2014 Value of Solar at Austin Energy

October 21, 2013

Prepared for
Austin Energy

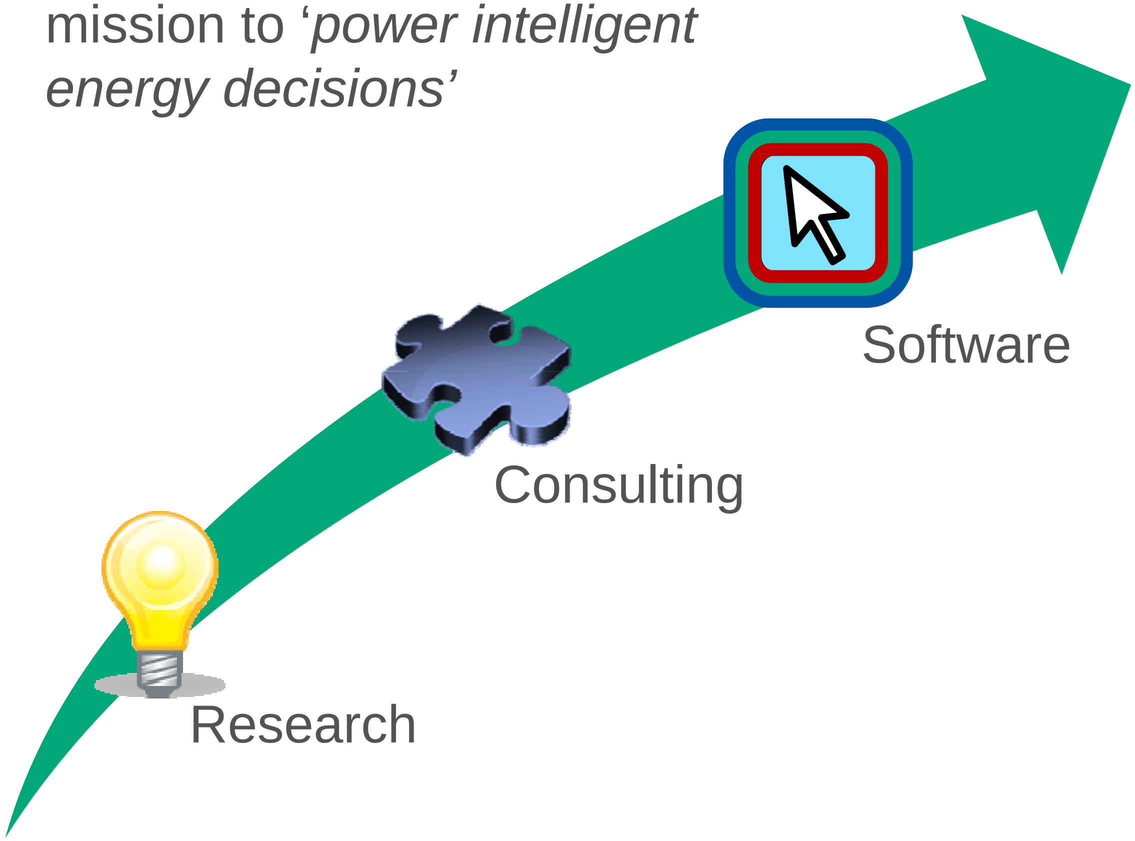
Prepared by
Clean Power Research

Austin Energy's Leadership in Value of Solar has Received National Recognition

- Nationally referenced in media about Value of Solar tariff with references very favorable toward the Austin Energy (more than a dozen references last time I looked)
- Austin Energy's Value of Solar was showcased at Valuing Distributed Energy Princeton Roundtable (attendees including chair of FERC, multiple chairs of PUCs, multiple CEO of East Coast utilities, …)
- State of Minnesota is patterning their program after Austin Energy's

Clean Power Research®

Founded in 1998 with the mission to ‘*power intelligent energy decisions*’



SOLAR PREDICTION

Most widely used solar resource database

ECONOMIC VALUATION

> 25 million solar estimations performed

PROGRAM OPTIMIZATION

2.75 GW of renewable incentives processed

Objective

- Calculate long-term value of solar to Austin Energy
- This information will be used by Austin Energy as input for the basis of a rate offered to customers
- Rebates are not included in the analysis
- Societal benefits are not included in the analysis

Value of Solar

Value of Solar Components

Value Component	Basis
Guaranteed Fuel Value	Cost of fuel to meet electric loads and T&D losses inferred from nodal price data & guaranteed future NG prices
Plant O&M Value	Costs associated with operations and maintenance
Generation Capacity Value	Capital cost of generation to meet peak load inferred from nodal price data
Avoided T&D Capacity Cost	Cost of money savings resulting from deferring T&D capacity additions.
Avoided Environmental Compliance Cost	Cost to comply with environmental regulations and policy objectives.

Nodal Price Approach

Nodal Price Approach to Calculate Energy and Capacity Value of PV

- Obtain hourly nodal prices (2011 to 2012)
- Obtain PV fleet production that is time-correlated with hourly nodal prices
  - PV system specs provided by Austin Energy
  - Solar resource data provided by SolarAnywhere
  - Fleet simulation performed using SolarAnywhere FleetView
- Calculate weighted average solar value by multiplying PV fleet production by nodal prices
- Project future value

PV Fleet Analysis

Fleet Data Import

- Only systems that had a final approval date were considered
- Inverter/module names modified to match equipment database (more work required here due to naming inconsistencies)
- If equipment match found, used inverter efficiency and module PTC ratings listed by the CEC
- If no match, created "generic" system using the tilt, azimuth, and inverter efficiency from the spreadsheet
- Systems with missing ratings or equipment were excluded
- Geocoded exact latitude and longitude of systems (Bing Maps API). Unable to locate 88 systems in this manner (zip code centroid used)
- Arrays combined into multi-array systems based on common application ID

PV Rating Convention

kW-AC = DC-STC x Module Derate x Inverter Efficiency x Loss Factor

Example:

10 kW DC-STC

X 90% module derate factor (CEC lookup)

X 95% inverter load-weighted efficiency (CEC lookup)

