Pepco Holdings Inc

How to Determine the Costs and Value of Solar PV

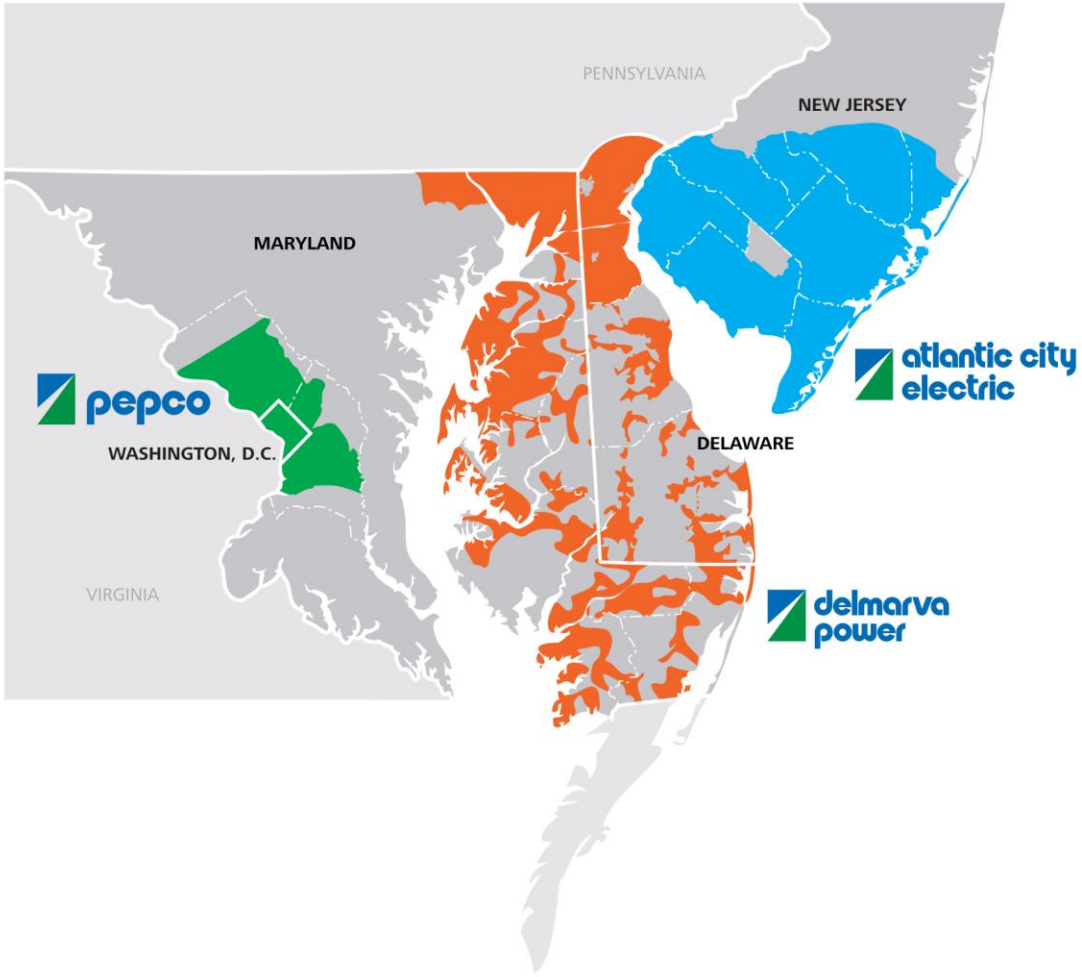
April 10, 2014

Overview

- PHI Service Territory and PV Activity
- Impact on the Grid
- Who places more demand on the Grid and who pays for grid usage?
- Short Term, Low Penetration
- Longer Term, High Penetration
- Unintended Consequences
- Conclusion

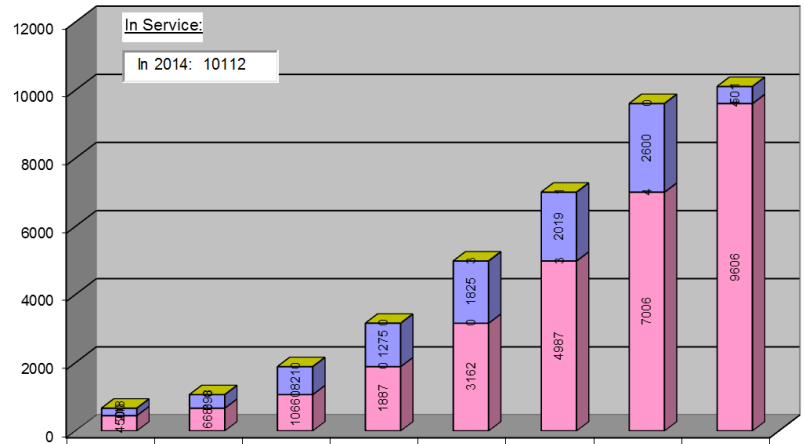
Pepco Holdings, Inc. Quick Facts

- Incorporated in 2002
- Service territory:
  8,340 square miles
- Customers served
  - Atlantic City Electric:
    - 545,000 – electric
  - Delmarva Power:
    - 503,000 – electric
    - 125,000 – natural gas
  - Pepco:
    - 793,000 – electric
- Total population served:
  5.6 million



PHI: NEM &PJM Projects In Service (Cumulative By IS Year)

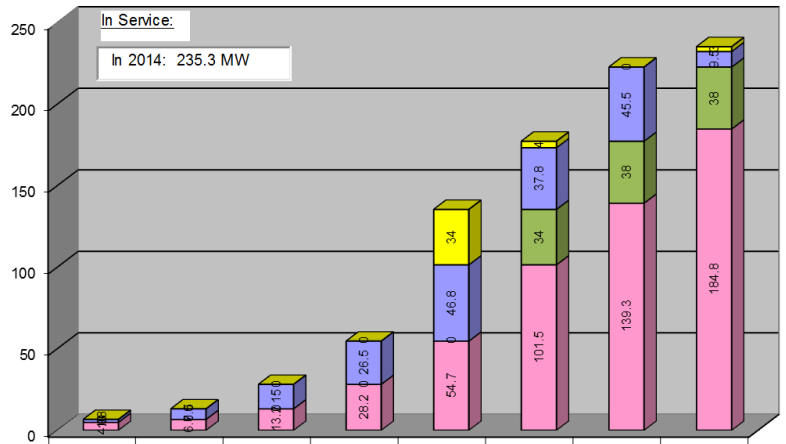
As Of: 3/3/2014



	2007	2008	2009	2010	2011	2012	2013	2014
PV-New (PJM)	0	0	0	0	3	1	0	1
PV-New (NEM)	218	398	821	1275	1825	2019	2600	501
PV-Existing (PJM)	0	0	0	0	0	3	4	4
PV-Existing (NEM)	450	668	1066	1887	3162	4987	7006	9606

