The Levelized Cost of Electricity from Existing Generation Sources

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Background: What is LCOE?

- LCOE = Levelized Cost Of Electricity
- "Summary measure" used by the U.S. Energy Information Administration (EIA) and others
- Compares different sources of electricity generation (coal, natural gas, wind, solar, hydro, geothermal, etc.)
- Looks at *new* generation resources power plants coming online 5 years in the future (EIA released "LCOE 2020" in June 2015 based on AEO 2015)

Background: What is LCOE?

What costs are levelized?

- Capital costs, fixed O&M, variable O&M (incl. fuel costs)
- Costs levelized over: financial life of the plant, unit of production (MWh)

More production and/or longer plant life = lower LCOE
LCOE sensitive to capacity factor

Policy and Regulatory Context

- Standard LCOE analysis becoming less relevant
- Federal policies are changing the makeup of the electric power grid; these include:
 - **Subsidies**, e.g. federal wind PTC and solar ITC
 - **Mandates**, e.g. state Renewable Portfolio Standards
 - **Regulations**, e.g. EPA's "Clean Power Plan"



Source: EIA, Annual Energy Outlook 2015, p. 24, http://www.eia.gov/forecasts/aeo/pdf/0383(2015).pdf How about "LCOE Existing"? IER commissioned a study on the LCOE of existing sources By Tom Stacy and George Taylor http://instituteforenergyresearch. org/wp-content/uploads/2016/07/ IER LCOE 2016-2.pdf

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The Levelized Cost of Electricity from Existing Generation Resources

JULY 2016 | THOMAS F. STACY | GEORGE S. TAYLOR, PH.D.

Methodology: Sources and Data

- Data from two federal databases:
 - Federal Energy Regulatory Commission (FERC) Form 1
 - Primary source of information for nameplate capacity, annual generation, ongoing capital expense, annual operating expense, and fuel expense
 - 20 years of forms publicly available online
 - U.S. Energy Information Administration (EIA) Form 860
 Cross reference tool for clarifying or confirming data

FERC Form 1

The fields used to calculate LCOE from existing sources are highlighted in the picture and include:

- Plant type
- Installed capacity
- Net generation
- Fuel cost
- Equipment cost
- Total production expenses

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		ATIME DI AMIT ETATIETI	CE IL ADOR DI ANTES	
Research data for stora in Construction	STEAM-ELECTRIC GENER	ATTING PLANT STATISTI	CS (LARGE PLANIS)	
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ne	ltem	Plant	Plant	
lo.		Name:	Nam	01
	(a)	1	b)	(c)
1 Kind of Plant (Internal Comb	, Gas Turb, Nuclear)			
2 Type of Constr (Conventiona	I, Outdoor, Boiler, etc)			
3 Teal Originally Constructed				
4 Year Last Unit was Installed				
5 Fotal Installed Cap (Max Ge	n Name Plate Ratings-MW)			
6 Net Peak Demand on Plant	More (our Minutes)			
Plant Hours Connected to Lo	CONTRACTOR AND			
9 When Not Limited by Cond	anser Water			
10 When Limited by Condense	r Mater			
11 Average Number of Employe	1000			
12 Not Generation, Exclusion of	Plant Use - KWb			
13 Cost of Plant: Land and Land	Rights			
14 Structures and Improvement	5			
15 Equipment Costs				
16 Asset Retirement Costs				
17 Total Cost *Reported as an i	aggregate figure since inception			
18 Cost per KW of Installed Car	pacity (line 17/5) Including			
19 Production Expenses: Oper,	Supy & Engr			
20 Fuel * Reported as an annua	l expense			
21 Coolants and Water (Nuclea	r Plants Only)			
22 Steam Expenses				
23 Steam From Other Sources				
24 Steam Transferred (Cr)				
25 Electric Expenses				
26 Misc Steam (or Nuclear) Pov	ver Expenses			
Z / Ments				
Allowances	a for a local data			
 Maintenance Supervision an Maintenance of Structure 	a Engineering			
1 Maintenance of Boiler from	acted Plant			
12 Ataintenance of Electric Bine	a constant a second			
13 Maintenance of Misc Steam	for Nuclear) Plant			
4 Total Production Expenses	Annual			
15 Expenses per Net KWh				
6 Fuel: Kind (Coal, Gas, Cillion	Nuclear		1	
7 Unit (Coal-tons/Oil-barrel/0	las-mot/Nucleat-indicate)			
8 Quantity (Units) of Fuel Burn	ed * Annual			
19 Avg Heat Cont - Fuel Burned	(btu/indicate if nuclear)			
10 Avg Cost of Fuel/unit, as De	lvd f.o.b. during year			
41 Average Cost of Fuel per Un	4 Burned			
12 Average Cost of Fuel Burner	t per Million BTU			
13 Average Cost of Fuel Burned	i per KWh Net Gen			
4 Average BTU Per KWh Net C	ieneration		1	
C FORM NO. 1 (REV. 12-03)		Sourc	e: LCOE S	Study n 13

Cross-Referencing with EIA

Field Retrieved		EIA Generator Data	FERC Form 1 Data
Utility ID	Dutu	×	
Utility Name	×	×	
Plant Code	x	x	
Plant Name	×	x	INCS
Plant/Unit Ownership			x
County	x		
State	x	x	x
ISO RTO	×		
Prime Mover (generator technology)		x	INCS
Energy Source 1		x	INCS
Energy Source 2		x	
Operational Status		x	x
Nameplate Capacity	×	×	x
Summer Capacity	x	×	x
Unit Initial Operating Year	×		x
Annual Generation			RDCT
Annual Fuel Expense			RDCT
Annual Total Operations Expense			x
Annual Aggregated Plant Capital Spending			x

