A Conversation on Incorporating batteries in long-term demand forecasting model

July 8th 2016

Webinar

Goal of this meeting

- Identify issues and solutions for incorporating battery technology in long-term enduse load forecast.
  - Batteries as stand-alone backup technology
  - Batteries and rooftop solar
  - Charging and discharge decision
    - Customer
    - Utility
    - 3rd party investors/aggregators?

Background
2014 Solar installs, and sell back

From EIA 861 reported Solar capacity installed, number of customers and Solar Energy Sold Back

		State											
Unit	Data	AZ	CA	CO	ID	MT	NM	NV	OR	UT	WA	WY	WECC
MW	Sum of Solar Cap Residential	314	1,593	136	2	4	34	23	35	15	29	1	2,187
MW	Sum of Solar Cap Commercial	229	705	120	2	2	41	28	33	14	7	1	1,182
MW	Sum of Solar Cap Industrial	59	494	1	-	-	1	8	2	2	0	0	567
MW	Sum of Solar Cap Transportation	-	-	-	-	-	-	-	-	-	-	-	-
MW	Sum of Solar Cap Total	602	2,792	258	4	6	76	59	71	32	36	2	3,936
Count	Sum of Solar Customers Residential	51,282	324,529	25,197	439	1,109	7,305	4,198	8,086	3,561	6,067	211	431,984
Count	Sum of Solar Customers Commercial	1,923	10,598	2,681	109	274	660	461	905	406	536	54	18,607
Count	Sum of Solar Customers Industrial	305	1,972	25	-	-	3	68	117	30	4	7	2,531
Count	Sum of Solar Customers Total	53,510	337,099	27,903	548	1,383	7,968	4,727	9,108	3,997	6,607	272	453,122
MWH	Sum of Solar Energy Sold Back Residential	46,597	10,446	1,949	-	49	3,505	355	1,064	118	9,603	82	73,767
MWH	Sum of Solar Energy Sold Back Commercial	4,511	3,558	1,146	-	78	771	34	204	1,131	2,168	28	13,628
MWH	Sum of Solar Energy Sold Back Industrial	48,722	45	130	-	-	-	24	51	31	-	-	49,002
MWH	Sum of Solar Energy Sold Back Total	99,830	14,048	3,224	-	127	4,276	412	1,319	1,281	11,772	109	136,398

Background: if information on net-metering is correct, it seems very little rooftop solar energy is put back into the grid

2014 Average installed capacity (KW) per customer	AZ	CA	CO	ID	MT	NM	NV	OR	UT	WA	WY	WECC
Residential	6	5	5	4	3	5	5	4	4	5	5	5
Commercial	119	67	45	16	7	62	61	37	35	13	10	64
Industrial	192	250	56			182	119	20	79	13	30	224
Total	11	8	9	7	4	9	13	8	8	5	7	9

2014 Average Solar Energy Sold Back MWH per Customer	AZ	CA	CO	ID	MT	NM	NV	OR	UT	WA	WY	WECC
Residential	0.91	0.03	0.08	-	0.04	0.48	0.08	0.13	0.03	1.58	0.39	0.17
Commercial	2.35	0.34	0.43	-	0.29	1.17	0.07	0.23	2.79	4.05	0.51	0.73
Industrial	159.74	0.02	5.20			-	0.35	0.43	1.05	-	-	19.36
Total	1.87	0.04	0.12	-	0.09	0.54	0.09	0.14	0.32	1.78	0.40	0.30

Energy Returned as fraction of Sales	AZ	CA	CO	ID	MT	NM	NV	OR	UT	WA	WY	WECC
Residential	0.1441%	0.0116%	0.0108%	0.0000%	0.0010%	0.0530%	0.0030%	0.0057%	0.0013%	0.0274%	0.0030%	0.0311%
Commercial	0.0154%	0.0026%	0.0057%	0.0000%	0.0016%	0.0086%	0.0003%	0.0012%	0.0102%	0.0075%	0.0007%	0.0049%
Industrial	0.3323%	0.0001%	0.0009%	0.0000%	0.0000%	0.0000%	0.0002%	0.0004%	0.0003%	0.0000%	0.0000%	0.0251%
Total	0.1308%	0.0049%	0.0060%	0.0000%	0.0008%	0.0185%	0.0011%	0.0027%	0.0043%	0.0125%	0.0006%	0.0192%

Background

GROWTH IN ENERGY STORAGE DEPLOYMENT NATIONWIDE- (GREENTECHMEDIA)

Background:
Forecast of Energy Storage suggests fast growth while costs drop - But mostly at utility scale.

According to market research firm IHS, energy storage growth will "explode" from .34 GW in 2012-2013 to 6 GW by 2017 and over 40 GW by 2022.

- 90% of 2014 energy storage deployments by capacity were in front of the meter, while 10% were behind the meter.