PHI: NEM &PJM MW In Service (Cumulative By IS Year)

As Of: 3/3/2014

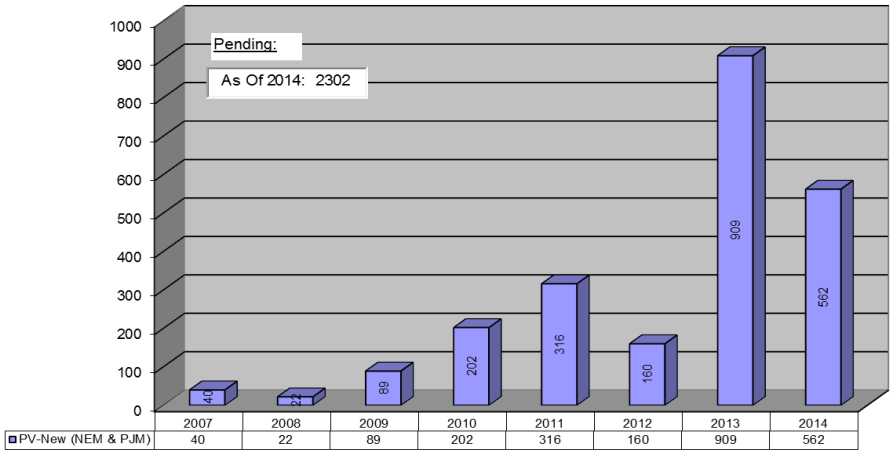


	2007	2008	2009	2010	2011	2012	2013	2014
PV-New (PJM)	0	0	0	0	34	4	0	3
PV-New (NEM)	1.8	6.5	15	26.5	46.8	37.8	45.5	9.5
PV-Existing (PJM)	0	0	0	0	0	34	38	38
PV-Existing (NEM)	4.9	6.7	13.2	28.2	54.7	101.5	139.3	184.8

PHI: NEM &PJM Projects Pending (By IS Year)

As Of: 3/3/2014

NEM= 2279

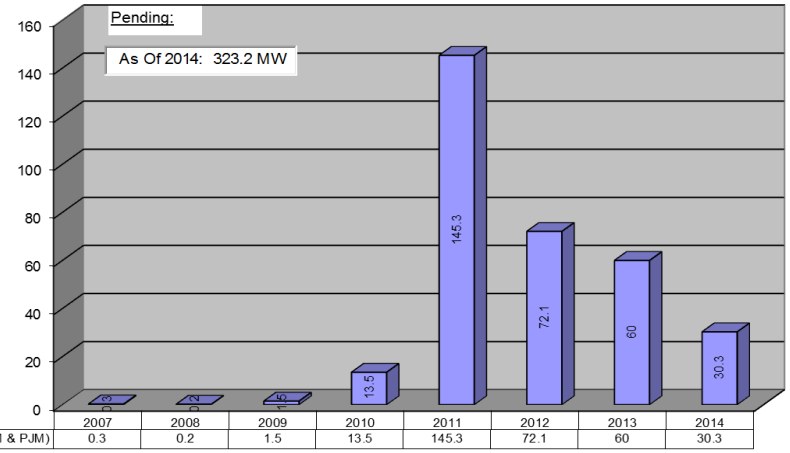


	2007	2008	2009	2010	2011	2012	2013	2014
PV-New (NEM & PJM)	40	22	89	202	316	160	909	562

PHI: NEM &PJM MW Pending (By IS Year)

