Energy Systems Integration Group 2019 Fall Technical Workshop

Opening Plenary Session: Considerations for the System of the Future

T. BRUCE TSUCHIDA

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THE Brattle GROUP

ESIG
ENERGY SYSTEMS INTEGRATION GROUP

Agenda

Past: Renewables have been growing

- Favorable policies and cost reduction
- Industry evolution
- Diversified off-takers

Future: Renewables will likely continue to grow

- Various de-carbonization regulations and aspirations
- Plausible realization via clean electricity and deep electrification
- Impacts the shape and form of energy markets (and transactions)

Implications of impacts on asset values, contract design, and performance

Past: Renewables have been growing

Favorable Policies and Markets

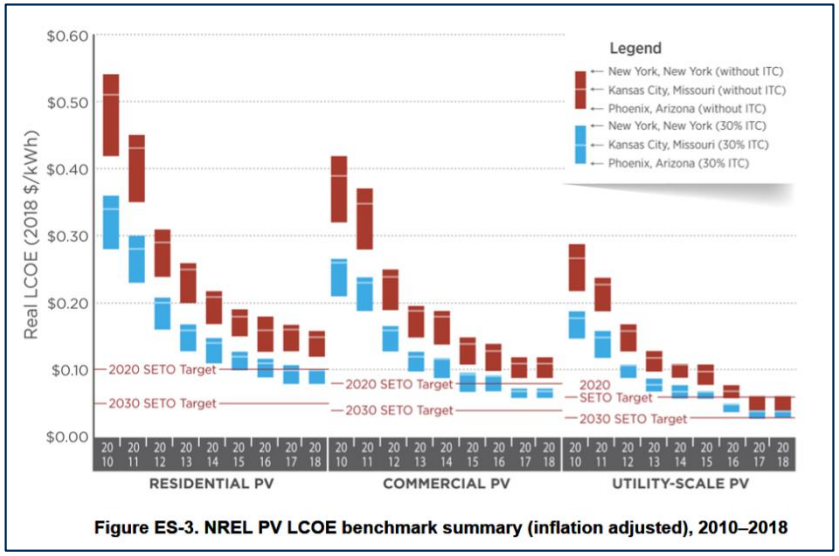


Figure ES-3. NREL PV LCOE benchmark summary (inflation adjusted), 2010–2018

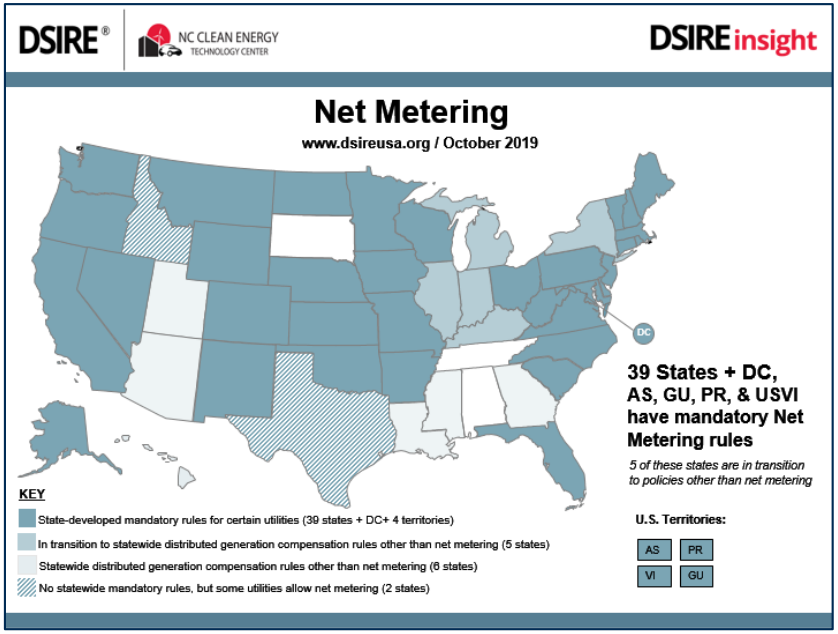
Source: U.S. Solar Photovoltaic System Cost Benchmark: Q1 2018, National Renewable Energy Laboratory

Market Forces:

- Dropping costs of renewables (~ 80% for solar PV installations, and ~40% for onshore wind over the past five years).
- Lower energy costs (partially driven by lower natural gas prices) and competition leading to lower PPAs.

Policy Incentives:

- Renewable Portfolio Standards (RPS).
- Tax Credits (Federal, State etc).
- Renewable Energy Credits.
- Other various rebates and incentives from utilities and governments.

