energy Pathway:** Accelerates electrification with more rapid ramp-up of new sales, along with early retirements of older fossil vehicles and building equipment. Additional fossil fuel displacement by advanced biofuels. Greater energy sector emission reductions in case of more limited non-energy reductions and NWL sink contribution
CLCPA directs New York State to adopt a 20-year global warming potential and incorporate upstream emissions associated with fossil fuels into its GHG emissions accounting framework.

- Work to develop this emissions accounting framework is underway. Under this new emissions accounting framework, fossil fuel use, as well as all sources of short-lived climate pollutants, which include methane and HFCs, will carry a higher GHG impact on a tons of carbon dioxide equivalent basis than in the current accounting framework used in this analysis.

With coal phased out of the electricity mix, natural gas represents primary source of emissions from power generation.

Non-hydro renewables represent small share of current generation and need to be scaled up rapidly to meet 70x30 target.

Notes: SF6 associated with transmission and distribution is accounted for in Industrial Processes in the NY GHG Inventory.
Emissions have been dropping primarily as a result of eliminating coal and reducing oil-fired generation in the New York system.

Load is projected to decline over the forecast period as a result of New York’s energy efficiency investments.

In the absence of the CLCPA, renewable capacity additions occur primarily in the 2020-2030 timeframe to meet 50x30 CES goal and technology-specific targets.
Opportunities for Decarbonization
### Pillars of Deep Decarbonization in Electricity

<table>
<thead>
<tr>
<th><strong>Energy Efficiency and Conservation</strong></th>
<th><strong>Switching to Low Carbon Fuels</strong></th>
<th><strong>Decarbonizing Electricity Supply</strong></th>
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<tbody>
<tr>
<td>+ Demand-side energy efficiency will be key to mitigating impacts of electrification</td>
<td>+ Electrification of buildings and transportation will drive significant load growth</td>
<td>+ Transforming New York’s electricity supply to a zero-carbon system will be the lynchpin of economy-wide decarbonization</td>
</tr>
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<td>+ Building shell measures and balanced heat pump adoption can reduce “peak heat” impacts of building electrification</td>
<td>+ Renewable natural gas and hydrogen can serve as zero-carbon fuels for existing gas generators, providing key source of firm, zero-carbon capacity</td>
<td>+ New York can rely on a diverse mix of resources, including wind, solar, nuclear, hydro, onshore and offshore wind, hydro, CCS, biofuels, hydrogen, battery storage, and others</td>
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Pillars of Carbon Neutrality

Energy Efficiency and Conservation
[site energy consumed per person]

Switching to Low Carbon Fuels
[% site energy consumed as electricity, biofuels, hydrogen, synthetic fuels]

Decarbonizing Electricity Supply
[% electricity supplied by wind, solar, hydro, nuclear, CCS, biofuels, hydrogen]

Negative Emissions
[total emission reductions from net land use sink, BECCS, DAC]
Opportunities to Decarbonize the Electricity Sector

+ Energy efficiency and managed electrification will be critical to mitigating load growth and “peak heat” impacts
+ To decarbonize electricity supply, New York has access to a diverse portfolio of renewable resources
+ Battery storage and demand-side flexibility can play a key role in intraday balancing
+ A number of firm, zero-carbon resources can help solve interday balancing challenges, e.g. multi-day periods of low renewable output

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Sectoral Findings
Zero carbon electricity is a lynchpin of pathways to reach CLCPA goals.
Electrification of buildings and transportation drives significant increase in electric load

- Analysis within range found in the literature, which project annual load increases ranging 20%-100% by midcentury
- Range primarily reflects extent and timing of end-use electrification, with some studies assuming lower electrification and larger role for renewable gas and/or renewable transportation fuels
To decarbonize electricity supply, New York must meet rapidly growing loads while transforming.

