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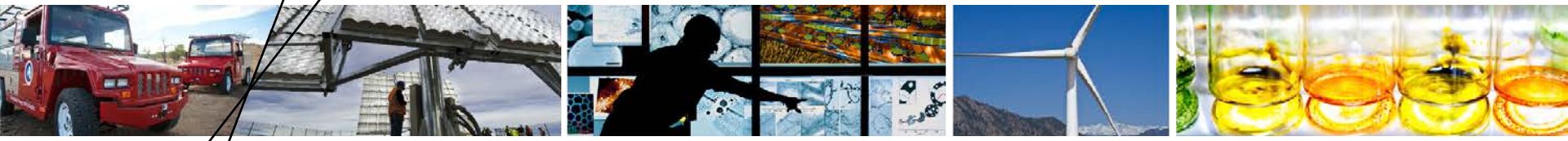
Distributed PV Adoption in Maine through 2021



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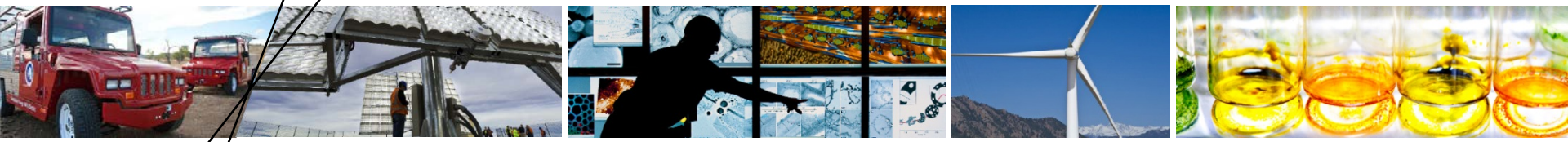

Team and Request Background

Solar Technical Assistance Team (STAT)

Who are we: The Solar Technical Assistance Team (STAT) is a DOE-funded program that gathers NREL solar technology and deployment experts to provide unbiased information on solar policies and issues for state and local government decision makers. In general, the expert assistance is intended to support legislators, regulators, and their staff members in order to develop the market for solar photovoltaic (PV) technologies.

For additional information, please visit:
http://www.nrel.gov/tech_deployment/state_local_governments/stat.html

Maine Public Utilities Commission Request

Maine PUC requested assistance from STAT. Based on scoping calls the assistance provided is as follows:

NREL will produce an analysis through the dSolar model that addresses 3 potential distributed solar scenarios projecting low, medium, and high estimates of the total installed DG Solar PV through 2021 assuming no changes in policy concerning retail rate structures, net energy billing, or other solar incentives. NREL will consult with Maine PUC to develop a set of assumptions for each scenario, which could include: solar capital cost reductions, ITC step down scenarios, load and retail rate growth forecasts, and consumer demand for solar.

Project Description

- **NREL expert staff used the dSolar (distributed solar) model to generated low-medium-high estimates of distributed PV adoption in Maine through the year 2021.**
- **This slide deck presents a high-level overview of the model and modeling results. For complete documentation of the model, see *The Distributed Generation Market Demand Model (dGen): Documentation* (Sigrin et al., forthcoming December '15) and *The Solar Deployment System (SolarDS) Model: Documentation* (Denholm et al. 2009)**