As Of: 3/3/2014

NEM = 85.2 MWs

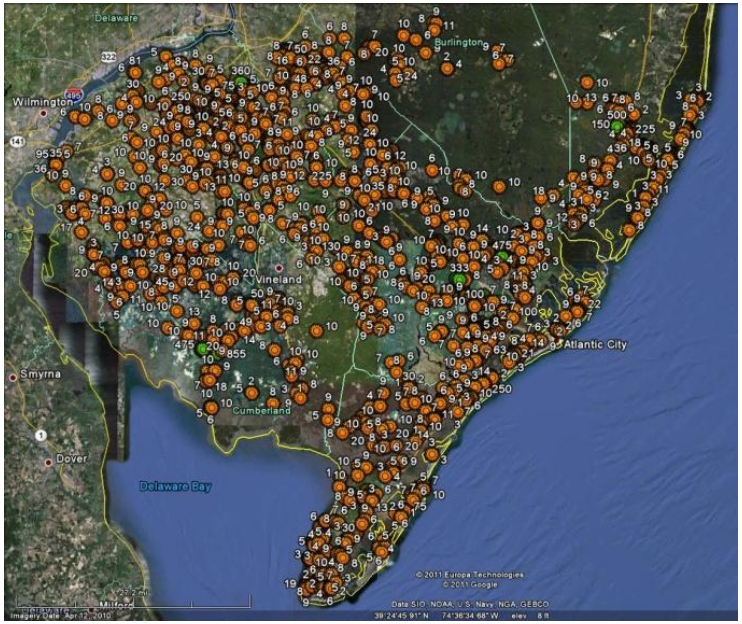


	2007	2008	2009	2010	2011	2012	2013	2014
PV-New (NEM & PJM)	0.3	0.2	1.5	13.5	145.3	72.1	60	30.3

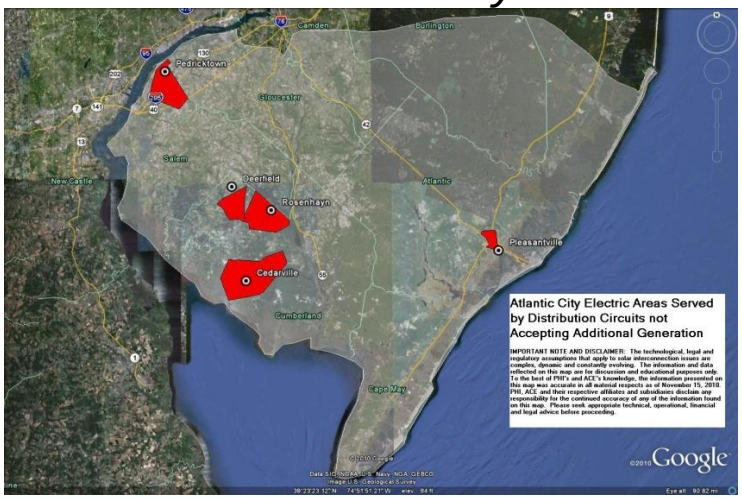
Current State

- Successfully completed the interconnection of over 10,000 customers…greater than 99% acceptance (more that 5,400 in New Jersey)
- Density of solar request requires detailed studies to prevent flicker and other power quality issues for customers on the circuit with high solar penetration (Note: high voltage complaints are on the rise)
- Saturated circuits can cause voltage fluctuations that are outside the regulated requirement
- Only 6 out of 345 circuits are closed to any new intermittent generation
- Only 2 circuits out of 461 are closed in DPL
- 48 additional circuits are restricted to solar installations 250 kW or less based on active/pending requests. These “Restricted Circuits” already have 3 MW of large (>250 kW) projects active or pending

Active Renewable



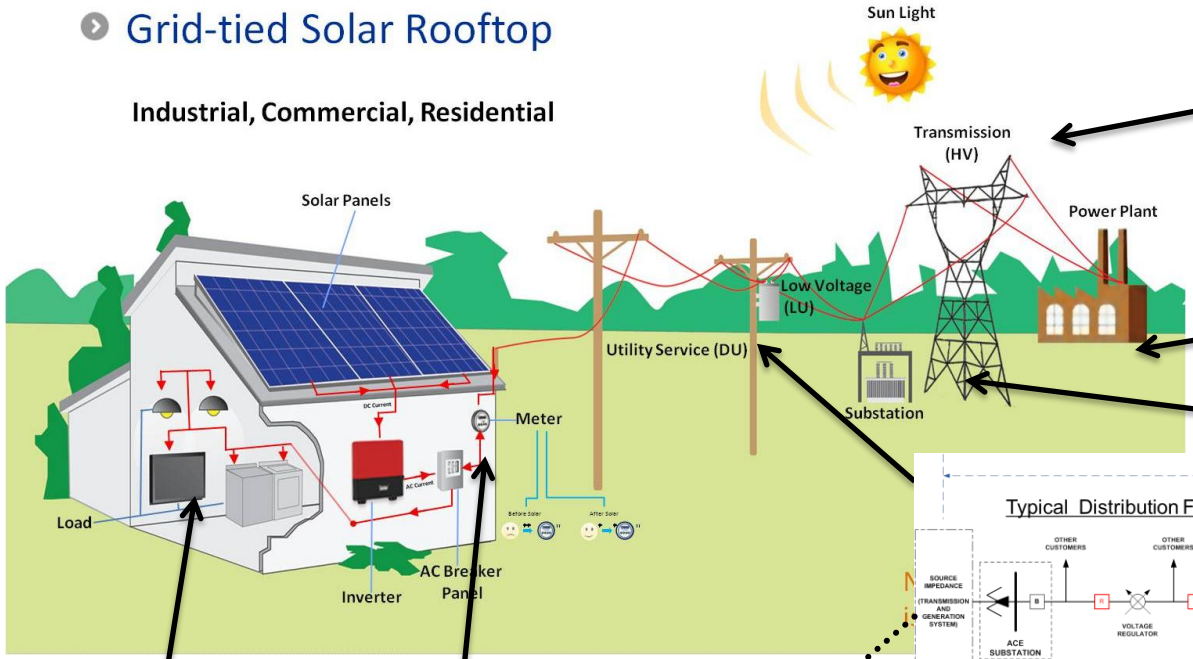
Circuits Closed – NJ ACE Service Territory

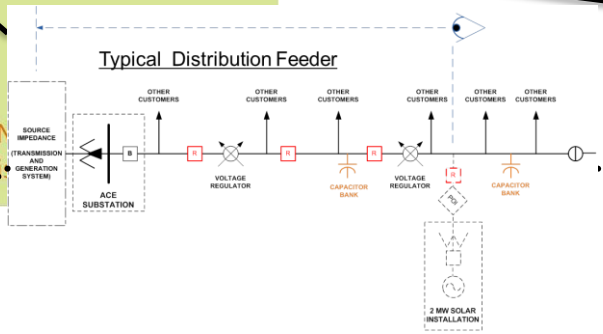


PV Affects the Entire Electric System

Grid-tied Solar Rooftop

Industrial, Commercial, Residential





Transmission

- Voltage challenges at low load.
- Near term, it will reduce losses, on high penetration losses may increase

Generation

- Scheduling changes required to meet volatile load.
- May increase need for ancillary services.
- Steep ramp rate when sun goes down affects capacity needs

Fdr & Substation

- Increase phase unbalance for three phase circuits.
- Capacity spikes may overload equipment.

Home Power Quality

- Higher voltage caused by generation reduces efficiency of appliances and HVAC,
- Can stress appliances or motors.

Interconnection Pt.

- Inverters trip or cloud shear can create volatility
- Must maintain voltage within mandated bands.
- Net metering masks true load demand.

POI

- Every POI requires study to determine impacts to the system and other customers
- The customer is required to pay for the upgrades

Dist. Automation

- PV can prevent DA schemes from locating fault
- True load to be transferred not easy to calculate