Battery storage and demand-side flexibility can play a key role in balancing output of high levels of variable renewables.
+ NYS shifts from summer peak to winter peak around 2040, driven primarily by electrification of heating in buildings and EV battery charging

+ Flexibility in electric vehicles and building loads can significantly reduce peak demands and the need for new generation capacity
New York State has significant potential renewable energy resources and zero-carbon technology options, as well as access to adjoining states, provinces, and regional transmission systems, which offer additional options for energy supply.

Significant in-state renewable development will require careful siting considerations.

**Upstate in 2050:**
- Land-based wind: 8.9 GW
- Solar: 36.1 GW

**Downstate in 2050:**
- Offshore wind: 15.5 GW
- Solar: 9.8 GW
Battery storage deployment will play an important role, even after accounting for declining effective load carrying capability and end-use load flexibility. Transmission investments will be needed to enable the delivery of 100% zero-emission electricity.

**Upstate in 2050:** 3.7 GW of Battery Storage*

**Downstate in 2050:** 5.8 GW of Battery Storage

*Total 5.1 GW includes existing pumped storage capacity.

Forthcoming Power Grid Study will explore transmission needs in greater detail.
As the share of intermittent resources like wind and solar grows substantially, some studies suggest that complementing with firm, zero-emission resources, such as bioenergy, synthesized fuels such as hydrogen, hydropower, carbon capture and sequestration, and nuclear generation could provide a number of benefits.  

The need for dispatchable resources is most pronounced during winter periods of high demand for electrified heating and transportation and lower wind and solar output.

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Peak Electricity Demand

- NYS shifts from summer peak to winter peak around 2040, driven primarily by electrification of heating in buildings and EV battery use
- Flexibility in electric vehicles and building loads can significantly reduce peak demands and the need for new generation capacity
- Flexible loads can also serve a similar role to battery storage, shifting demand to times of high renewables output

Note: the chart above contains a 24-hour set of hourly loads for each month, representing an approximate monthly average hourly load; as a result, the chart above will not capture seasonal peaks. The “flex down” area represents the portion of load that can be reduced in that hour and shifted to other times of day.
Next Steps
Next Steps

+ **Adding CLCPA GHG Accounting Viewpoint**
  - Upstream emissions from imported fuels
  - 20-year Global Warming Potential

+ **Review of performance and cost assumptions**

+ **Exploration of limits to bioenergy**

+ **Incorporation of Panel input into integrated, economy-wide pathways analysis**
Questions?
Pathways analysis uses bottom-up, user-defined scenarios to test “what if” questions—or “backcasting”—to compare long-term decarbonization options and allows for development of realistic & concrete GHG reduction roadmaps.

Bottom-up stock rollover modeling approach (based on EIA Nat’l Energy Modeling System and NYS-specific inputs) validated with top-down benchmarking (NYS actuals and forecasts).

Model framework incorporates interactions between demand- and supply-side variables, with constraints and assumptions informed by existing analyses of resource availability, technology performance, and cost.
Electricity Modeling Approach

- Analysis uses E3’s RESOLVE model to develop optimal resource portfolios under varying levels of decarbonization and different sectoral transformations and strategies.
- Load forecasts from PATHWAYS are fed directly into RESOLVE, which is used to analyze the least-cost resource portfolios and overall costs of electric sector transformation.
- RESOLVE modeling relies on the following key inputs:
  - **Characterization of existing generators**: NYISO Gold Book
  - **Costs of candidate resources**: NYISO Demand Curve Study (gas CCGTs and CTs); Clean Energy Standard Whitepaper and NREL Annual Technology Baseline (renewables); Lazard Levelized Cost of Storage and NYSERDA Storage Roadmap (battery storage).
  - **Fuel prices**: NYISO CARIS Study, EIA Annual Energy Outlook.