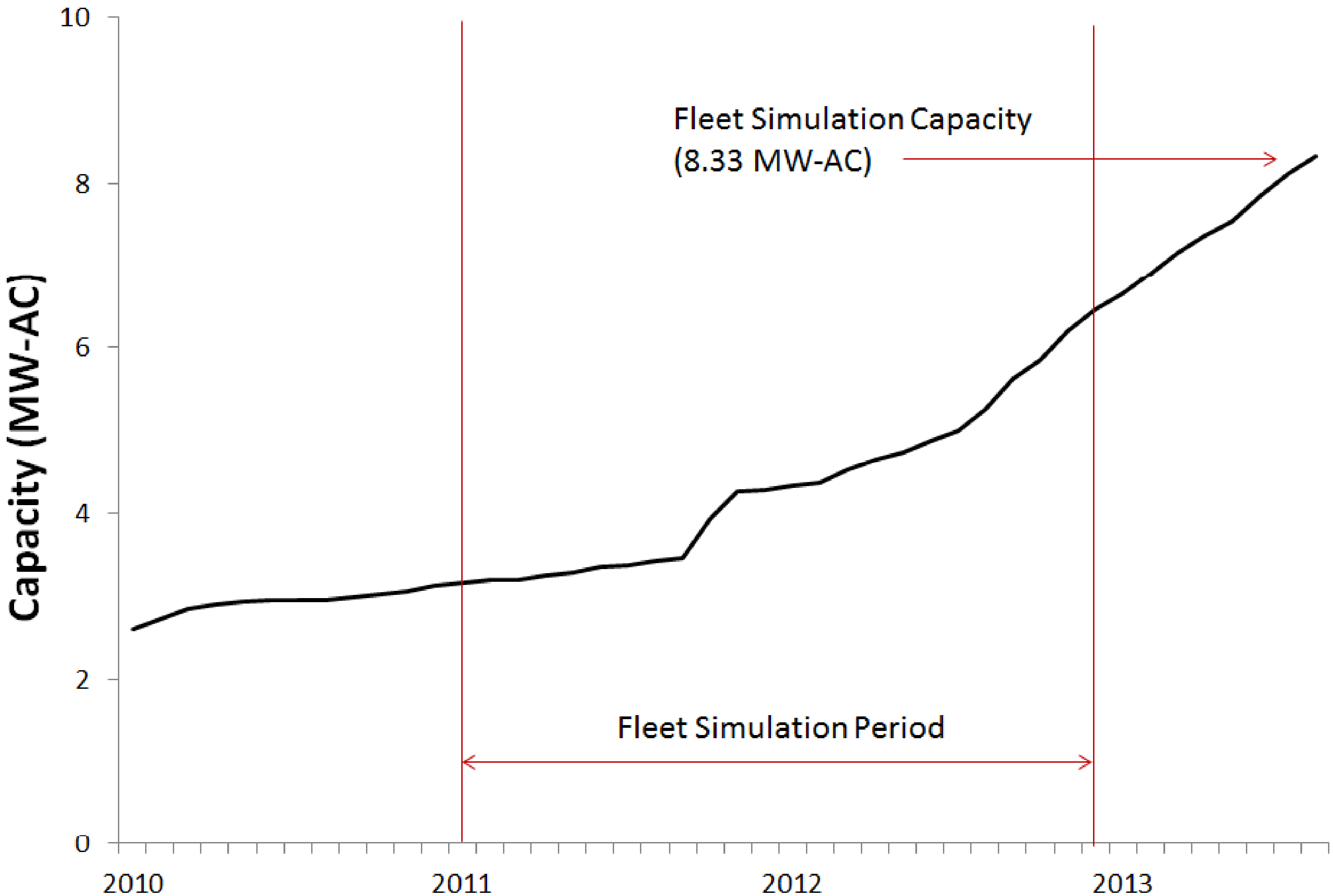
X 85% other loss factor

7.27 kW-AC

Relationship Between System Rating and Capacity Factor

- 1 kW-AC PV system (as defined on previous slide)
  - Has 22% capacity factor
  - Produces 1,927 kWh per kW-AC per year
- 1kW-DC (i.e., nameplate module rating)
  - Has 16% capacity factor
  - Produces 1,400 kWh per kW-DC per year
- 1.376 kW-DC of PV are required to have same energy as 1 kW-AC of PV
  - 1.376 * 1,400 kWh per year = 1,927 kWh per year

Fleet Capacity

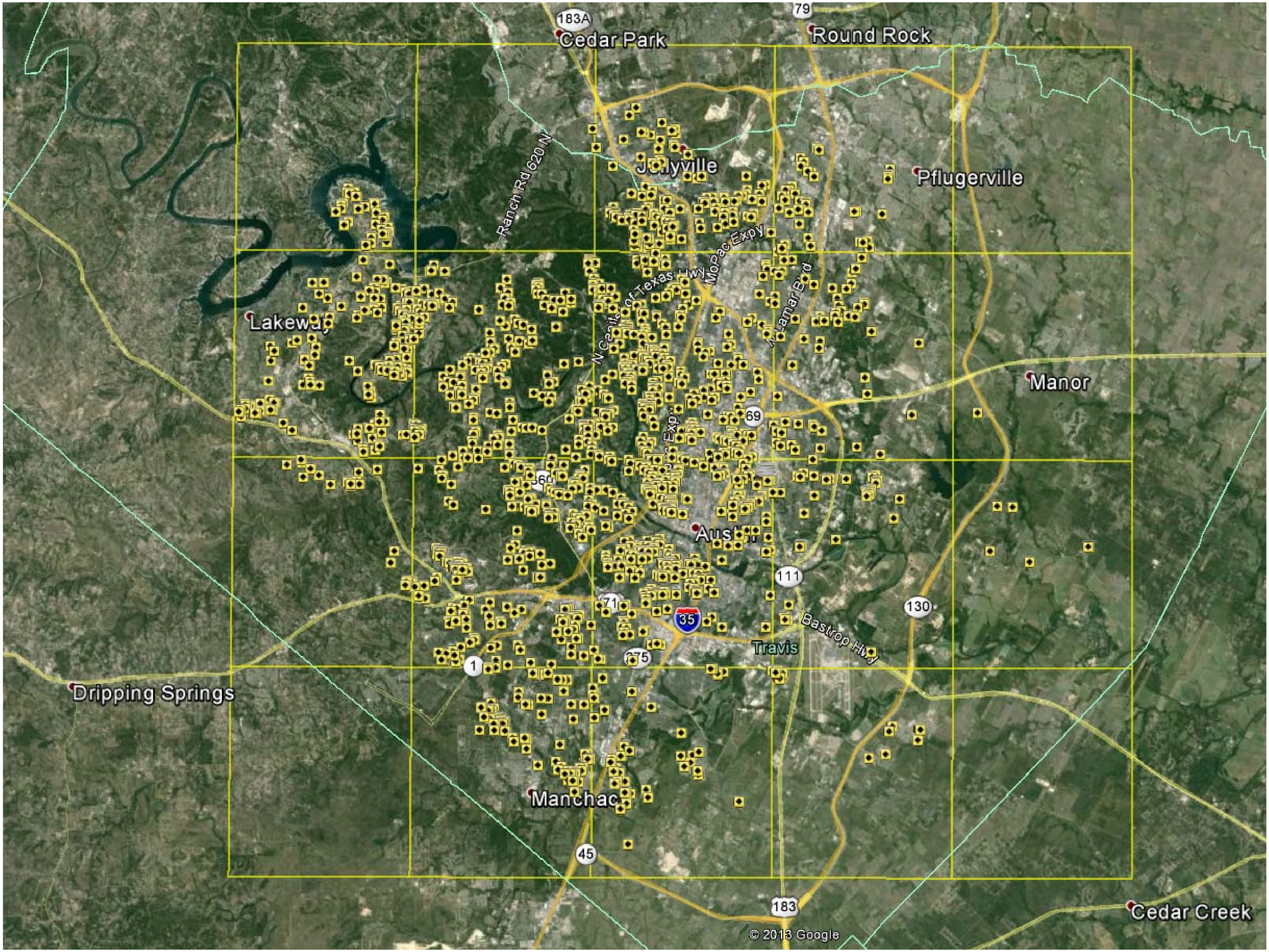


Fleet Modeling

- Modeling is based on static fleet as of July 31, 2013. All systems are modeled for period of 1/1/2010 to 12/31/2012 regardless of actual installation date. This results in a representative fleet shape for economic modeling purposes.
- Individual systems are modeled hourly, and AC power is summed to give hourly fleet production
- Modeling uses SolarAnywhere Standard Resolution (10 km x 10 km), 17 tiles