Cost: Declines Predicted

- Navigant: current cost 4-hr battery $720–$2,800/ kWh depending on scale (battery only $500-700)
- Oncor: $350/kWh installed cost projection based on discussions with vendors, consistent with industry sources
- Morgan Stanley: battery-only costs may reach $125– $150/kWh down from the $500/kWh
- Tesla: battery-only cost $110/kWh

Value: Residential Energy Storage Back-Up for Rooftop Solar Support

Photo SMA Courtesy PV-Tech

Background:
Use for retired batteries

Used Chevrolet Volt batteries are helping keep the lights on at the new General Motors Enterprise Data Center at its Milford Proving Ground in Milford, Michigan. Five Volt batteries work with an adjacent solar array and two wind turbines to help supply power to the data center's administrative offices. (Photo by John F. Martin for General Motors)

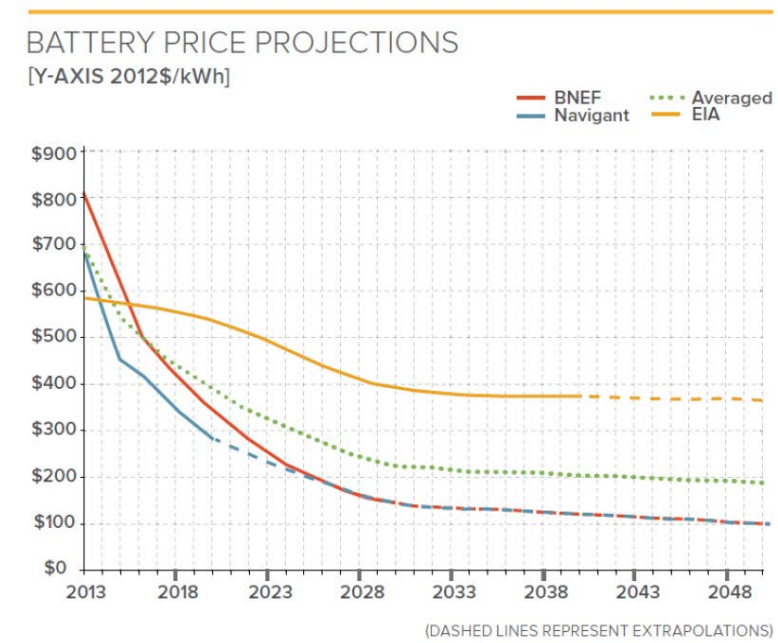
Assuming 10 year battery life.
By 2035, at the level of market penetration rate assumed in Council's EV analysis, over 4 million replaced batteries would be available for secondary repurposing.

With storage capacity 24 KWH and
Assumed 30% degradation at the time of replacement,

storage capability of the batteries about 74 GWH.

It is All about the Batteries

Figure 41: Blended Battery Price Projections



Source: Rocky Mountain Institute

Cost of battery in 2007-2010 $/KWH	$1000
2010-2014	15%
2015-2020	9%
2020-2035	5%

Batteries make up a third of the cost of an EV.

Future batteries may be more of fast charging Lithium Capacitors.

General Motors says the cost the battery cells in its 2016 EV Volt to be an *"industry-leading"* **$145 per kWh**.
A Price point that was expected to be reached by 2027.

How Solar PV was modeled in the 7th plan

- Rooftop solar was modeled as a fuel competing with grid purchased electricity.
- 2010-2014 actual installed rooftop solar capacity by sector and states was used to calibrate the model.
- Solar generation was netted out of the load.
  - Roughly 2000 MW of solar capacity was forecast to be installed over the next 20 years.
  - Analysis was done at sector and building type level.

Background on Council's Model

- Energy 2020 is a all fuels, multiple sector, enduse model
- Solar (both passive and PV) are fuel types in the model
- Model uses consumer decision making, along with historic information to forecast market share of various fuel and technologies for various enduses.
- Rooftop solar was added to the Council's model in 2012 and used to estimated range of demand reduction from installation of rooftop solar.
- 1) rooftop solar was modeled as a fuel competing with grid purchased electricity. Solar generation was netted out of the load.
- 2) Utility scale PV was evaluated as a renewable resource.

For the 8th Plan – (2020-2040)

- Incorporating rooftop solar with battery
  - Only for cases with rooftop solar
  - Charge battery using net solar (solar generation net of behind the meter load)
    - If solar generating less than load, balance is purchased from grid.
    - If solar generating more than load needs then excess is sent to battery.
      - Battery is discharges in response to:

    1. Customer peak – Myopic control with daily/weekly battery
    2. System peak – Optimal control with daily/weekly battery
    3. A combination of the two (optimal control with utility off-peak charging
    4. Other strategies??
- Incorporating battery as a backup power(enduse by itself)
  - For residential sector (most likely single family only)
    - Charge the batteries from grid during off-peak and discharge for behind the meter use during high peak. This changes the load shape for the residential sector.
    - Battery sized to daily and weekly needs

Major assumptions

- For solar generation we will be using NREL's PVWatts model for 18 different locations in the Council's footprint.
- Size of battery 7 kWh to 50 kWh.
- Cost of battery will decline using cost curves consistent with Generation Resource Advisory Committee information.
- Market penetration rates will be based on cost of purchased electricity and cost of solar + battery.
- Life of batteries 20 years but can change over-time, starting at 10 years and expanding to 20 years

Are these Profile and control options reasonable?

- Profile 1 – Myopic Control - If the consumer operates Solar and Battery with minimal control and without regard to matching the customer peak. Charging battery when the sun is out and discharging them as soon as possible.

- Profile 2 – Optimal Control - If we assume the units are operated to maximize the reduction at the time of peak, then we develop a second profile in which we only release energy when we have enough stored to maximize the reduction to the peak. This would mean storing overnight in the winter. We may want to modify the profile to insure that power is available for the near peak hours as well.

- Profile 3 – Program Control - We now have two profiles. The actual contribution to the peak will be a fraction of each profile. The fraction will depend on the effectiveness of the program in moving the discharging to the peak hour. The program could be direct utility control, time-of-use rates, information or other programs.

Next steps

- Based on feedback from today, we will incorporate batteries and their deployment strategy.
- An initial forecast of impact of batteries will be produced in 2017
  - Forecast will be by sector and building type.
- We will discuss the findings in subsequent DFAC meetings.
- Finalized model will be used in developing load forecast net of solar and battery for the 8th plan.