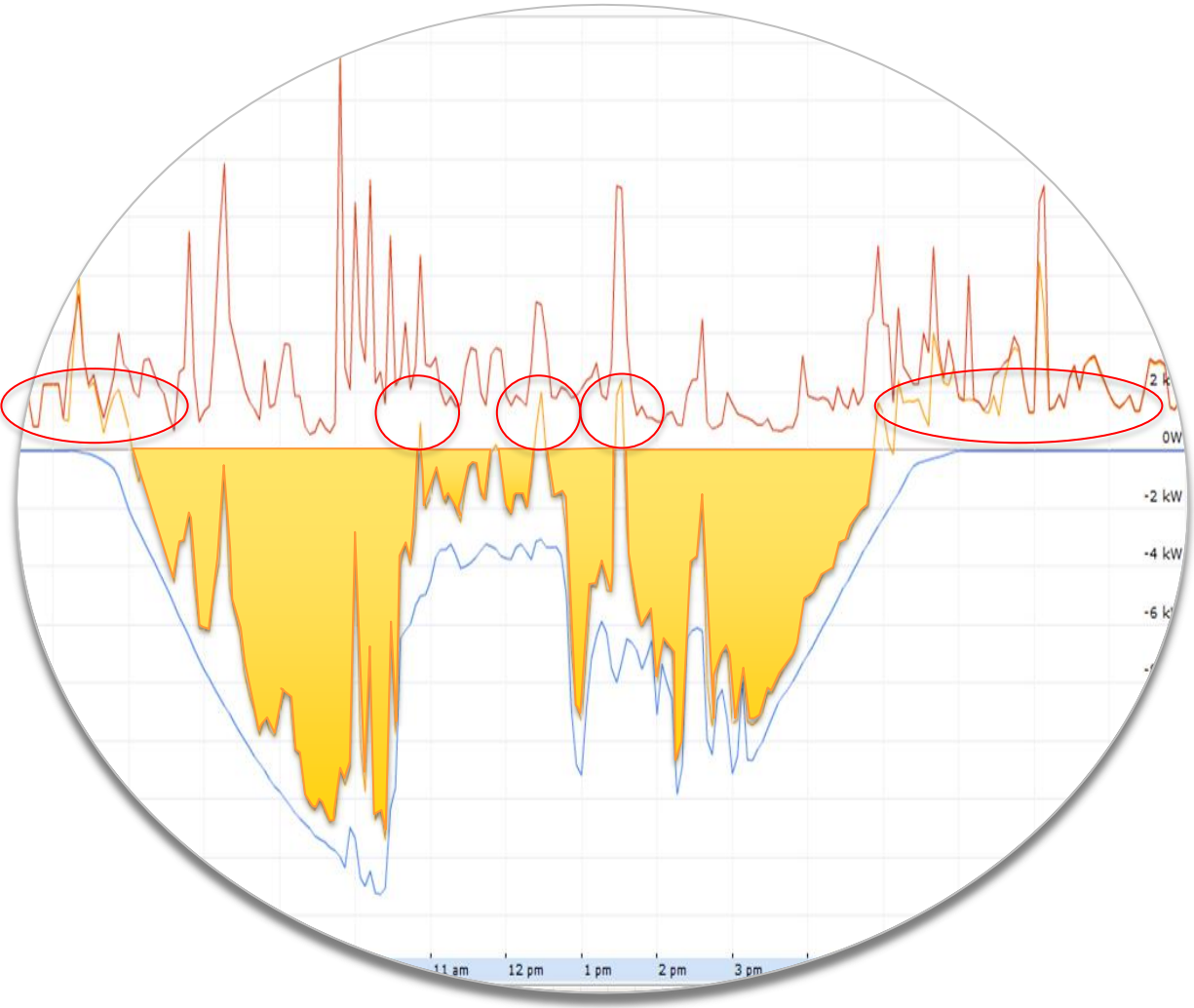
Voltage

- High or low voltage can result in mis-operation, damage, or reduced equipment life – both on the grid or at premises

Safety

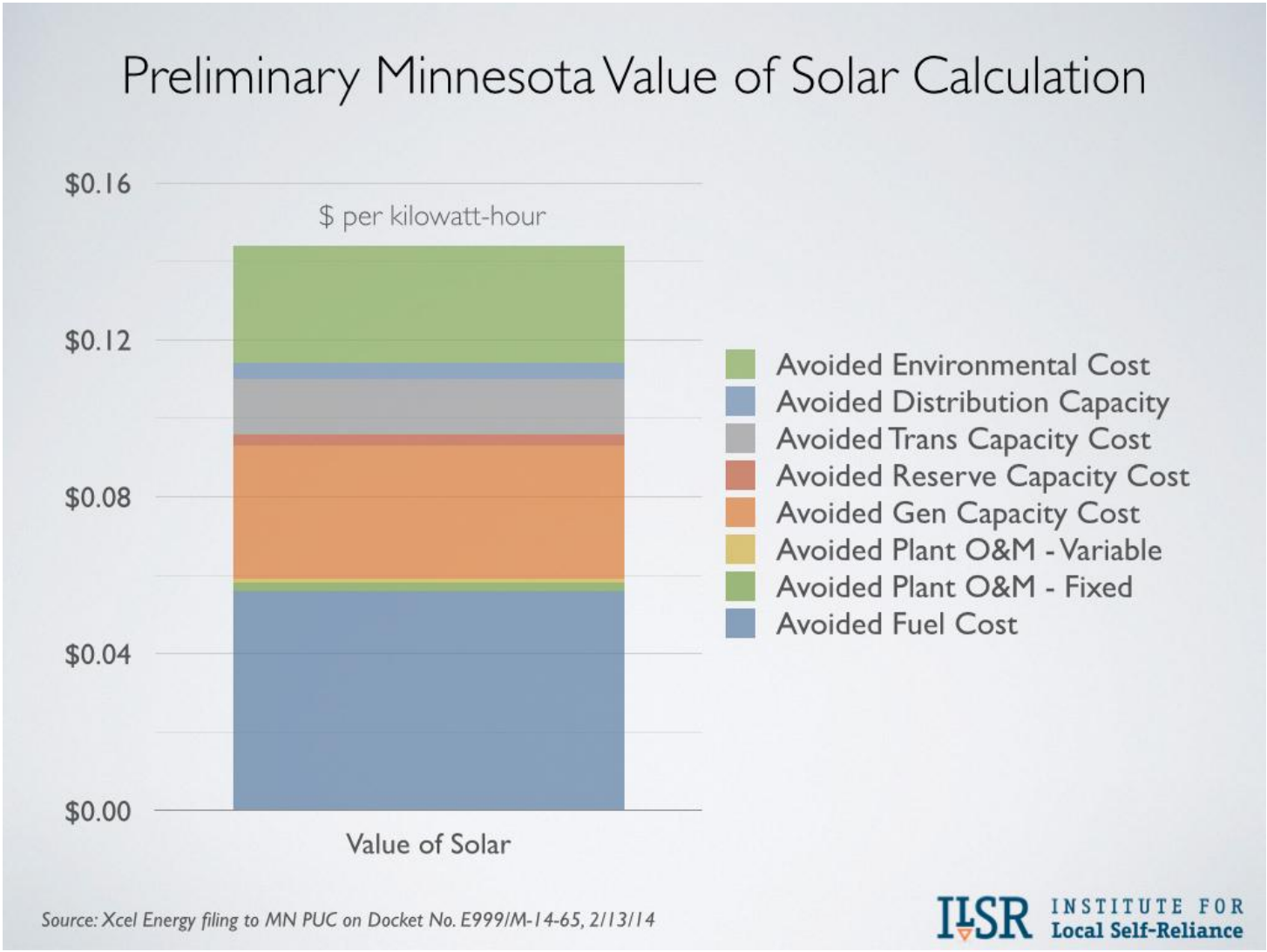
- Can increase fault current level
- Trip of breaker or recloser may result in inverter out of synchronization
- Reduction of protective reach

Who uses the grid more? A cost being avoided by NEM PV.