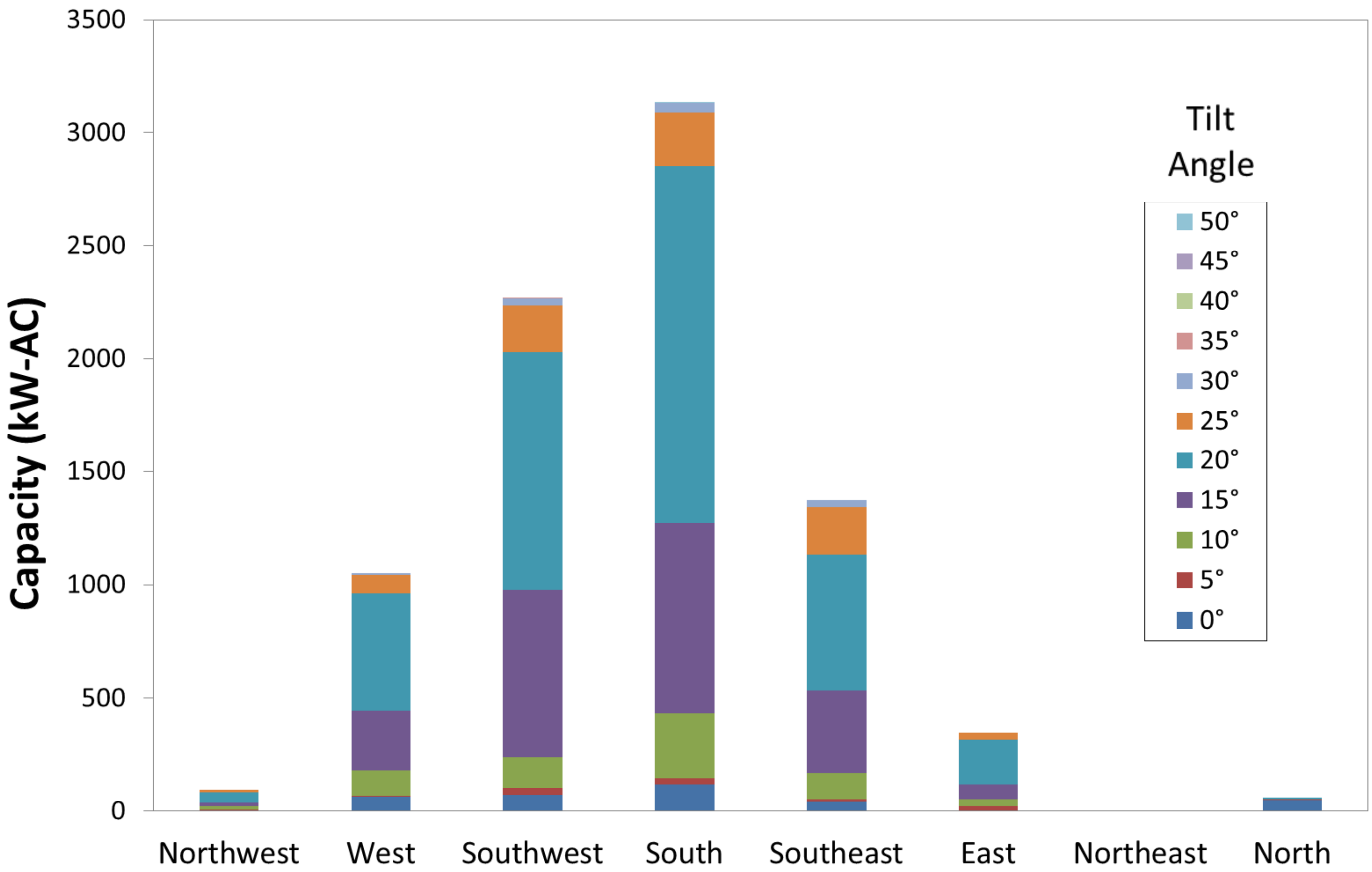
Fleet Statistics

- A total of 2,423 systems were included in the fleet. These systems contained 2,900 arrays. 1,004 of the systems are generic
- The fleet, as simulated, has a capacity of 8.33 MW-AC



183A
Cedar Park
79
Round Rock
Jollyville
Pflugerville
Ranch Rd 620 N
MoPac Expy
Lakeway
Manor
69
Austin
111
130
35
Bastrop Hwy
Travis
1
Dripping Springs
Manchac
45
183
Cedar Creek
© 2013 Google

Fleet Orientations



Fleet Results

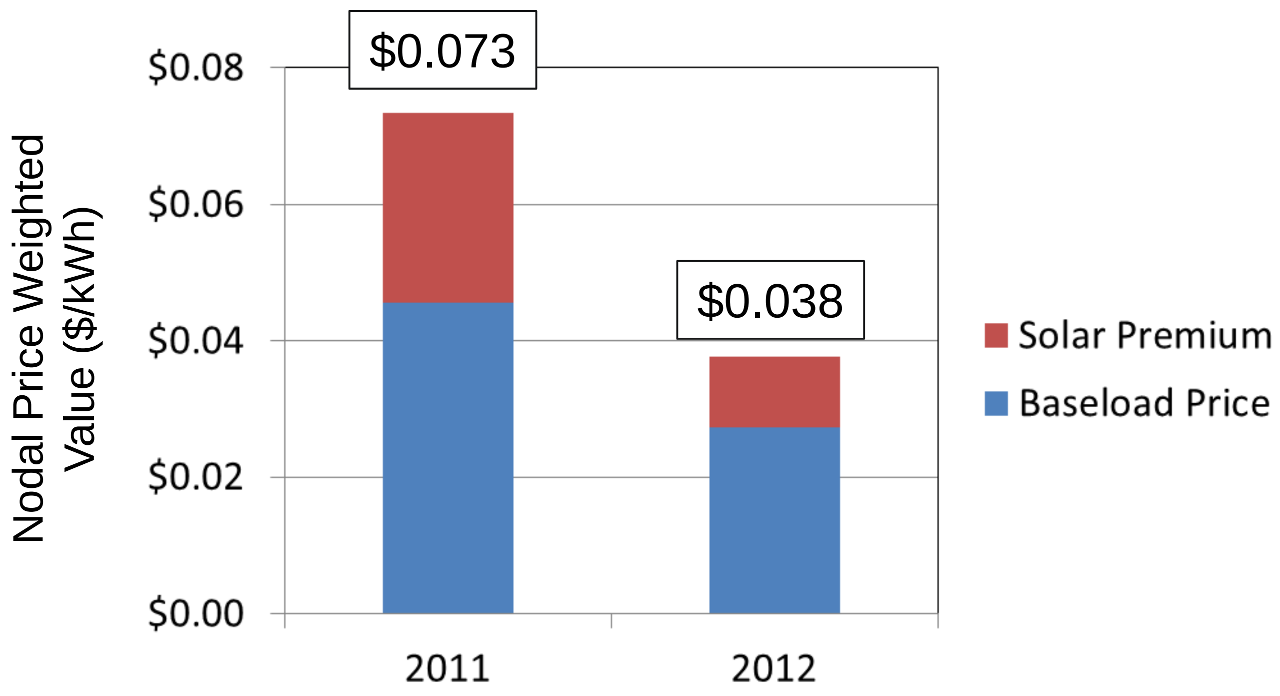
- Resulting dataset: hourly Austin Energy fleet output for 2011 and 2012