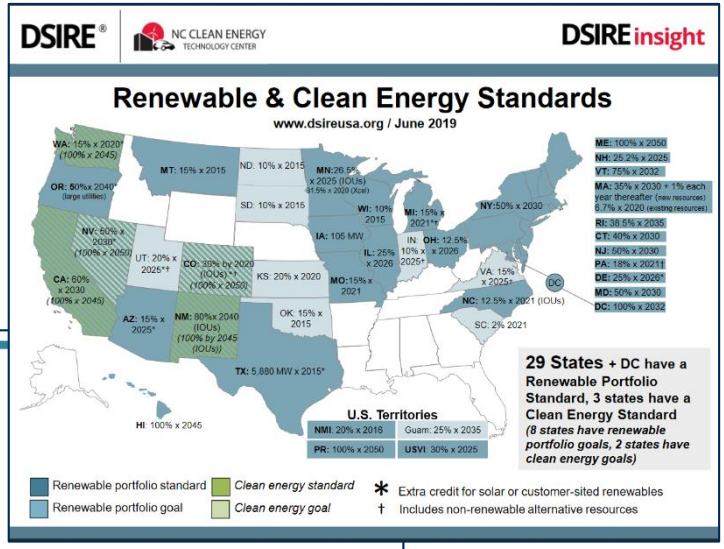


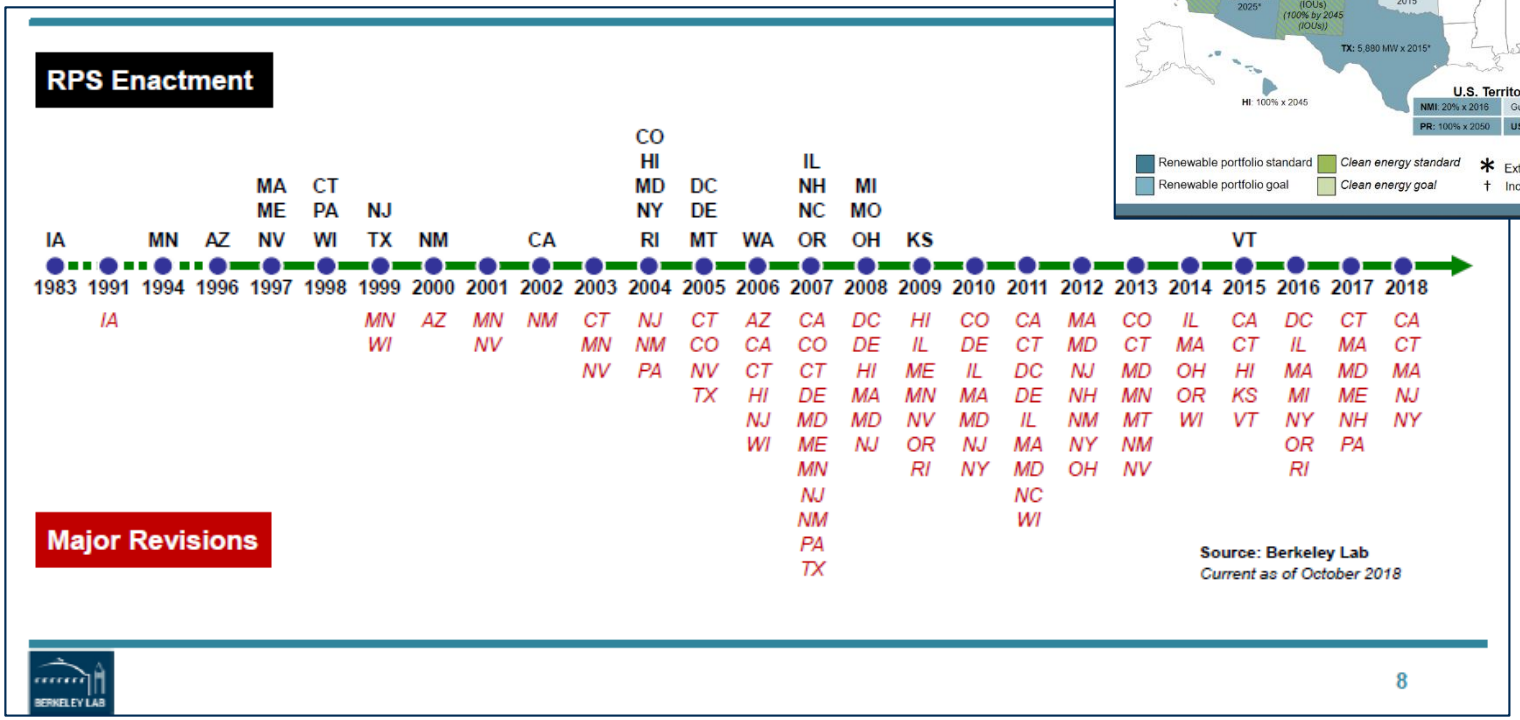
Source: https://www.dsireusa.org/resources/detailed-summary-maps/

Past: Renewables have been growing

Favorable Policies - RPS

While most RPS are at least ten years old, they are constantly being revised–oftentimes with upwards targets.