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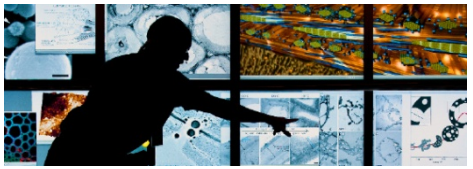
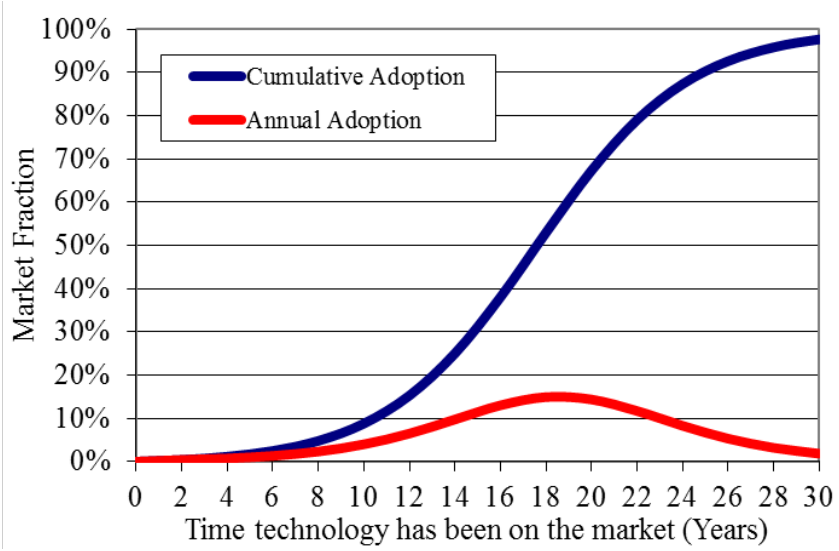


Model Background

dSolar Model Description

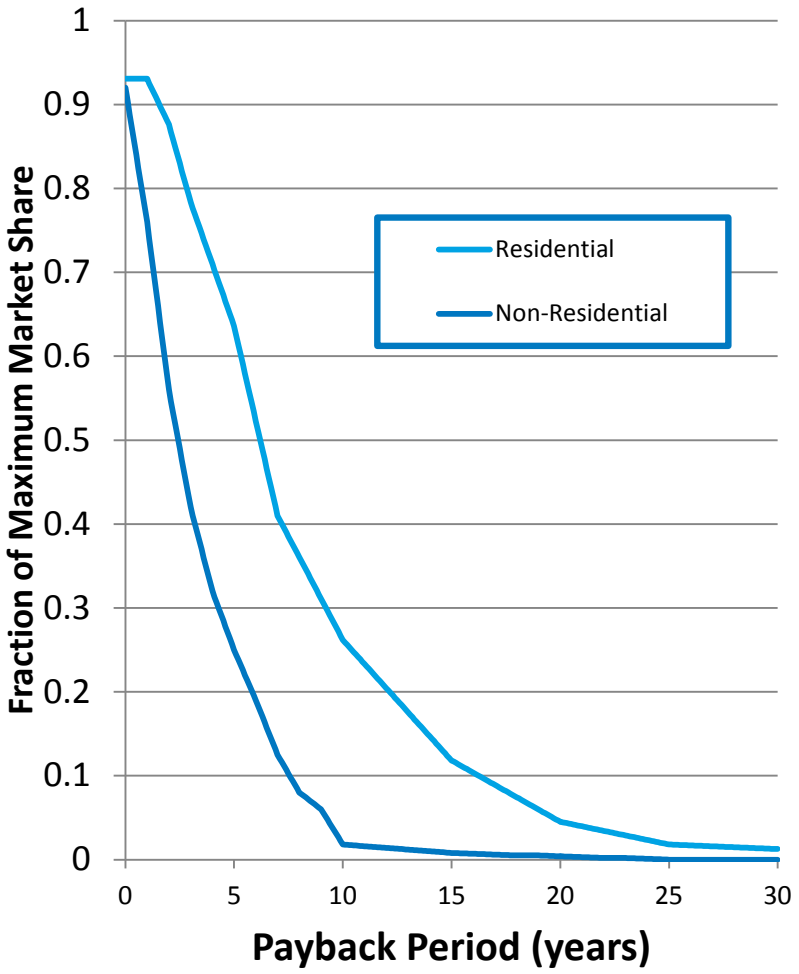
- The Distributed Generation Market Demand model (dGen) is a National Renewable Energy Laboratory (NREL) tool used for predicting the adoption of behind-the-meter PV in the continental United States.
- dGen forecasts the adoption of PV based on the Diffusion of Innovations framework popularized by Bass (1969) and Rogers (2003). The framework posits that the diffusion of a novel technology occurs in an epidemic-like fashion, where the cumulative adoption pattern follows a logistic "S-curve", as seen in the figure to the right. The curves shown are representative of the diffusion concept, and are not the shapes used in this analysis.
- For this analysis, the shape of the S-curve was tuned for both the residential and non-residential sectors in Maine, such that the curve matched historical PV adoption trends.