Nodal Price Value Calculation

HE (CST)	[A] Fleet Energy (MWh)	[B] Nodal Price ($/MWh)	= [A] x [B] Value ($)
1/1/2011 6:00	0.000	28.46	0.00
1/1/2011 7:00	0.000	32.39	0.00
1/1/2011 8:00	0.385	34.80	13.38
1/1/2011 9:00	1.953	36.20	70.68
1/1/2011 10:00	4.016	36.97	148.47
1/1/2011 11:00	5.599	34.06	190.71
1/1/2011 12:00	6.587	41.78	275.21
1/1/2011 13:00	6.940	29.13	202.17
1/1/2011 14:00	6.767	32.46	219.66
1/1/2011 15:00	6.037	29.13	175.85
1/1/2011 16:00	4.782	26.90	128.64
1/1/2011 17:00	2.921	27.76	81.08
1/1/2011 18:00	0.895	34.59	30.96
1/1/2011 19:00	0.036	46.81	1.67
1/1/2011 20:00	0.000	44.77	0.00
1/1/2011 21:00	0.000	42.59	0.00

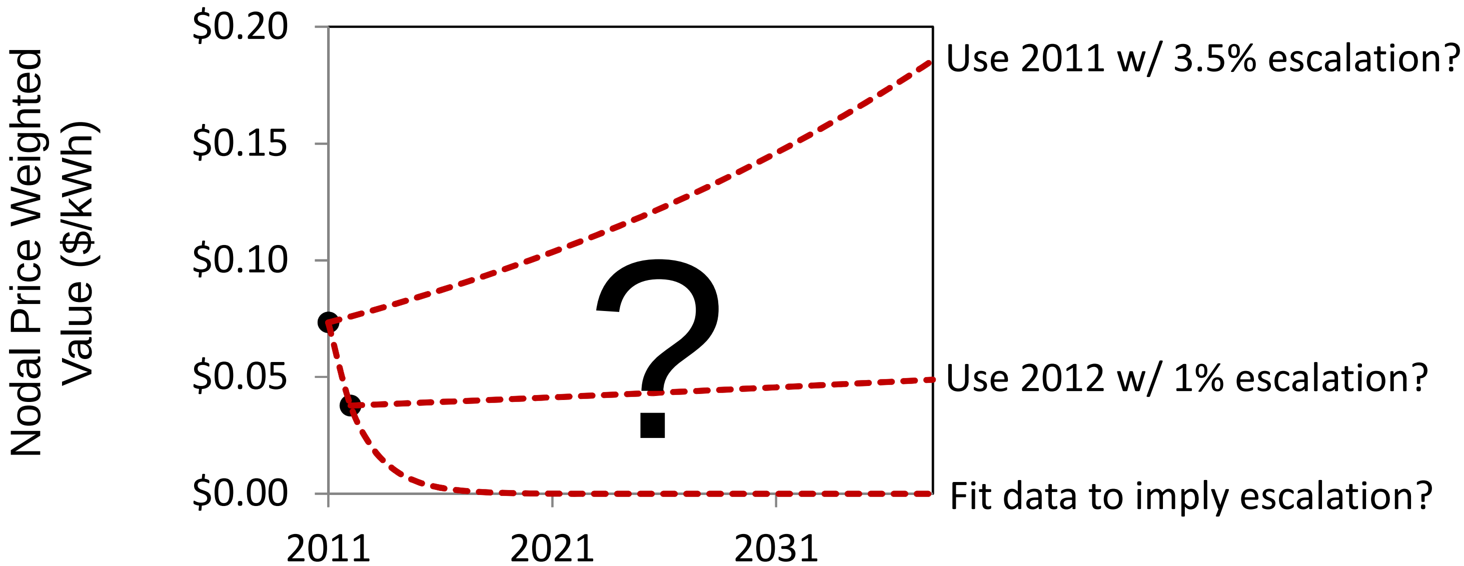
* Repeat calculation for all hours of year and sum result.

Results (Excluding All Other Benefits)



How Should Results Be Used to Forecast Future Energy/Capacity Value?

- Value varies by a factor two from 2011 to 2012
- Which year and escalation rates should be used to project 25 years into the future?



Analysis of Austin Energy Heat Rate Forecast

- It is important to match time-correlated PV production data to nodal prices in order to correctly calculate value
- Time-correlated PV production data, however, is impossible to obtain for projected nodal prices
- The best-available alternative is to use historical solar data with projected nodal price data
- This approach risks not capturing the correlation between nodal prices and PV production

Austin Energy Scenario #2: Heat Rate Analysis Approach

- Obtain implied hourly heat rates provided by Austin Energy from 2014 to 2022
- Match 2011 PV fleet production to 2014 – 2022 hourly heat rates
- Multiply 2011 PV fleet production times 2014 - 2022 heat rates
- Sum results and divide by energy to obtain results in $/kWh
- Perform for both solar and baseload plants for comparison purposes

Example for 2014

Hour Ending Time	2014 Heat Rate (Btu/kWh)	2011 PV Fleet Production (kWh)	Heat Rate x PV (Btu)
Jan. 1, 1:00	7,153	0	0
Jan. 1, 2:00	6,348	0	0
Jan. 1, 3:00	5,553	0	0
Jan. 1, 4:00	5,301	0	0
Jan. 1, 5:00	5,188	0	0
Jan. 1, 6:00	5,254	0	0
Jan. 1, 7:00	5,305	0	0
Jan. 1, 8:00	5,572	385	2,142,580
Jan. 1, 9:00	5,580	1,953	10,894,533
Jan. 1, 10:00	6,243	4,016	25,070,085
Jan. 1, 11:00	6,742	5,599	37,750,390
Jan. 1, 12:00	7,598	6,587	50,052,280
…	…	…	…