For Discussion Purposes

Sources: U.S. Renewable Portfolio Standards, 2018 Annual Status Report, Lawrence Berkeley National Laboratory, November 2018, and https://www.dsireusa.org/resources/detailed-summary-maps/

Past: Renewables have been growing

Various Non-Utility Off-takers

Non-utility off-taker examples:

- Google, Facebook, Apple, Microsoft, Amazon, AT&T, 3M, General Motors, Royal Dutch Shell, Exxon Mobile, Walmart, Various Academic Institutes, etc.

Offtaker	GW under contract	# of PPAs	% of market share (MW)
Facebook	2.2	24	14.1%
Google	2.1	15	13.7%
Amazon	1.1	14	7.3%
AT&T	0.8	4	5.2%
Walmart	0.8	10	5.1%
Apple	0.8	7	5.0%
Microsoft	0.6	5	4.1%
Exxon Mobil	0.5	2	3.2%
Equinix	0.4	3	2.4%
Zotos International	0.3	3	2.2%
Other	5.9	138.0	37.7%

Source: Wood Mackenzie

In 2018 alone, more than six GW of *power purchase agreements (PPAs)* were inked by private industry.

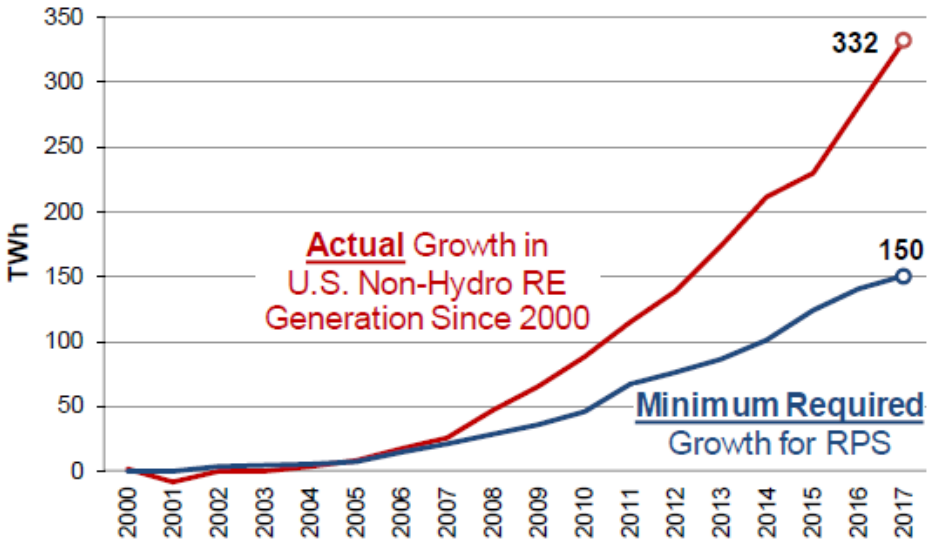
Source for figure and table: Analysis of Commercial and Industrial Wind Energy Demand in the United States, Wood Mackenzie, August 2019

Past: Renewables have been growing

Review of the Last 20 Years

Renewables (largely wind and solar) have been growing significantly.

Growth in Non-Hydro Renewable Generation: 2000-2017



Notes: Minimum Growth Required for RPS excludes contributions to RPS compliance from pre-2000 vintage facilities, and from hydro, municipal solid waste, and non-RE technologies. This comparison focuses on non-hydro RE, because RPS rules typically allow only limited forms hydro for compliance.

Source: U.S. Renewable Portfolio Standards, 2018 Annual Status Report, Lawrence Berkeley National Laboratory, November 2018

ESIG Trivia (Industry Evolution)

- 1989: Utility Wind Interest Group (6 members).

  "What is wind?"
- 2006: Utility Wind Integration Group (80 members).

  "Can we integrate 10% wind? What about 20%?"
- 2012: Utility Variable-Generation Integration Group (160 members).

  "We can get 30% wind, what about solar?"
- 2018: Energy Systems Integration Group (180 members).

Source:

For Discussion Purposes

Future: Renewables will likely continue to grow

Still Favorable Policy Outlooks

RPS goals

- States have generally met their interim RPS targets in recent years, with only a few exceptions reflecting unique, state-specific policy designs.
- Meeting future RPS demand growth requires:
  - Reach 15% of electricity sales by 2030 (compared to ~11% today).
  - Roughly a 50% increase in renewable generation by 2030 (~56 GW of new renewables capacity).

De-carbonization goals

- Several states and cities have introduced de-carbonization goals (e.g., 80% reduction from 1990 level by 2050).
- The Green New Deal calls for net-zero global emissions by 2050 and an interim target of curbing emissions from 2010 levels by 40% to 60% by 2030.
- Several utilities have committed to de-carbonization goals.
  - National Grid, AEP, Duke, NRG, DTE, etc.
- Private businesses have also committed to de-carbonization goals.
  - AstraZeneca: 16,000 EVs by 2030, Ingka Group (IKEA): 100% RE offset, Novo Nodisk (healthcare): 100% RE at all sites by 2020, Amazon (100% net zero by 2050), Nokia Corp.: realign emissions targets to 1.5 degrees-C global warming target of the Paris Accord, etc.