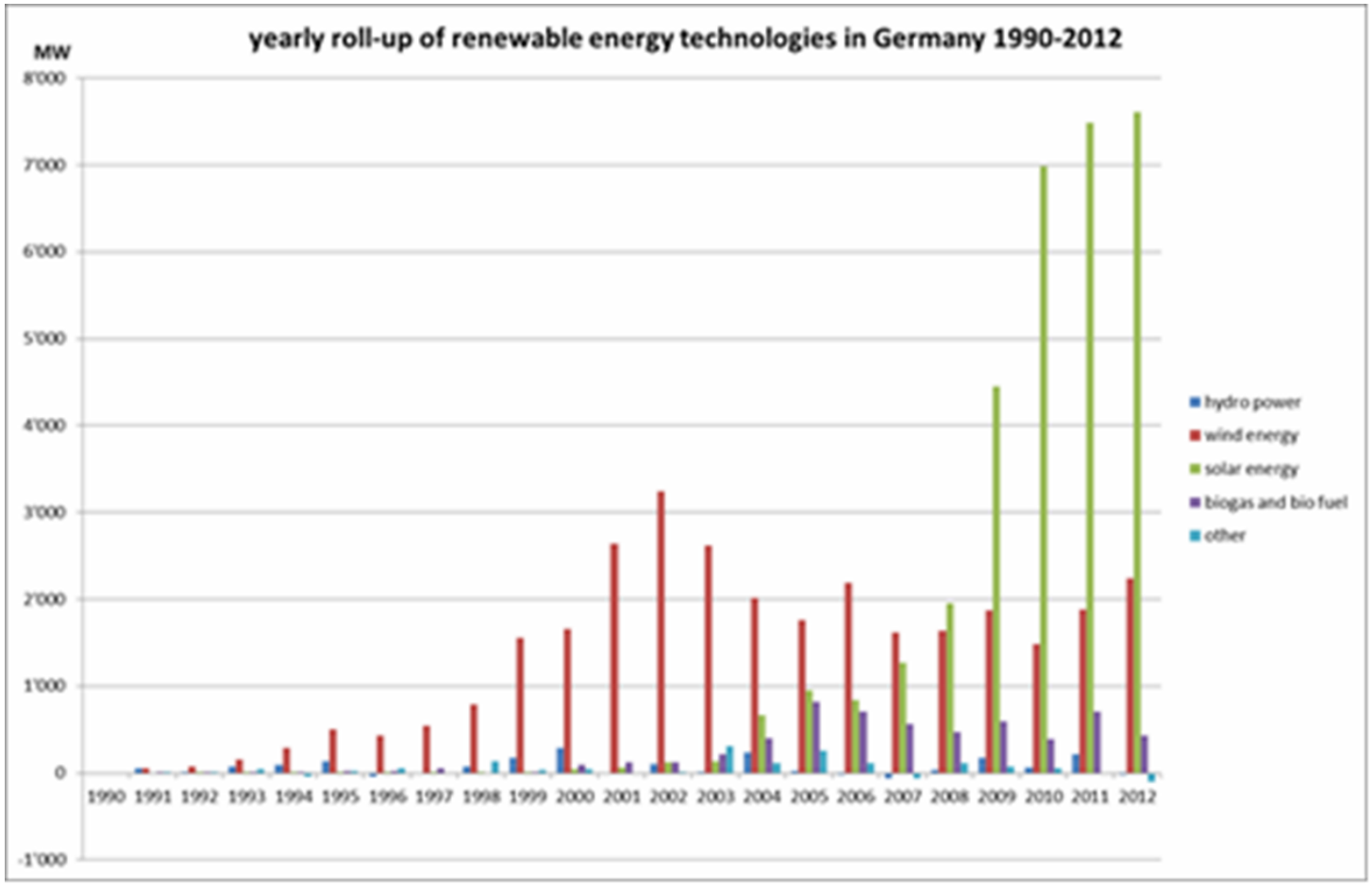
- Voltage Regulation
- Starting Current
- Power Quality
- All equipment & maintenance to deliver power both directions
- “Storage”
- Energy Transactions
- Ancillary Services
- Reliability – Synchro Signal, night, clouds

“Short Term – Low Penetration”



From “Could Minnesota’s “Value of Solar” make Everyone a Winner?

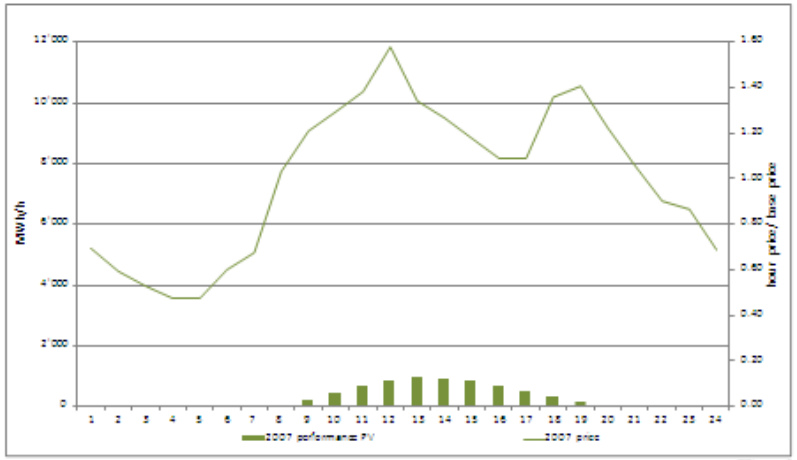
Longer Term – Higher Penetration -- Germany



Source: German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety and Finadvice

How adoption has effected the price of electricity

2007: Annual performance PV and power price (standardized)