General Diffusion Trend



dSolar Model Description

- dSolar uses the curves shown to characterize the relationship between PV's economic attractiveness and its maximum market share. For example, with a 15-year payback, we predict 12% of possible residential customers and 1% of possible commercial and industrial customers would be willing to adopt solar PV.
- These figures set the upper bound of the S-curve curve (in red) of the previous slide. The model recalculates economic conditions for every 2 years in the forecast, and adjusts the shape of the curve (and therefore the rate of diffusion) accordingly.
- This method reflects the fact that system cost is the primary driver of PV adoption, while also capturing the non-economic considerations of customers. For example, even with long payback periods that would achieve lower rates of return than other potential investments, we would still expect a small percentage of possible customers to adopt PV. Conversely, even if the payback period is zero, we would expect a small number of eligible customers to still not adopt.
- The residential curve was generated by survey: ***Diffusion into New Markets: Economic Returns Required by Households to Adopt Rooftop Photovoltaics*** (Sigrin and Easan, 2014)
- The non-residential curve was generated through payback modeling: ***Rooftop Photovoltaics Market Penetration Scenarios*** (Paidipati et al., 2008)



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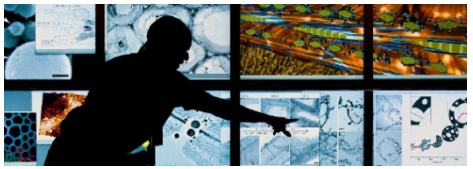


Modeling Assumptions and Results

Scenario Assumptions

Scenario	Installed PV cost trajectory	Retail electricity price	Load Growth	Investment Tax Credit (ITC) extension
Low PV adoption	50% Sunshot	AEO 2015 Low Economic Growth Scenario	No growth	Expires as planned
Medium PV adoption - ITC Expires	62.5% Sunshot	AEO 2015 Reference Scenario	AEO 2015 Reference Case	Expires as planned
Medium PV adoption - ITC Extends	62.5% Sunshot	AEO 2015 Reference Scenario	AEO 2015 Reference Case	Extended through 2021
High PV adoption	75% Sunshot	AEO 2015 Reference Scenario	AEO 2015 High Growth Case	Extended through 2021