Future: Renewables will likely continue to grow

Clean Energy and De-carbonization

States with Clean Energy Goals/Commitments

- **California**: State-wide goal of 100% renewable electricity by 2045.
- **Hawaii**: State-wide goal of 100% renewable electricity by 2045.
- **Maine**: State-wide commitment of 80% renewable energy by 2030 and 100% by 2050.
- **Nevada**: Goal of 50% renewable electricity statewide by 2030, and 100% clean energy by 2050.
- **New Mexico**: Requires electricity generation in the state to be 80% renewable by 2040, and 100% carbon-free by 2045.
- **New York**: Mandates New York reduce 85% greenhouse gas emissions economy-wide by 2050; sources 70% of electricity from renewables by 2030 and achieves a 100% carbon-free electric sector by 2040.
- **Washington D.C.:** Committed to achieve 100% clean, renewable electricity supply across the district by 2032.
- **Washington**: Mandates an equitable transition to 100% clean electricity generation for the entire state by 2045.
- **Puerto Rico**: Established a territory-wide goal of 100% clean, renewable electricity by 2050.

Future: Renewables will likely continue to grow

Clean Energy and De-carbonization

Cities with active de-carbonization commitments

Source: https://www.c40.org/case_studies

There are over 100 cities in the US with similar commitments:

- Amherst MA, Atlanta GA, Boulder CO, Cambridge MA, Chicago IL, Cleveland OH, Cincinnati OH, Columbia SC, Concord NH, Denton TX, Denver CO, Fort Collins CO, Gainesville FL, Golden CO, Hannover NH, Hillsborough NC, Kansas City MO, Madison WI, Minneapolis MN, New Brunswick NJ, Orlando FL, Palo Alto CA, Park City UT, Philadelphia PA, Salt Lake City UT, San Francisco CA, San Diego CA, San Jose CA, Santa Barbara CA, Santa Monica CA, Spokane WA, St Louis MO, St Paul MN, Tallahassee FL, Traverse City MI, Town of Truckee CA, West Hollywood CA and more…….

Signatory Cities

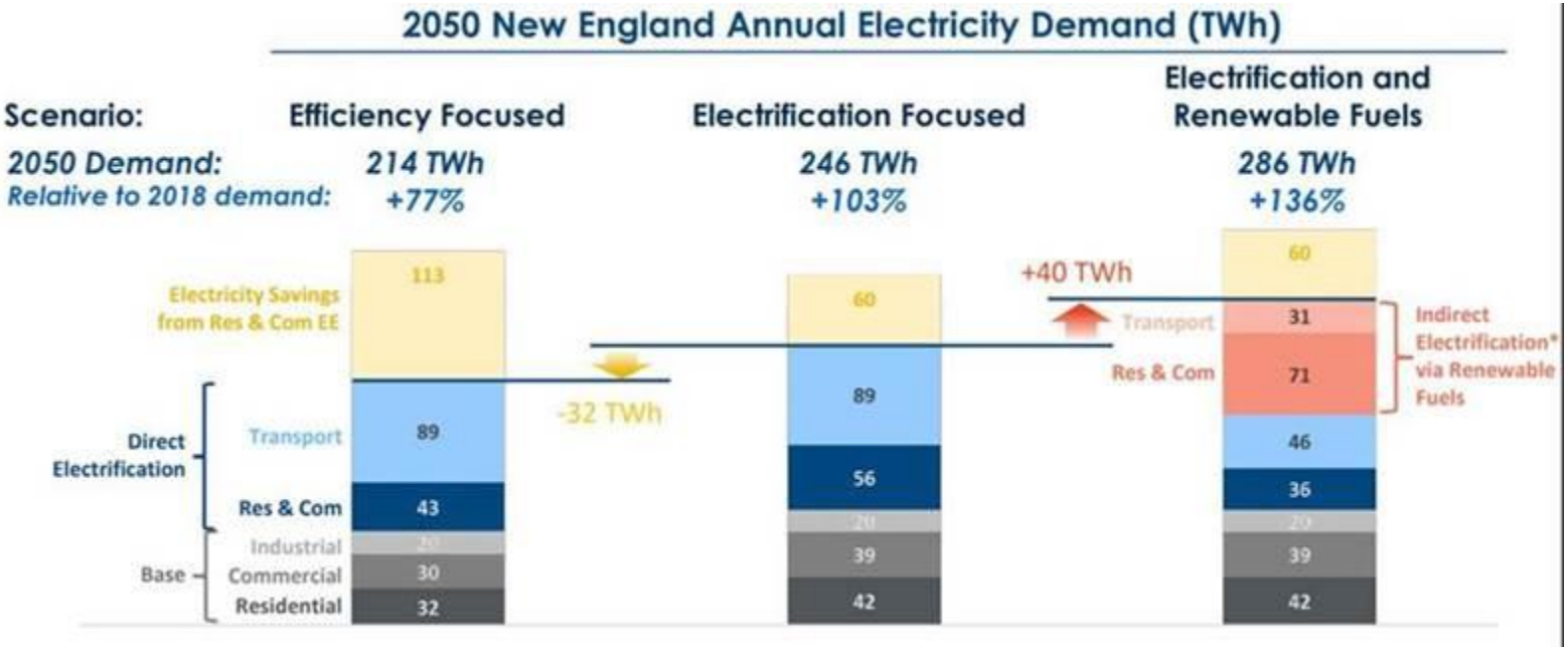
London
Amman
Austin
Barcelona
Bengaluru
Berlin
Buenos Aires
Copenhagen
Delhi
Dubai
Durban (eThekwini)
Guadalajara
Heidelberg
Houston
Jakarta
Los Angeles
Lima
Lisbon
Madrid
Medellin
Mexico City
Milan
Oslo
Paris
Portland
Quezon City
Quito
Rotterdam
Seoul
Stockholm
Sydney
Tel Aviv – Yafo
Tokyo
Warsaw
Washington DC