### Objective Function
- **Fixed Costs**
  - Renewables
  - Energy storage
  - EE & DR
  - Thermal
  - Transmission

- **Variable Costs**
  - Variable O&M
  - Start costs
  - Fuel costs
  - Carbon

### Decisions
- Investments
- System Operations

### Constraints
- RPS Target
- GHG Target
- PRM
- Operations
- Resource Limits
Key Takeaways

+ Achievement of emissions reductions to meet state law **requires action in all sectors**
+ A 30-year transition demands that action begin now

- Increased sales of high efficiency appliances, LEDs
- Ramp up sales of heat pump space heaters and water heaters
- Ramp up sales of electric light-duty vehicles

- 50-70% sales of heat pumps
- 85-100% sales of efficient building shells
- 60-70% sales of ZEVs in LDVs
- 1.8-2.2 Million ZEVs on the road
- 35-50% sales of ZEVs in MDV/HDVs*

- 40% renewable diesel in transportation, buildings, and industry
- Advanced bio-refining with CCS begins
- 70% Ren. 85% ZEE

- 100% sales of ZEVs in LDVs
- ~95% sales of ZEVs in MDV/HDVs*

- 60% electrified industry
- 95-100% sales of heat pumps
- 9% reduction in LDV VMT from BAU
- 60% electrified industry
- 100% sales of ZEVs in LDVs
- 95% sales of heat pumps

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- 9% reduction in LDV VMT from BAU
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- 100% sales of ZEVs in LDVs
- 95% sales of heat pumps

*Zero-Emissions Electricity (ZEE) includes wind, solar, large hydro, nuclear, CCS, and bioenergy; MDV includes buses
New York Net Greenhouse Gas Emissions for Selected Years by Scenario

Note: CO2e calculations do not fully reflect methodology required by CLCPA

<table>
<thead>
<tr>
<th>Year</th>
<th>High Technology</th>
<th>Limited Non-Energy</th>
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<tbody>
<tr>
<td>1990</td>
<td>32%</td>
<td>38%</td>
</tr>
<tr>
<td>2005</td>
<td>6%</td>
<td>30%</td>
</tr>
<tr>
<td>2016</td>
<td>31%</td>
<td>33%</td>
</tr>
<tr>
<td>2030</td>
<td>4%</td>
<td>26%</td>
</tr>
<tr>
<td>2050</td>
<td>53%</td>
<td>56%</td>
</tr>
</tbody>
</table>

Percent reduction from 2016:

- 2030:
  - Electricity: 53%-56%
  - Non Combustion and Other Energy: 4%-26%
  - Transportation: 31%-33%
  - Residential: 30%-40%
  - Industry: 6%
  - Commercial: 32%-38%
  - BECCS: 86%-97%

- 2050:
  - Electricity: 100%
  - Non Combustion and Other Energy: 47%-54%
  - Transportation: 86%-97%
  - Residential: 88%-97%
  - Industry: 81%-82%
  - Commercial: 81%-86%
  - BECCS: 81%-86%