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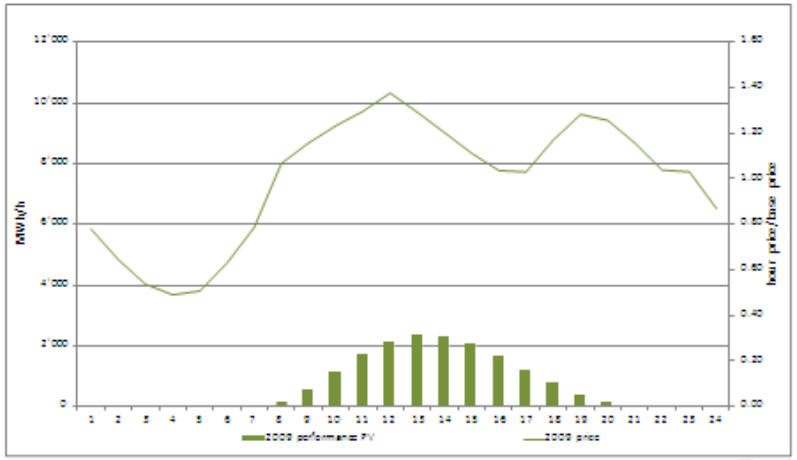
2009: Annual performance PV and power price (standardized)



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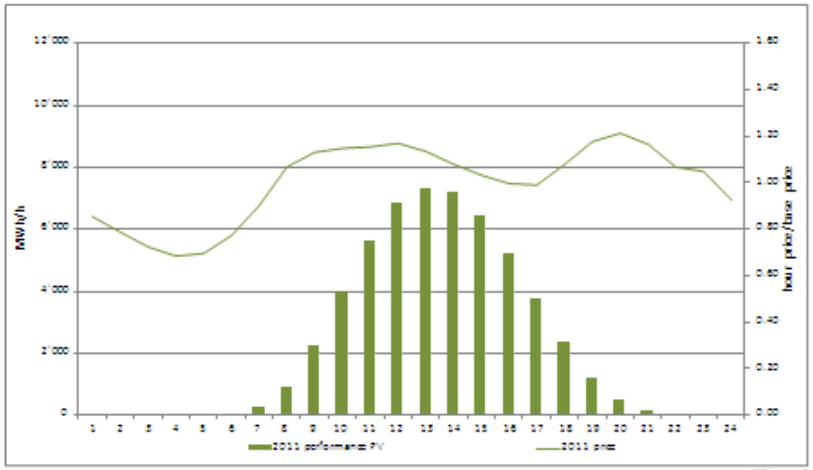
2011: Annual performance PV and power price (standardized)



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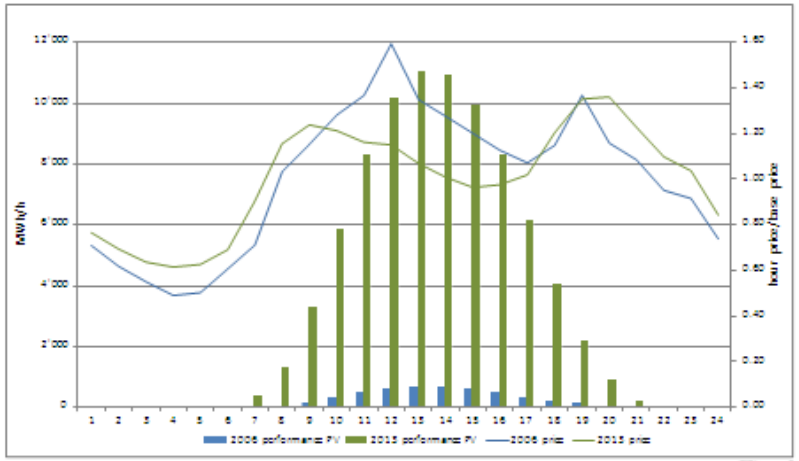
Comparison Annual performance PV and power price (standardized) 2006/2013



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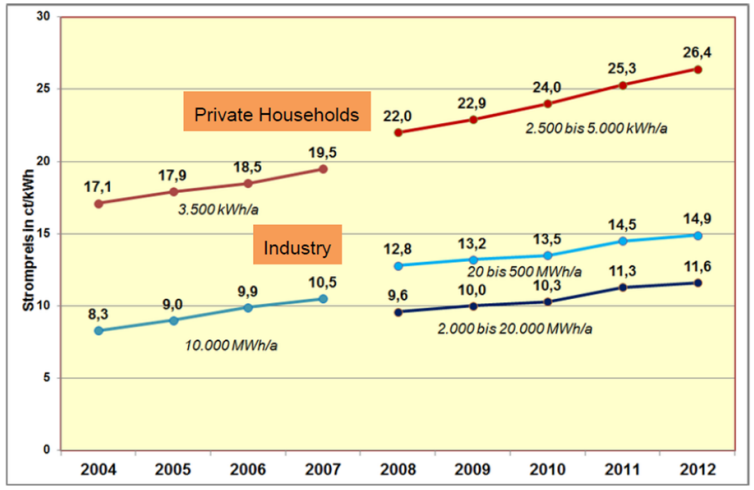
Impact to the Cost of Electricity