Future: Renewables will likely continue to grow

Clean Energy and De-carbonization

What does it look like?

- De-carbonization will likely induce huge load growth associated with electrification of load and increase in electric vehicles (unless other industry sectors figure out de-carbonization approaches outside of electrification).



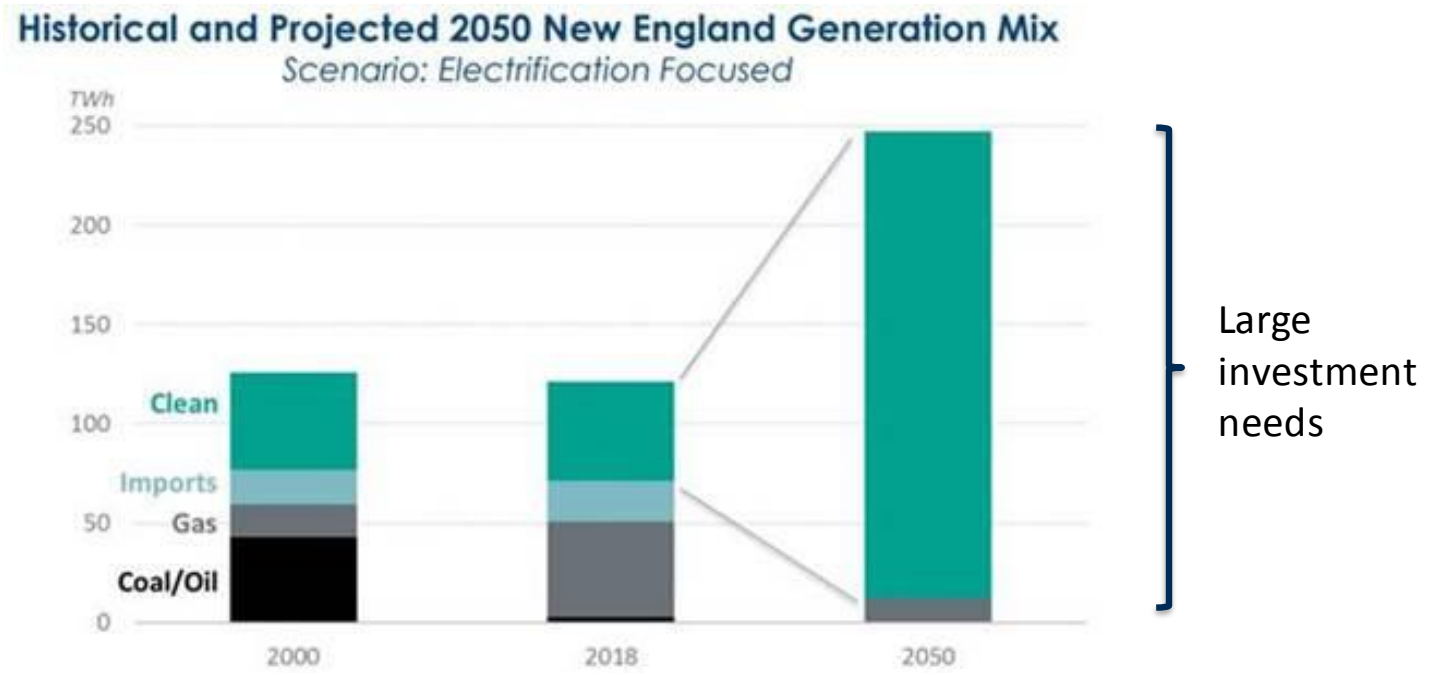
Source: :
https://brattlefiles.blob.core.windows.net/files/17233_achieving_80_percent_ghg_reduction_in_new_england_by_20150_september_2019.pdf

Future: Renewables will likely continue to grow

Clean Energy and De-carbonization

What does it look like?

- The increased load will be served largely by renewable resources (that have lower capacity values), requiring significant investments.