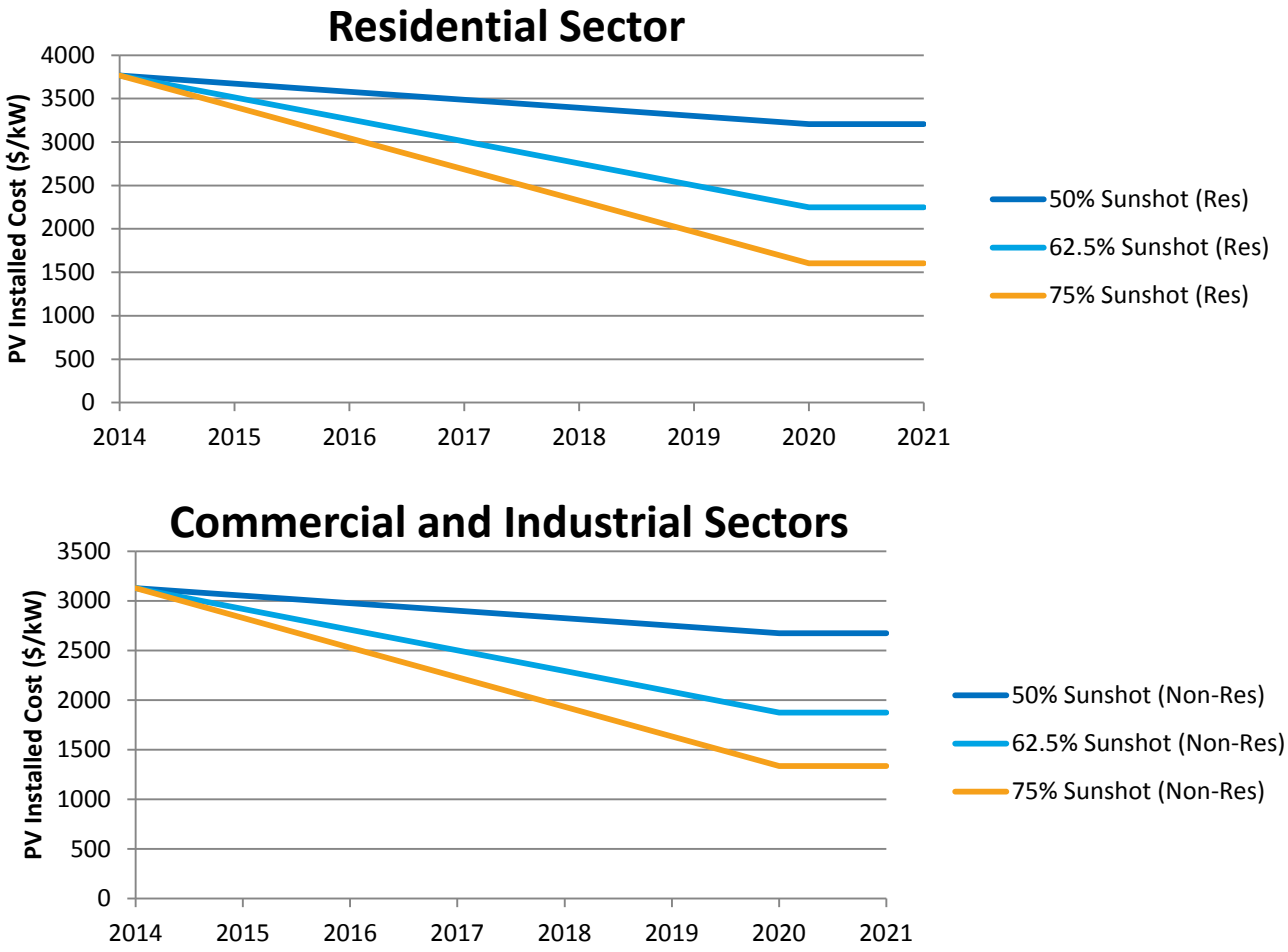
- The four varying parameters are detailed in the following slides.
- All other assumptions held constant between scenarios (next slide)

Fixed Assumptions

These assumptions are constant between the four scenarios:

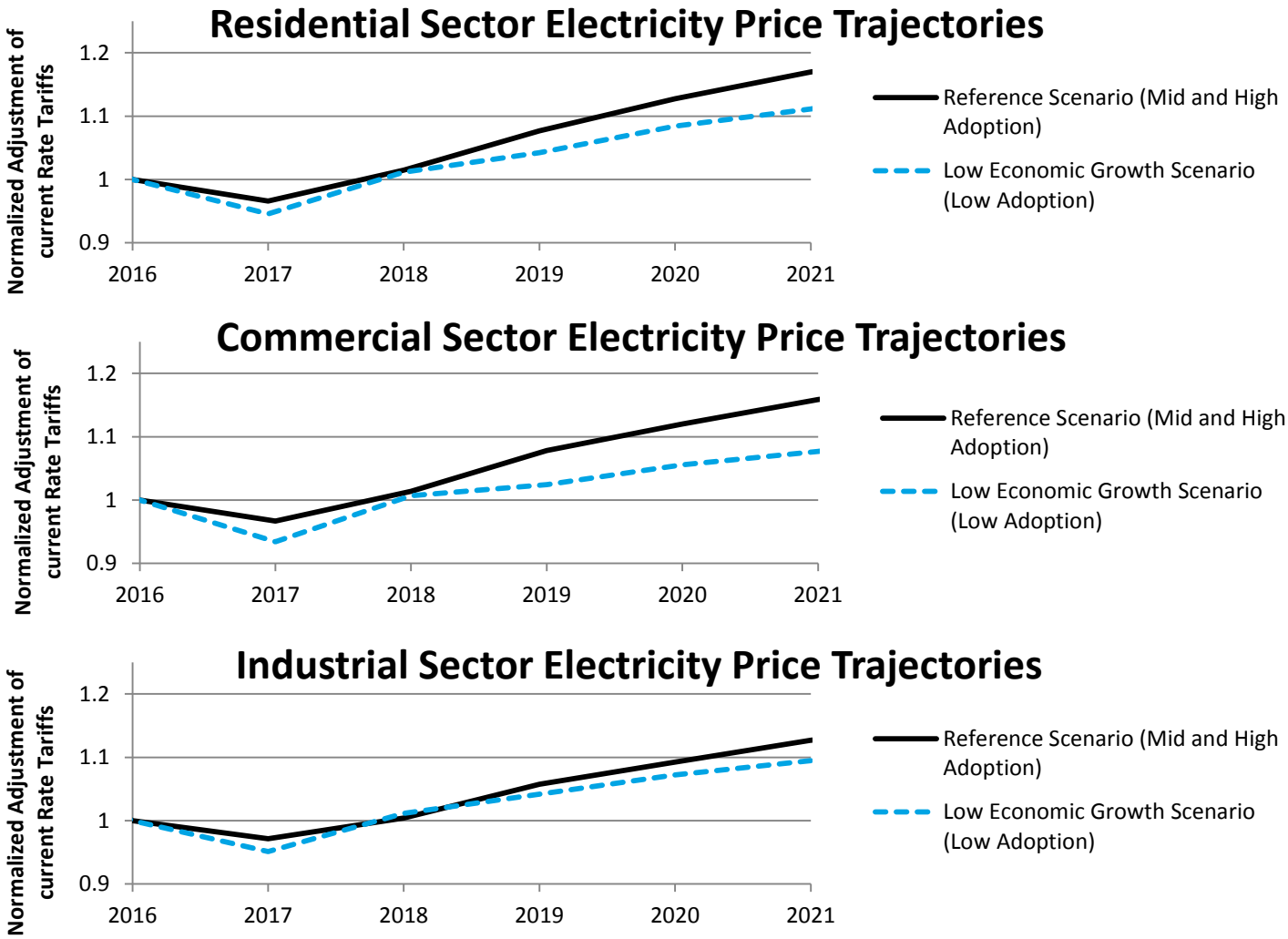
- **Residential customers evaluate economics with a 20% down payment, and finance the rest with a 15-year, 4.99% loan (PACE Loan)**
- **Non-residential systems evaluate economics with a 40% equity, and finance the rest with debt, a 20-year, 6.00% loan**
- **Only owner-occupied buildings can adopt PV.**
- **Currently net metering policies are active through 2021 in all scenarios**
- **5-year federal MACRS depreciation is available for non-residential customers. Residential customers do not depreciate systems.**
- **The maximum market share (which influences the rate of adoption) is based on the market-share-vs-payback curves shown on slide 4.**
- **PV payback periods are evaluated based on current rate tariffs in the 3 regions and no new rate structures are evaluated. Current tariffs are scaled by forecasted electricity rate changes. Rate tariffs are assigned to customers based on their characteristics (for example, a customer with a maximum demand of 500 kW would not be eligible for CMP's Medium General Service rate)**