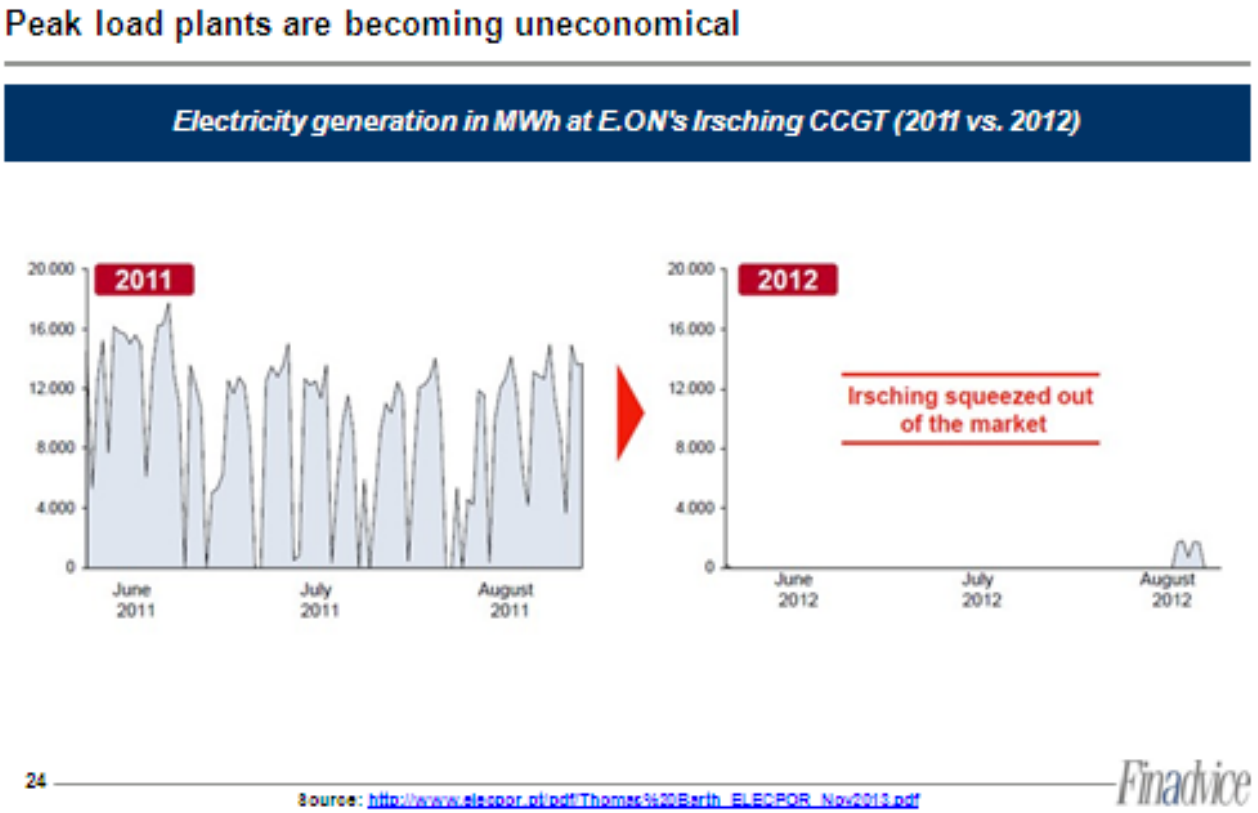
- As expected there are times when the cost has come down – where solar output and peak demand coincide.
- There are also the periods when PV doesn't output, that have increased since much of the generation fleet has retired.
- The unintended consequences must be studied because they aren't immediately obvious and certainly aren't obvious when thinking in terms of the short term and low penetration.
- Price for manufacturing is getting so high that they are either considering moving out of Germany or providing their own generation.
- The cost increases also impact those without the means to install solar systems of their own.

Comparison Electricity Price for Households and Industry (ct/kWh)



Traditional “Clean Capacity” driven out of business

Traditional thermal plants, equipped to run during the daily peak hours, now have only short intermittent time periods they need to run and so they are shut down. In Germany, a brand new 60% efficient natural gas Combined Cycle Gas Turbine came on line in 2010, but was idled by 2013.



Impact on Emissions

- We saw how some of the traditional plants that would run 10-12 hours were forced to shut down – they now have minimum run hours, higher fixed costs and couldn't operate effectively for the short intermittent periods

- What this left were those plants with very low fixed and variable costs that could fill in the gaps more effectively – the dirtier plants. Brown coal is cheaper than natural gas so that plus intermittency is impacting what plants are able to run.

- Emissions are up about 40% in Germany

Potential Impact on Combined Heat and Power

- In the PHI service territory in New Jersey, there are about 600 MWs of heat and power plants used for industry. The minimum load for Atlantic City Electric was around 1000 MWs but has dropped. Although we have not reached 400 MWs of PV in southern New Jersey, and the system is tied into the “bigger” PJM system, it is easy to see how a higher penetration of PV could impact the operation of some of the above plants.
- PV goes in as “must run” and at low penetration, that makes sense, but at higher penetrations, that may not make sense.
- Several states are providing incentives for companies to install CHP (smaller systems).
- Germany now pays Poland to take excess power from them at times.

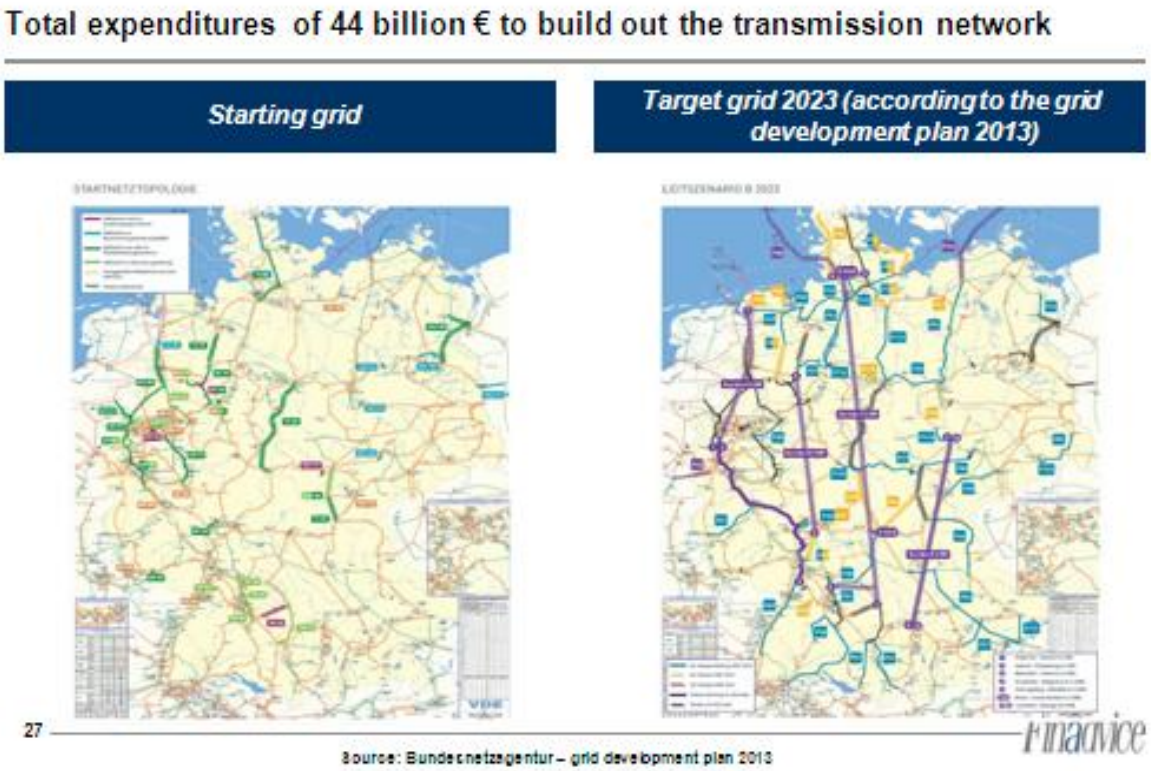
Impact to Distribution Costs

- Germany has some significant voltage regulation issues and has asked the Local Distribution Companies to replace the distribution transformers with voltage regulating distribution transformers as needed even though quite expensive.