Natural and Working Lands
# Key Assumptions

<table>
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<tr>
<th>Sector</th>
<th>Strategy</th>
<th>Expressed as</th>
<th>Reference</th>
<th>High Technology Availability</th>
<th>Limited Non-Energy</th>
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</thead>
<tbody>
<tr>
<td>Electricity Demand</td>
<td>Building Shell Efficiency</td>
<td>Efficient shell sales share</td>
<td>75% by 2030</td>
<td>85% by 2030, 100% by 2045</td>
<td>Same as HTA</td>
</tr>
<tr>
<td></td>
<td>Appliance Efficiency (non-HVAC)</td>
<td>Efficient appliance sales share</td>
<td>100% by 2025</td>
<td>90% by 2023, 100% by 2025</td>
<td>Same as HTA</td>
</tr>
<tr>
<td></td>
<td>Building Electrification</td>
<td>Electric heat pump sales share</td>
<td>6% by 2025</td>
<td>50% by 2030, 95% by 2050</td>
<td>70% by 2030, 100% by 2045*</td>
</tr>
<tr>
<td></td>
<td>Vehicle Electrification</td>
<td>ZEV sales share</td>
<td>LDA: 25% by 2025; LDT: 8% by 2025; MDV/Bus: 2% by 2050</td>
<td>LDV: 60% by 2030, 100% by 2040; Bus: 60% by 2030, 100% by 2040; MDV/HDV: 35% by 2030; 95% by 2040</td>
<td>LDV: 70% by 2030, 100% by 2035; Bus: 70% by 2030, 100% by 2035; MDV/HDV: 50% by 2030; 95% by 2040*</td>
</tr>
<tr>
<td>Electricity Supply</td>
<td>Clean Electricity Generation</td>
<td>Share of renewable/zero-emission generation</td>
<td>50% renewable by 2030</td>
<td>70% renewable by 2030, 100% zero-emission by 2040</td>
<td>Same as HTA</td>
</tr>
<tr>
<td>Technology-specific targets</td>
<td>Offshore wind capacity</td>
<td>2.4 GW by 2030</td>
<td>9 GW by 2035</td>
<td></td>
<td>Same as HTA</td>
</tr>
<tr>
<td></td>
<td>Behind-the-meter solar PV</td>
<td>3 GW by 2023</td>
<td>6 GW by 2025</td>
<td></td>
<td>Same as HTA</td>
</tr>
<tr>
<td></td>
<td>Energy storage</td>
<td>3 GW by 2030</td>
<td>3 GW by 2030</td>
<td></td>
<td>Same as HTA</td>
</tr>
</tbody>
</table>
End Use Flexible Loads

+ End use flexible loads can play an important role in renewables balancing and peak mitigation

+ We include significant amounts of flexibility in both buildings and transportation

+ We assume that by 2050:
  • 40% of space heating load can be shifted by up to 3 hours
  • 50% of light-duty EVs could charge flexibly and have access to chargers during the workday

<table>
<thead>
<tr>
<th>Sector</th>
<th>End use category</th>
<th>2030 - downstate (% flexible)</th>
<th>2030 – upstate (% flexible)</th>
<th>2050 - downstate (% flexible)</th>
<th>2050 – upstate (% flexible)</th>
<th>Hours Shiftable Daily</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>Space Cooling</td>
<td>10%</td>
<td>10%</td>
<td>60%</td>
<td>60%</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Space Heating</td>
<td>10%</td>
<td>10%</td>
<td>40%</td>
<td>40%</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Water Heating</td>
<td>10%</td>
<td>10%</td>
<td>40%</td>
<td>40%</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Refrigerators</td>
<td>20%</td>
<td>20%</td>
<td>60%</td>
<td>60%</td>
<td>2</td>
</tr>
<tr>
<td>Commercial</td>
<td>Space Cooling</td>
<td>20%</td>
<td>20%</td>
<td>60%</td>
<td>60%</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Space Heating</td>
<td>10%</td>
<td>10%</td>
<td>60%</td>
<td>40%</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Water Heating</td>
<td>10%</td>
<td>10%</td>
<td>60%</td>
<td>40%</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Refrigeration</td>
<td>20%</td>
<td>20%</td>
<td>60%</td>
<td>60%</td>
<td>2</td>
</tr>
<tr>
<td>Transportation</td>
<td>LDVs</td>
<td>25%</td>
<td>25%</td>
<td>50%</td>
<td>50%</td>
<td>12*</td>
</tr>
<tr>
<td>Other</td>
<td>Industry</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Electrification</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>12*</td>
</tr>
<tr>
<td></td>
<td>Direct Air Capture</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>12*</td>
</tr>
</tbody>
</table>

Note:
*This is a simplification for vehicle charging, electrolysis, and direct air capture. More details on the flexibility parameters and constraints of transportation, electrolysis, and direct air capture are provided in sections 7.6.3 and 7.6.4.
Low-Carbon Fuels

Advanced low-carbon liquid and gaseous fuels are key to decarbonizing sectors where electrification is challenging, such as freight transportation, aviation, marine, and high-temperature industrial applications.

“Starting Point” pathways can achieve deep decarbonization using in-state feedstocks for advanced biofuels.