Assumed PV Installed Price Trajectories



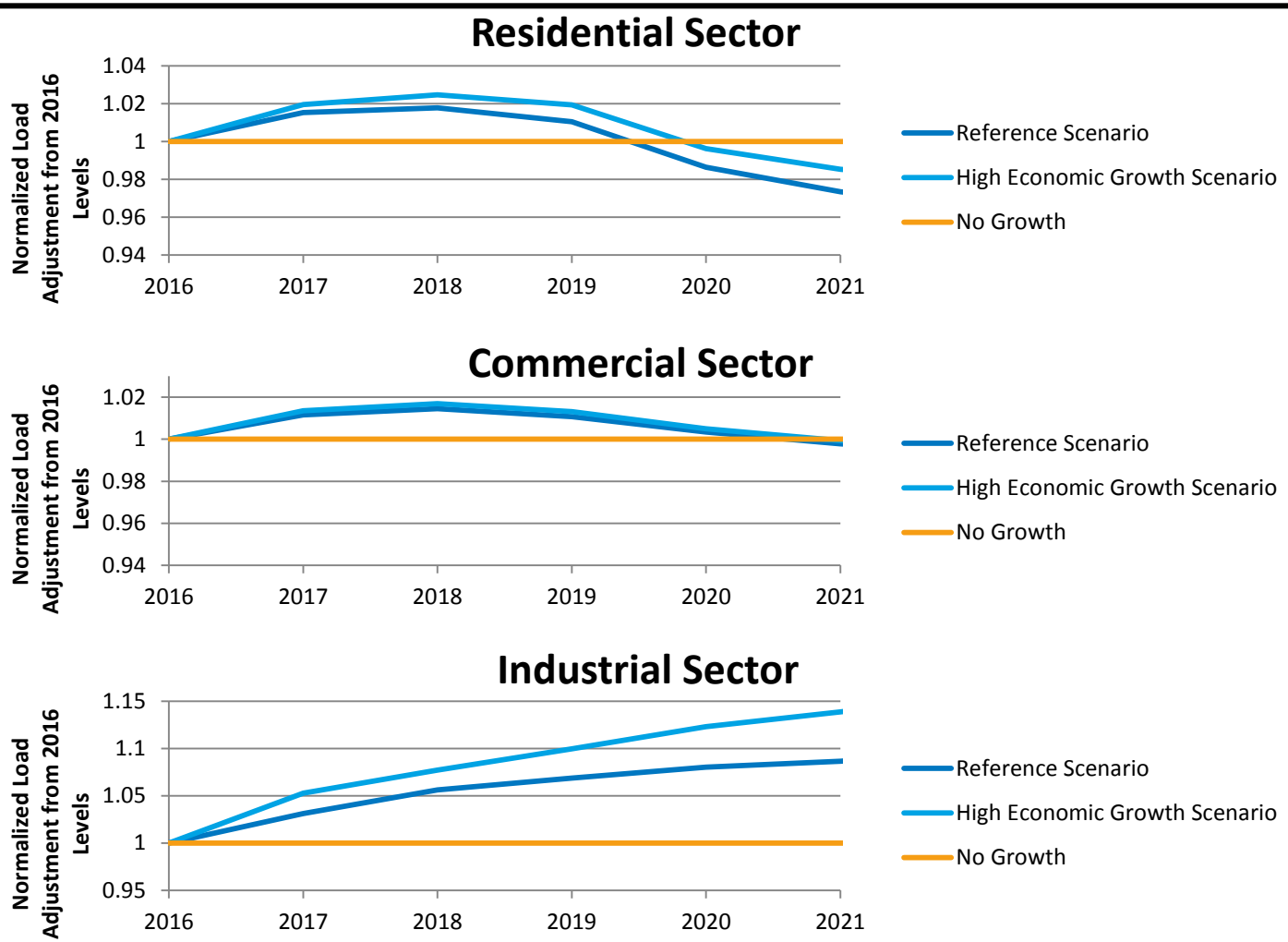
These are final installed prices of PV systems in real dollar terms. 2014 is the first simulated year, and is used to calibrate the model against historical adoption.