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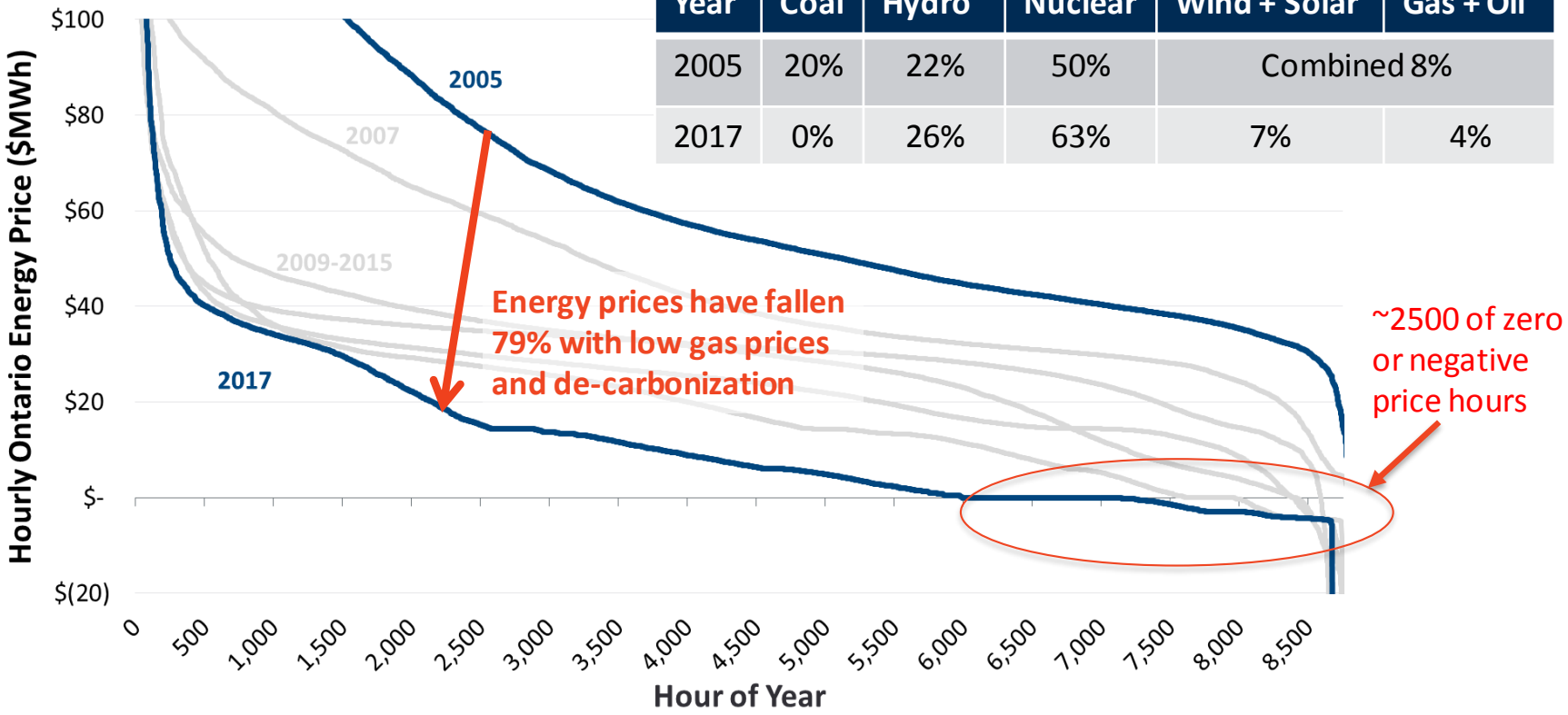
Future: Renewables will likely continue to grow

Impact on Electricity Markets

In Ontario, the power system is already at a 90% clean energy fleet—with dramatic consequences for power market prices.

Ontario Generation Mix (% of MWh)

Year	Coal	Hydro	Nuclear	Wind + Solar	Gas + Oil
2005	20%	22%	50%	Combined 8%	
2017	0%	26%	63%	7%	4%