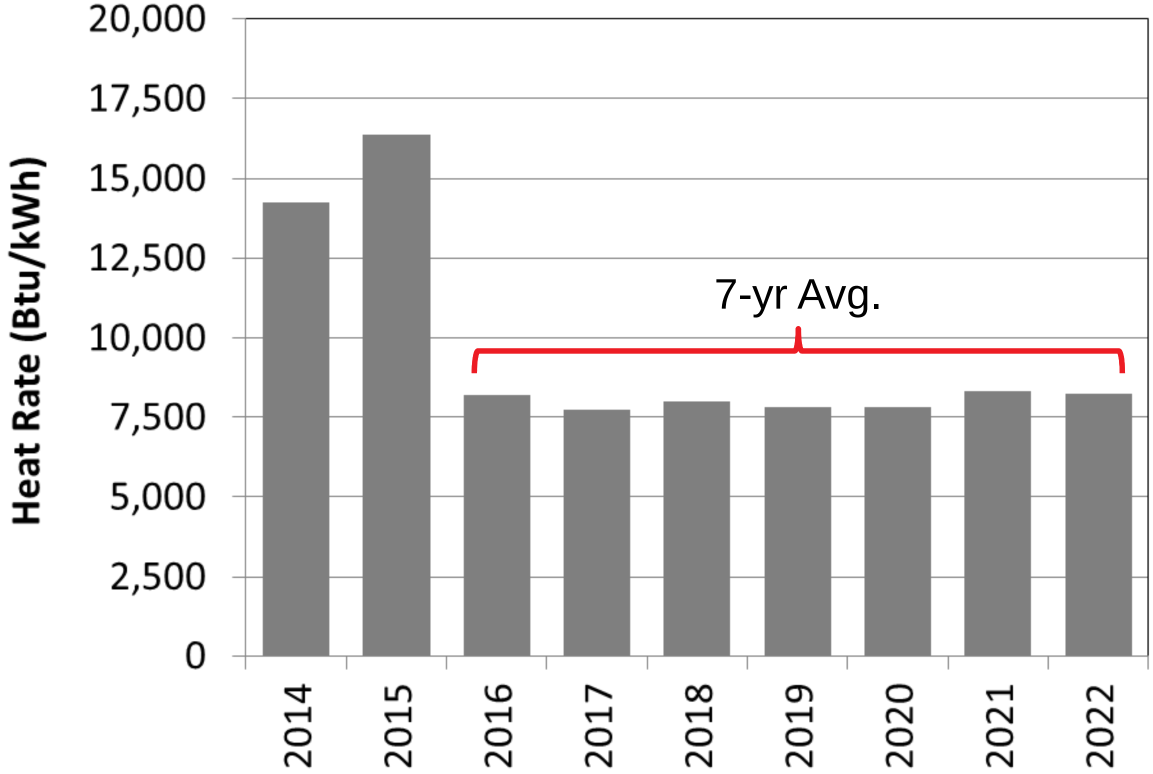
2014 Results

PV Fleet Production	16,050,103 kWh
Sum Hourly Heat Rate x PV Production	228,356,186,159 Btu
Solar Weighted Heat Rate	14,228 Btu/kWh
Avg. (Baseload) Heat Rate	9,497 Btu/kWh

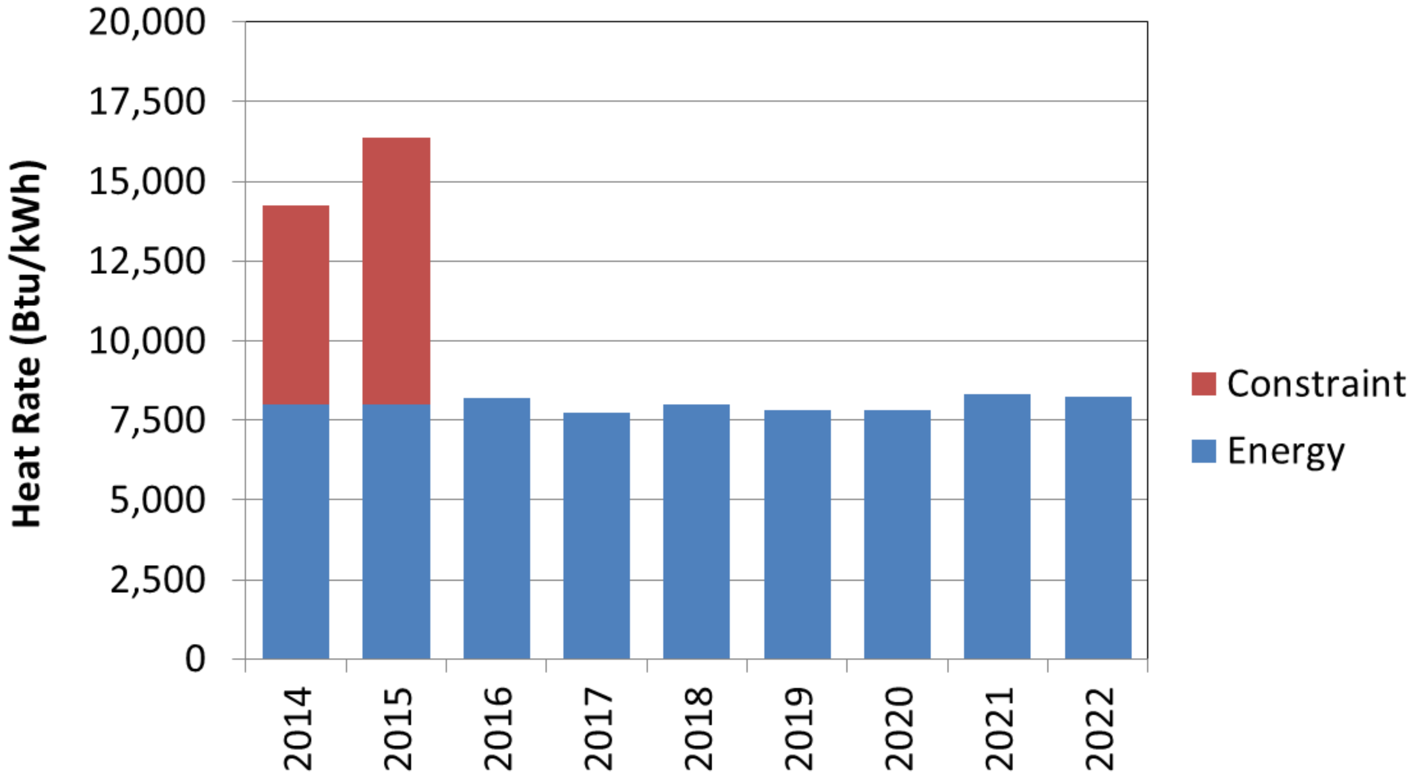
Results for All Years

	Weighted Heat Rates (Btu/kWh)					
	Solar			Baseload		
	Total	*Energy*	*Excess*	*Total*	*Energy*	*Excess*
2014	14,228	8,024	6,201	9,497	7,248	2,249
2015	16,382	8,024	8,358	10,109	7,248	2,861
2016	8,218	8,218		7,381	7,381	
2017	7,750	7,750		7,220	7,220	
2018	8,004	8,004		7,279	7,279	
2019	7,803	7,803		7,142	7,142	
2020	7,827	7,827		7,128	7,128	
2021	8,318	8,318		7,317	7,317	
2022	8,246	8,246		7,267	7,267	
Averages		8,024			7,248	