- Germany has also embarked on an effort to change out many inverters (that change solar DC output to AC) at a cost of about $300 million.

Needed Transmission Upgrades

- Germany has significant wind power installations at the coast. Due to the concentration of wind and the penetration and location of PV, they must now build transmission lines to get the wind power to the south of the country.

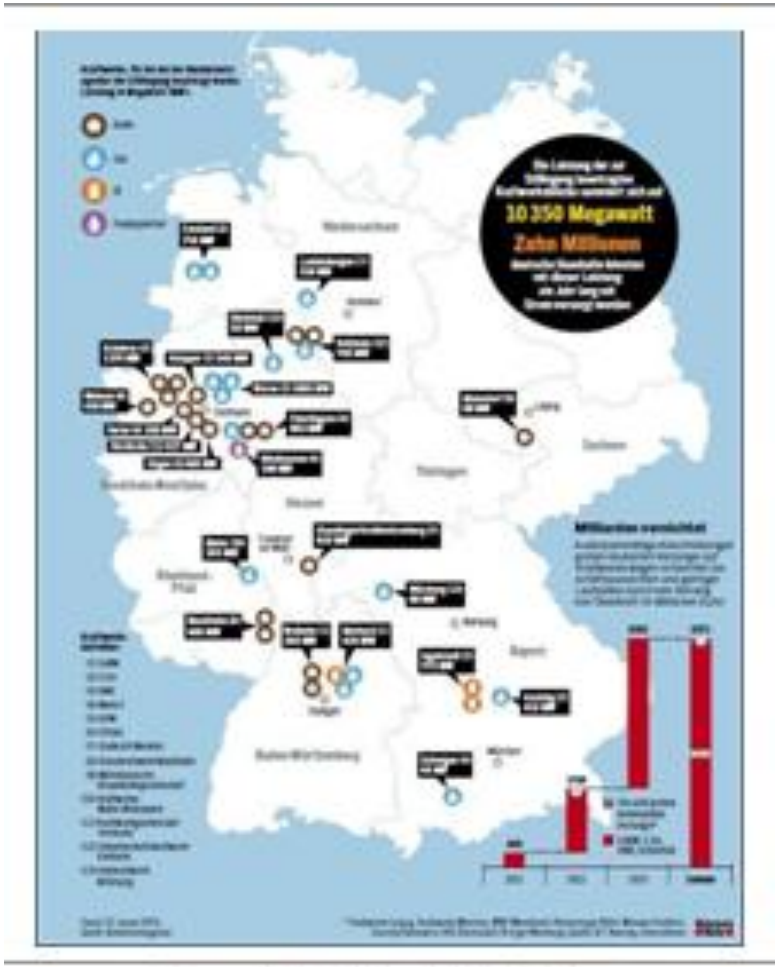


- This may not be the case in the USA, but may become a problem under high penetration. Remember that the grid was built around delivering power from established power generation areas. Changing the source significantly, may require new transmission lines, especially to deal with new contingencies.

Impact on the Capacity Market

- In Germany, 10,350 MWs of conventional plants were retired because they had become uneconomical to operate.

- Flexible capacity – peak load and storage plants will become more expensive.

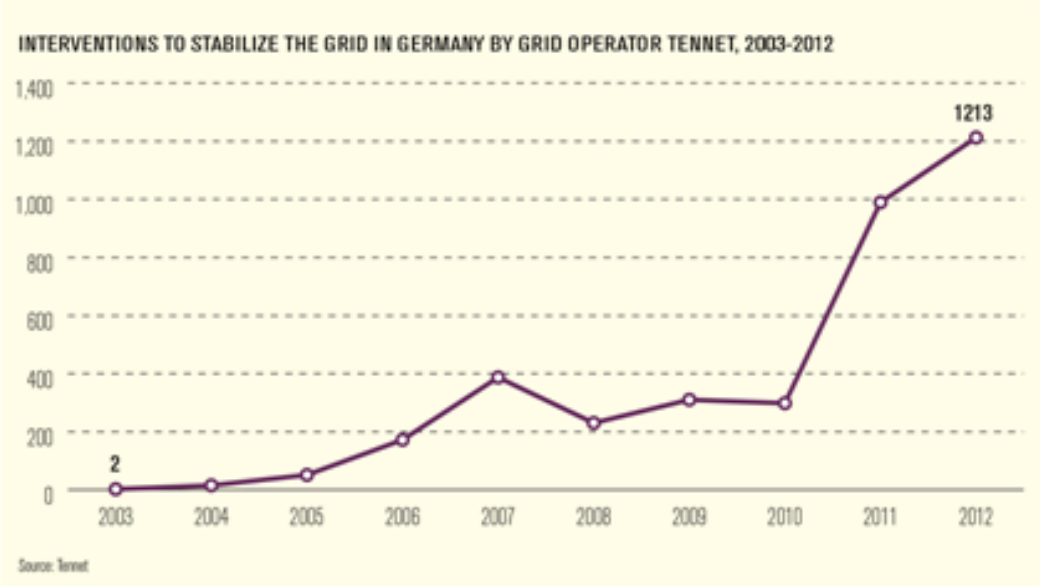


Source: Wirtschaftswoche 03.02.2014

Impact to System Stability and Reliability

- Small amounts of PV will not have a major impact, but it is important to understand the impact of significant amounts of intermittent resources such as solar.

Interventions by grid operator TenneT to stabilize the grid 2003 - 2012



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Source: TENNET

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Conclusion

- There are many promising things about renewables and specifically PV, but it is important to consider both long term and/or high penetration impacts to avoid unintended consequences.

Steve Steffel
Mgr., Distributed Energy Resources Planning and Analytics
Pepco Holdings, Inc.
steve.steffel@pepcoholdings.com