Assumed Electricity Price Trajectories



The model uses current rate tariffs for CMP, EM-BHD, EM-MPD, assuming the Standard Offer is taken for electricity supply. We then scale the components of the tariffs based on two of the EIA's AEO projections for New England. For example, we assume that the 2020 residential retail rates will be 113% of 2016 values in the reference case. Source: http://www.eia.gov/forecasts/aeo/

Assumed Load Growth Trajectories



Load growth is modeled by adding/removing total customers, keeping per capita consumption constant. Source: http://www.eia.gov/forecasts/aeo/

Solar Investment Tax Credit (ITC) Scenarios

ITC 'Expires' Scenario		
Year	Residential	Commercial, Industrial, and Leased Systems
2016	30%	30%
2017	0%	10%
2018	0%	10%
2019	0%	10%
2020	0%	10%
2021	0%	10%

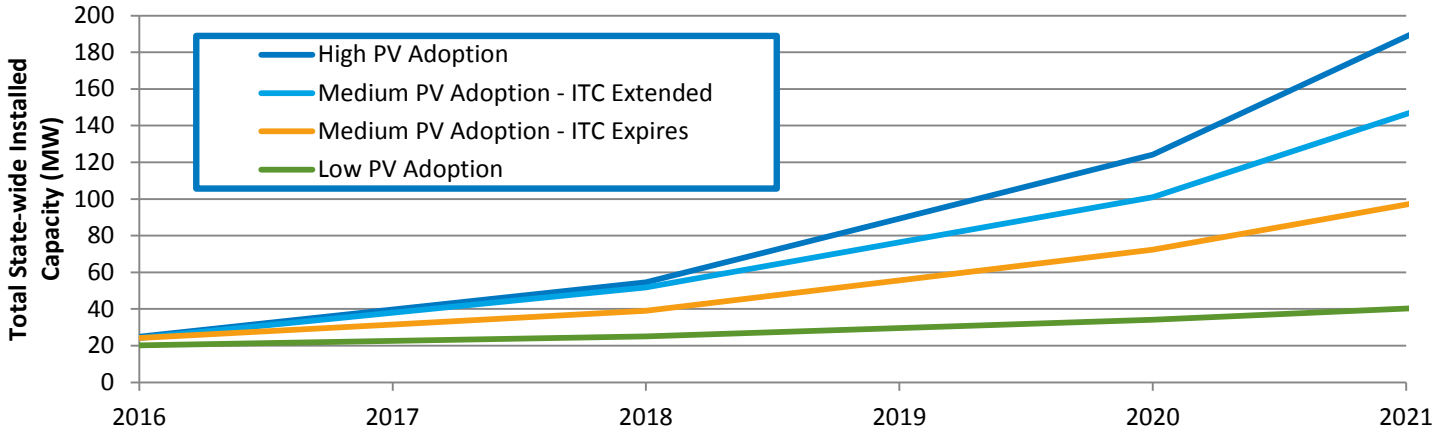
ITC 'Extends' Scenario		
Year	Residential	Commercial, Industrial, and Leased Systems
2016	30%	30%
2017	30%	30%
2018	30%	30%
2019	30%	30%
2020	30%	30%
2021	30%	30%

- The residential ITC is currently set to expire to 0% at the end of 2016. The non-residential ITC is set to be reduced to 10% at the end of 2016.
- For the ‘High PV Adoption’ and ‘Medium PV Adoption with ITC Extension’ we assume the current 30% ITC is extended through 2021.

PV System Design and Performance Assumptions

Characteristic	Value
System Size	Sized to provide 95% of annual consumption, constrained by available roof area
Module Type	Multicrystalline silicon
Module Power Density	150 W/m^2
Tilt	Follows distribution of buildings characteristics in Maine observed in LiDAR data
Azimuth	Follows distribution of buildings characteristics in Maine observed in LiDAR data
Ground Coverage Ratio	0.7 for systems on flat roofs. For systems on tilted roofs, PV installed flush roofs
Total System Losses	14.08%
Module Degradation	0.5%/year
Inverter Efficiency	95%
Inverter Lifetime	10 years
DC to AC Ratio	1.4

Results



Scenario	State-wide Installed Capacity of Distributed PV (MW)					
	2016	2017	2018	2019	2020	2021
High PV Adoption	25	40	54	89	124	189
Medium PV Adoption – ITC Extends	24	38	52	76	101	146
Medium PV Adoption – ITC Expires	24	32	39	56	72	97
Low PV Adoption	20	23	25	30	34	40