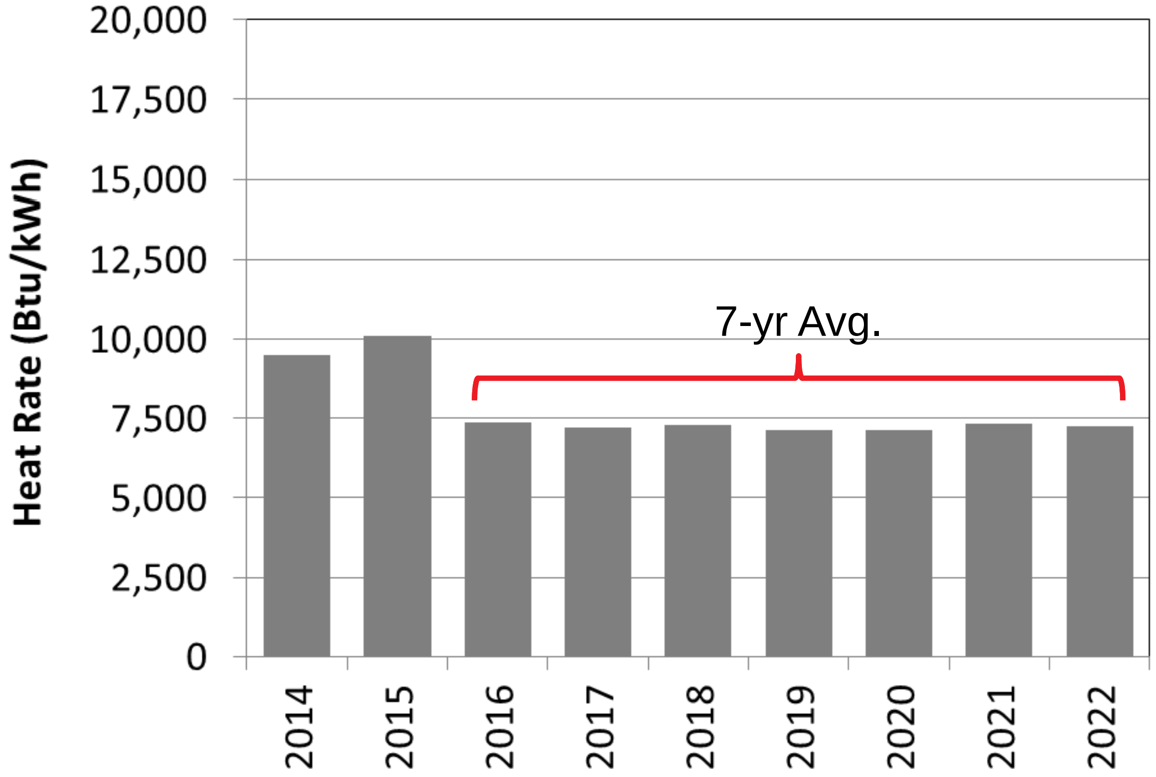
Solar Weighted Heat Rate Analysis Results Graphical Presentation



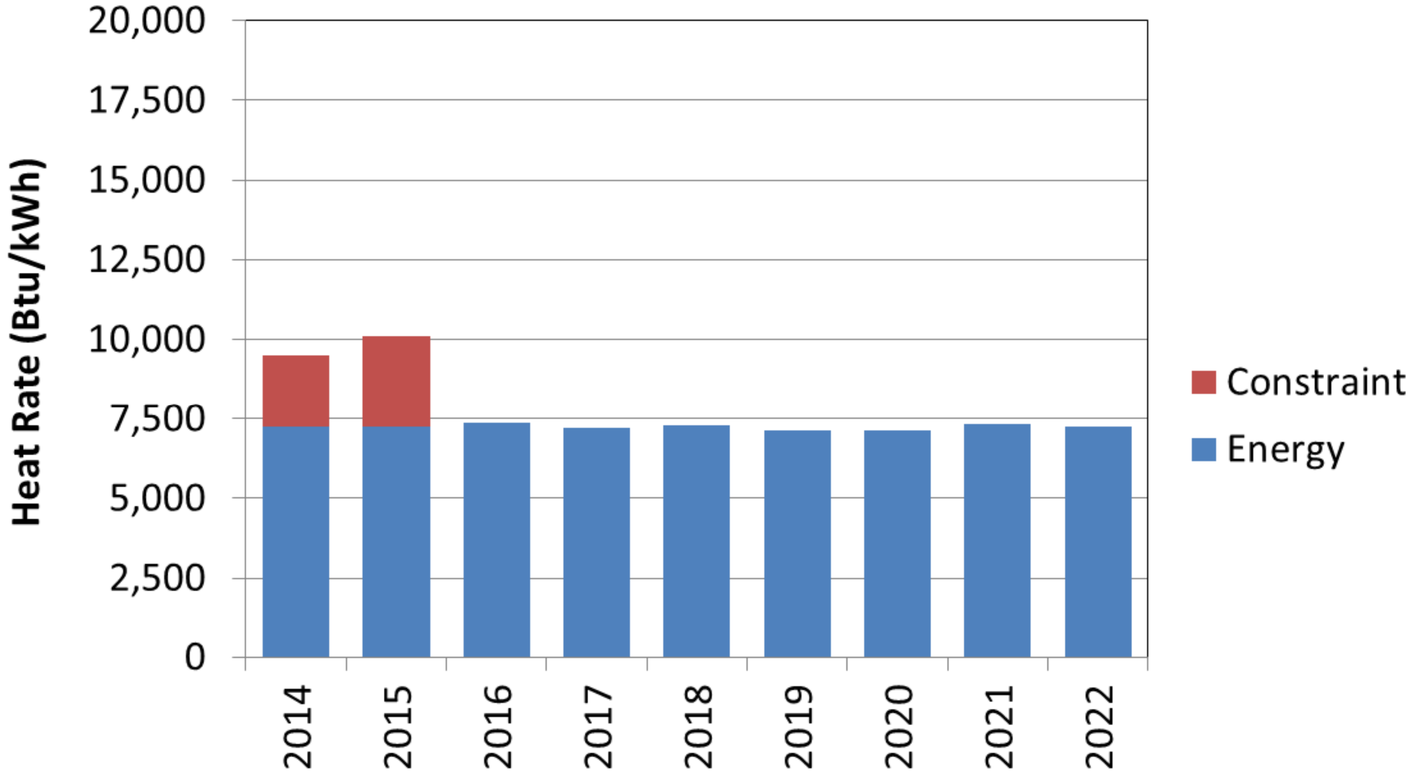
Solar Weighted Heat Rate Analysis Results Graphical Presentation