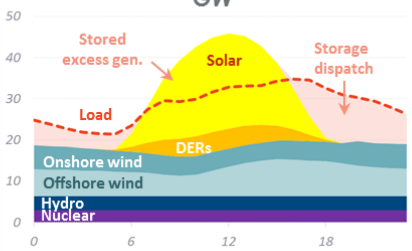
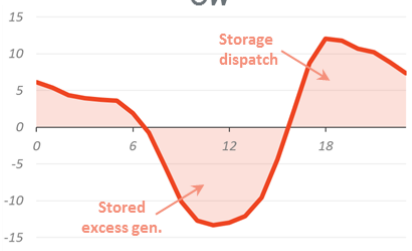
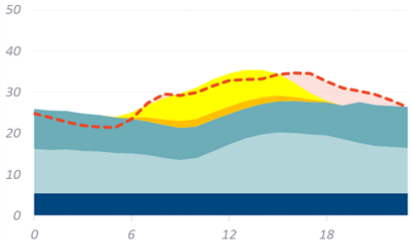
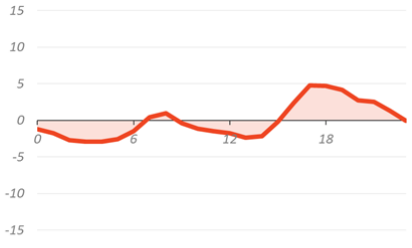
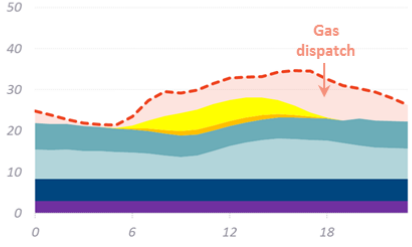
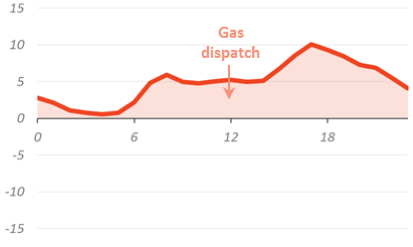
Source: http://www.ieso.ca/en/Corporate-IESO/Media/Year-End-Data

Future: Renewables will likely continue to grow

Impact on Operations

Load profiles (with electrification) are unlikely to coincide with renewable generation output, creating a huge ramping and load balancing problem (in the order of 1,000s of MW) requiring storage, load control and DR, or overbuilding (then curtailing) renewables.

Renewables and storage complement and compete at the same time.

Model Inputs	Daily Profile	Net Load
Grid 100% clean Some nuclear Solar & storage		
Grid mostly clean No nuclear Wind overbuild		
Grid only partially clean Some nuclear Wind & solar		

Seasonality and "extreme days" will be important considerations:

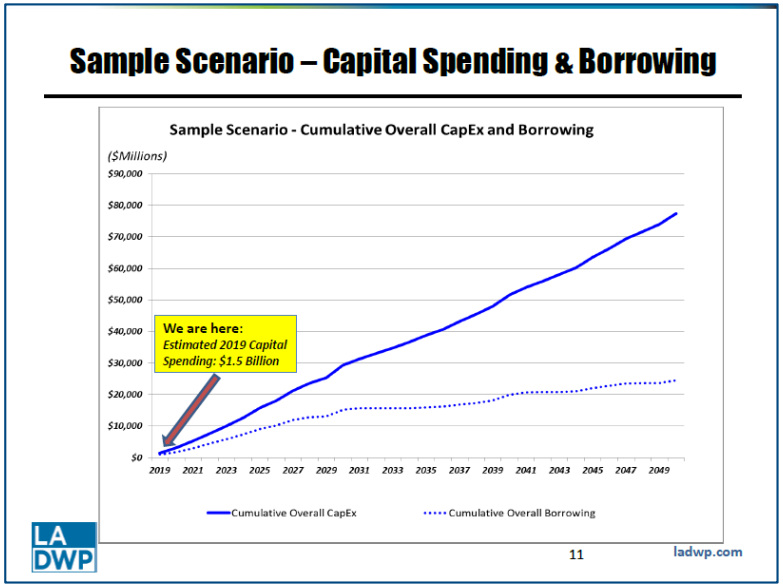
- Meeting protracted low-RE generation days (more likely in winter peak days with lower solar output) requires overbuild.
- Lower solar output indicates the need for more wind and storage during cold weather peak days.