Baseload Heat Rate Analysis Results Graphical Presentation



Baseload Heat Rate Analysis Results Graphical Presentation



Evaluation of Effective Capacity for Solar

Step 1: Estimate “capacity value” of solar and baseload plants for 2014 and 2014

		Heat Rate (Btu/kWh)		***Production***	***NG Price***	***Annual Value ($/kW-yr)***		
Year	***Plant Type***	***Total***	***Energy***	***(kWh/kW)***	***($/Mbtu)***	***Total***	***Energy***	***Capacity****
2014	Solar	14,228	8,024	1,927	$3.98	$109	$61	$48
2015	Solar	16,386	8,024	1,927	$3.82	$121	$59	$62
2014	Baseload	9,497	7,248	8,760	$3.98	$331	$252	$78
2015	Baseload	10,109	7,248	8,760	$3.82	$338	$243	$96

Step 2: Calculate ratio of capacity values

	Solar	Baseload	Ratio
2014	$48	$78	61%
2015	$62	$96	64%
Avg.			62%

Capacity Value Validation

	Excess Heat Rate (Baseload) (Btu/kWh)	NG Price Forecast (Real $/MBtu)	Excess Value ($/kW-yr)	Present Value of Excess Value ($/kW)	Reserve Planning Margin	Value Before Reserve Margin ($/kW)
	(A)	(B)	(C) = (A) x (B) * 8760 / 1,000,000	(D) = (C) / 10.6%	(E)	(F) = (D) / [1 + (E)]
2014	2,249	$3.98	$78	$738	13.75%	$649
2015	2,862	$3.75	$94	$885	13.75%	$778
Average						$714
Source	Heat rate analysis	Austin Energy			Austin Energy	

Compares well to $676/kW capacity value provided by Austin Energy

Annualization factor based on 10% discount rate, 30 year life

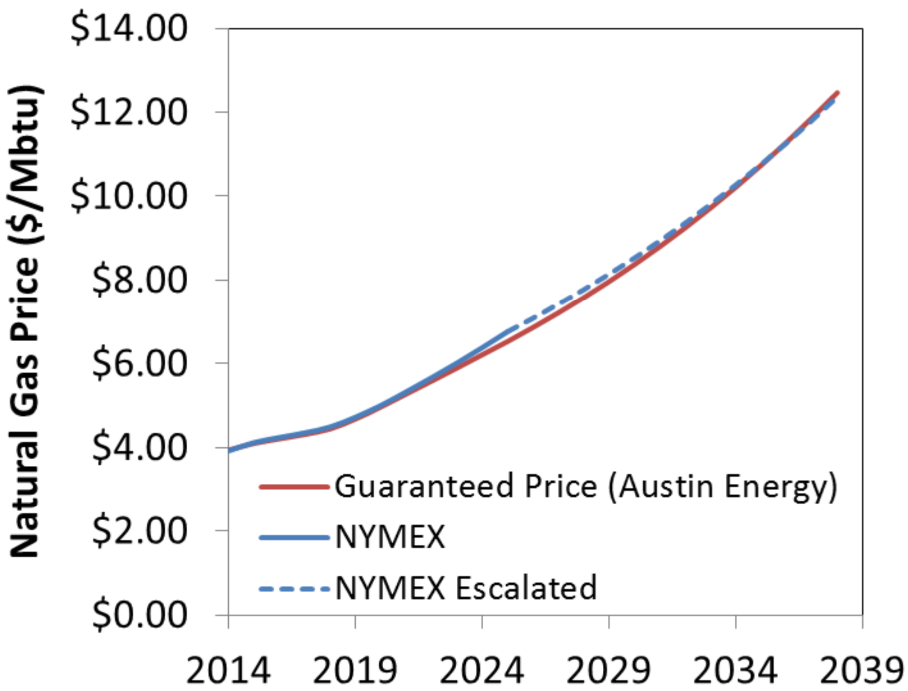
Key Parameters for Value of Solar

- Data inferred from Austin Energy's Heat Rate Forecast (2014-2022) and PV fleet production (2011)
  - Solar heat rate: ***8,024 Btu/kWh***
  - Effective capacity: ***62% of capacity cost***

- Data provided directly by Austin Energy
  - Capacity cost: ***$676/kW***
  - Planning Reserve margin: ***13.75%***
  - O&M cost: ***$7.04/kW-yr***

Key Parameters for Value of Solar
Natural Gas Prices

Guaranteed Price (Austin Energy) and NYMEX futures prices match well



Guaranteed Price (Austin Energy) is a 25-yr firm price quote Austin Energy received from a counter party with AA credit rating on 9/23/2013 willing to lock in prices

NYMEX futures prices are only available through 2025

NYMEX Escalated are futures prices escalated at 4.75% after 2025

Value of Solar Components

Value Component	Basis
Guaranteed Fuel Value	Cost of fuel to meet electric loads and T&D losses inferred from nodal price data & guaranteed future NG prices
Plant O&M Value	Costs associated with operations and maintenance
Generation Capacity Value	Capital cost of generation to meet peak load inferred from nodal price data
Avoided T&D Capacity Cost	Cost of money savings resulting from deferring T&D capacity additions.
Avoided Environmental Compliance Cost	Cost to comply with environmental regulations and policy objectives.

Inferred and Assumed Values

Inputs to Economic Analysis

Utility-Owned Generation		
Capacity		
Generation Overnight Capacity Cost	$676	per kW
Generation Life	30	years
Reserve Planning Margin	13.75%	
Energy		
Heat Rate	8024	BTU per kWh
Heat Rate Degradation	0%	per year
O&M cost (first Year) - Fixed	$7.04	per kW-yr
Economic Factors		
Discount Rate	Various	per year
General Escalation Rate	2.10%	per year

Environmental		
Avoided Environmental Cost	$0.020	per kWh
Environmental Value Escalation Rate	2.60%	per year
Transmission		
Capacity-related capital cost	$28.0	per kW-yr
Years until new capacity is needed	0	years
Distribution		
Capacity-related Capital Cost	$0	per kW
PV Assumptions		
PV Degradation	0.50%	per year
PV Life	25	years

Peak Losses

Calculation of combined T&D losses

Load - At generation	1.000
Transmision Losses	2.43%
Load - At substation high side	0.976
Distribution Losses	3.17%
Load - At meter	0.945

T&D Losses
5.52%

Average Losses

Calculation of combined T&D losses

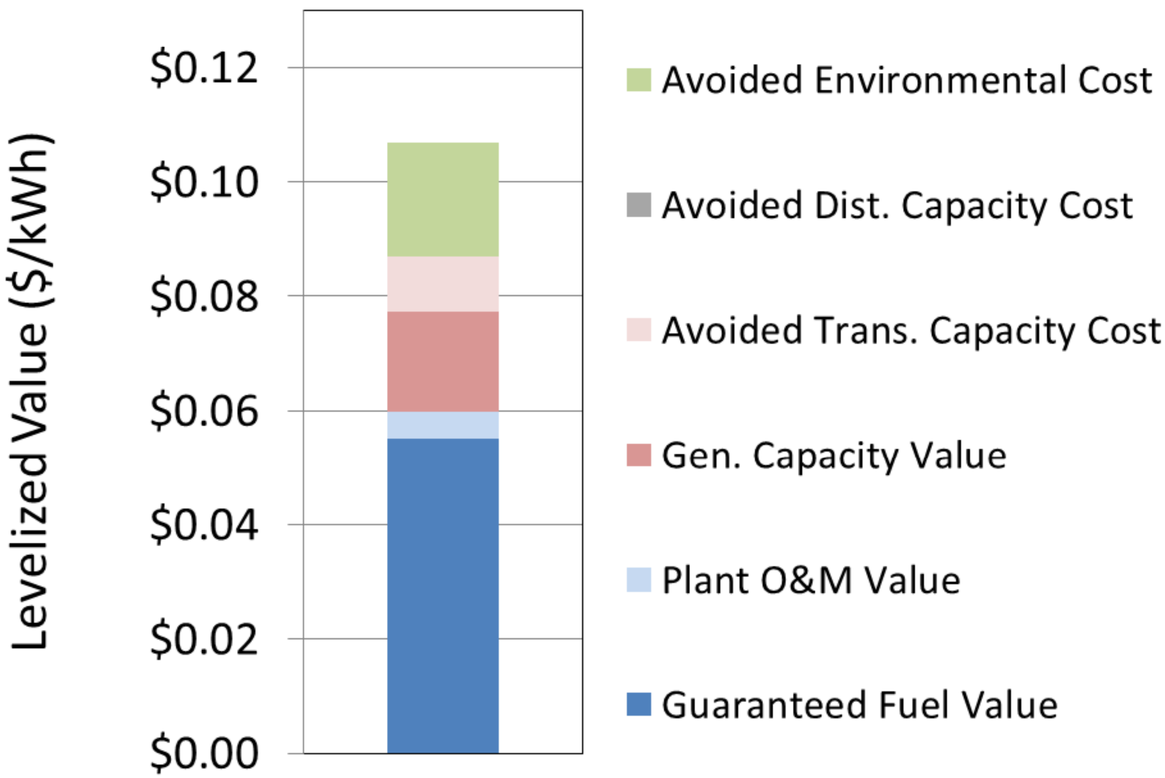
Load - At generation	1.000
Transmision Losses	1.60%
Load - At substation high side	0.984
Distribution Losses	2.88%
Load - At meter	0.956

T&D Losses
4.43%

Discount Rate Selection

- Options
  - Use utility discount rate, exclude effect of difference between utility discount rate and risk-free discount rate
  - Use utility discount rate, include effect of difference between utility discount rate and risk-free discount rate
  - Use risk-free discount rate to discount all costs and levelize VOS rate
- Recommendation
  - Use risk-free discount rate to discount all costs and levelize VOS
  - This captures the benefit of uncertainty reduction but eliminates discussion about what is the correct discount rate to use in the analysis because only one discount rate is used
- This assumption may not apply to other typical utility resource evaluations

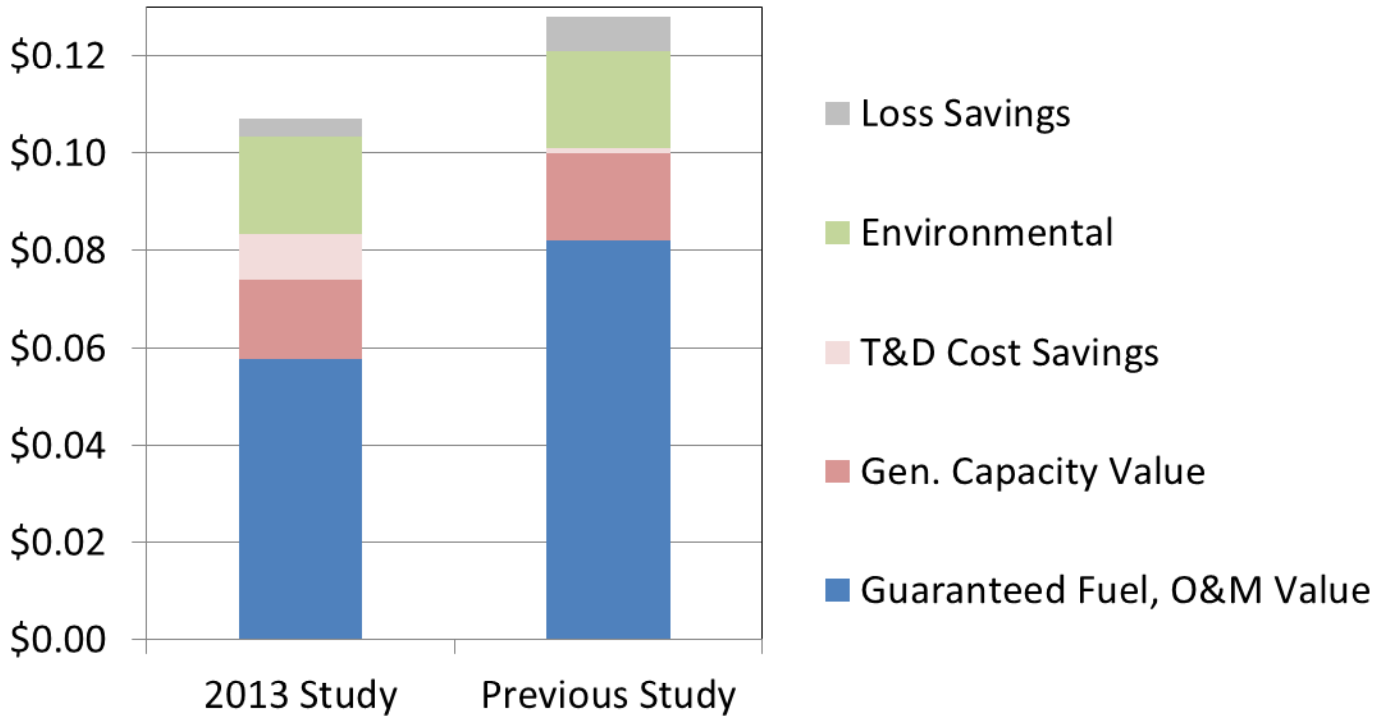
2014 VOS Results



2014 VOS Results

	Economic Value ($/kWh)	Load Match (No Losses) (%)	Distributed Loss Savings (%)	Distributed PV Value ($/kWh)
Guaranteed Fuel Value	$0.053		4%	$0.055
Plant O&M Value	$0.005		4%	$0.005
Gen. Capacity Value	$0.026	62%	6%	$0.017
Avoided Trans. Capacity Cost	$0.015	62%	6%	$0.010
Avoided Dist. Capacity Cost	$0.000	39%	7%	$0.000
Avoided Environmental Cost	$0.020		0%	$0.020
	$0.119			$0.107

How Do Results Compare to Previous Study?



Why Have Results Changed?

- Natural gas prices have declined
- Assumed life is 25 rather than 30 years
- Loss savings are slightly lower
- Transmission savings results have increased
- Methodology has been refined for ERCOT market