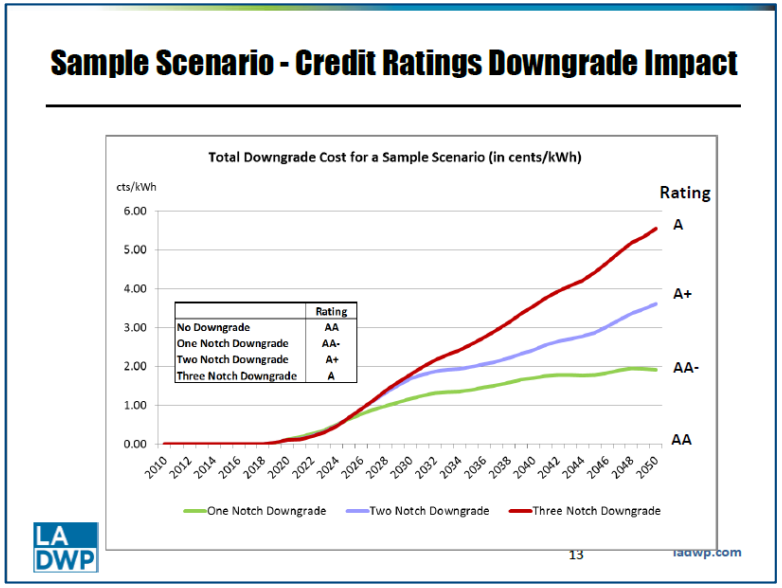
For Discussion Purposes

Future: Renewables will likely continue to grow

Impact on Utilities' Financing

Potential Impact on Rates: City of Los Angeles Example





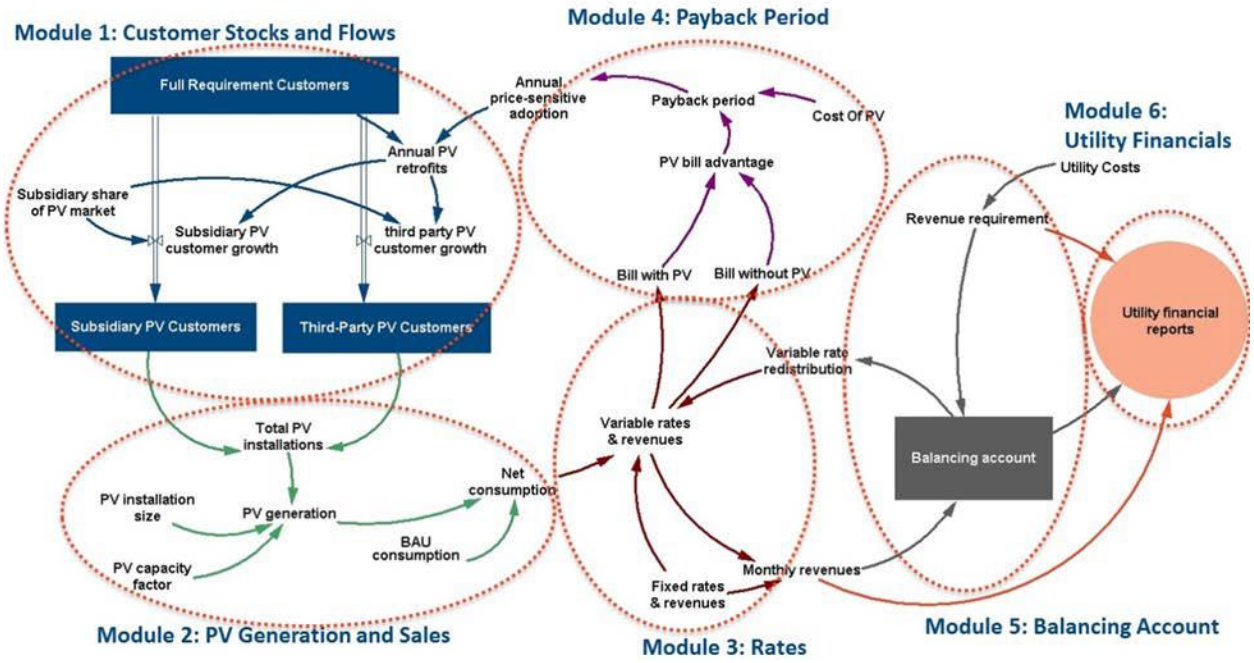
- Investment needs to reach 100% clean can be in the $70 billion range.
- The large investment (or contracts associated) could be seen as higher financial risks and impact credit ratings.
- Change in credit ratings by two notches could impact retail rates by 4 cents per kWh (roughly 20% if you assume the average residential rate to be about 20 cents/kWh)
- This impact is in addition to the rate increase associated with the new investments.

Source: https://www.ladwp.com/cs/idcplg?IdcService=GET_FILE&dDocName=OPLADWPCCB681897&RevisionSelectionMethod=LatestReleased

Future: Renewables will likely continue to grow

And the Ripple Effect on Rates

Inner-workings within a utility (illustrative example for a mid-sized US utility)



- **Increasing PV capacity factor by 2%** from 14% to 16% leads to a drop in PV LCOE and shorter payback period. This encourages more customers to adopt PV. The combined effect is the increase in rates (higher solar adoption leads to more revenue shortfall).
- Offsetting this impact through rate adjustments would require the **rate shift from 90/10 variables/fixed rate to 75/25 variable/fixed rate over a 10 year span**.

What does this mean for Renewables?

Considerations for future renewables

- **De-carbonization and clean energy goals are policy driven, rather than market driven**
  - Most de-carbonization policies aim at de-carbonizing the electric industry and then electrifying other industries (heating, transportation etc).
  - Regulatory authorities may use utilities as a contracting vehicle or create a centralized buyer (e.g., NYSERDA).
- **Energy market implications**
  - Increased renewables will lower energy prices, which helps incentivize load electrification.
  - Contracts may be more towards capacity than energy.
  - PPAs based on $/MWh sales may no longer be appropriate under such future world.
  - Storage and DR, which are often thought of as means to complement renewables today, could become a competitor.
- **Contracting Partner (Utility)**
  - Large investments (or contracts) needed by utilities could impact their ratings.
  - Lower ratings -> higher cost of capital -> higher rates.
  - Increased adoption of DERs could also impact rates.
  - Regulators want to avoid rate increases.

What should we do?

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