X Reported Consistently

INCS Reported Inconsistently

s Reported inconsisten

RDCT Partially Redacted

Source: LCOE Study, p. 15

Data Analysis

- Components of LCOE ^[1]:
 - Construction cost with a repayment term of 30 years
 - Ongoing capital expenditures (e.g. upgrades and overhauls)
 - Operations and maintenance expenses, both fixed and variable
 - Fuel costs (using 2015 avg. delivered fuel prices)
 - New transmission investment (not calculated for existing resources)
- Study's key additions:
 - Imposed costs when dispatchable generators back down to accommodate non-dispatchable resources, they run fewer hours without a substantial reduction of fixed costs
 - Capacity factors LCOE with average fleet capacity factors for each resource vs. EIA's "best case scenario"

Summary of Results

	LCOE Existing	LOCE New	LOCE New
Generator Type		AEO 2015	Average Fleet CF
	2013\$/MWh	2013\$/MWh	2013\$/MWh
Dispatchable Full-Time-Capable Resources			
Coal	39	95.1	N/A
Combined Cycle Natural Gas (CC gas)	34.4	75.2	55.3
Nuclear	29.1	95.2	90.1
Hydroelectric	35.4	83.5	122.2
Dispatchable Peaking Resources			
Combustion Turbine Gas (CT gas)	88.2	141.5	263
Intermittent Resources			
Wind including sost imposed on CC gas	NI/A	73.6	107.4
wind including cost imposed on CC gas	N/A	+ other costs*	+ other costs*
Solar DV/Including improved cost on CC and CT gos		125.3	140.3
Solar PV including imposed cost on CC and CT gas	N/A	+ other costs*	+ other costs*

* "Other costs" could add \$25 - \$50 per MWh and include transmission costs and subsidies not considered by EIA in their calculation of LCOE-New.

Best Case vs. Fleet Average Capacity Factors

	Fleet Average	Best-Case	Adjustment
Generator Type	Capacity Factors	Capacity Factor	Factor
Dispatchable Full-Time-Capable Resources			
Conventional Coal	54.6%	85%	1.56
CC Gas	56.3%	87%	1.55
Nuclear	92.2%	90%	0.98
Hydroelectric	35.9%	54%	1.5
Dispatchable Peaking Resource			
CT Gas	6.7%	30%	4.48
Intermittent Resources			
Wind .	32.5%	36%	1.11
Solar PV	28.6%	25%	0.87

LCOE	-NEV	V at	Fleet	Average	
	Сара	city	Facto	rs	
New Generator Type	Sum of Fixed Costs of LCOE-New as reported by EIA (2013 \$/MWh)	Capacity Factor Adjustment Multiplier	Adjusted Fixed Cost per MWh (2013 \$/MWh)	Variable Costs (2013 \$/MWh) including fuel at 2014 delivered price	EIA LCOE-New at Real-World Capacity Factors (2013 \$/MWh)
Dispatchable Full-Time-Capable Resources					
Conventional Coal					N/A
CC Gas	17.3	1.55	26.7	28.6	55.3
Nuclear	83.0	0.98	81.0	9.1	90.1
Hydroelectric	76.6	1.50	115.2	7.0	122.2
Dispatchable Peaking Resource					
CT Gas	47.0	4.48	210.4	52.5	263.0
Intermittent Resources					
Wind including cost imposed on CC gas	73.6	1.11	81.5	25.9 imposed on new CC gas	107.4
PV Solar Including imposed cost on CC and CT gas	125.3	0.87	109.5	30.8 imposed on new CC and CT gas	140.3

Premium	to Replac	e Exist	ing
with New	v of Same	Resour	ce
Generator Type	LCOE Existing at Real World Capacity Factors (2013 \$/MWh)	LCOE New (EIA) at Real-World Capacity Factors (2013 \$/MWh)	Premium for Replacing Existing with Same Resource New
Dispatchable Full-Time-Capable Resources			
Conventional Coal	39.9	N/A	N/A
CC Gas	34.4	55.3	61%
Nuclear	29.1	90.1	210%
Hydroelectric	35.4	122.2	245%
Dispatchable Peaking Resource			
CT Gas	88.2	263.0	198%
Intermittent Resources			
Wind including cost imposed on new CC gas		107.4	N/A
Solar PV including cost imposed on new CT and CC gas		140.3	N/A

Everything New is Expensive Used Cars and the CC Gas Paradox

If it ain't broke, don't replace it!

Existing CC gas plants (LCOE-Existing): **\$34.40 per MWh**



2003-2004 Honda Accord

New CC gas plants (LCOE-New): **\$75.20 per MWh**



2014 Honda Accord Plug-In Hybrid

Solar Generation vs. Net Demand



Duck Curve

The duck curve shows steep ramping needs and overgeneration risk

Net load - March 31



Solar's Falling Capacity Value in California

PV ENERGY MARKET SHARE	CAPACITY VALUE OF MARGINAL PV CAPACITY (PERCENT OF NAMEPLATE CAPACITY)
1%	32.6%
2%	25.3%
3%	16.2%
4%	7.1%
5%	4.7%
6%	0.0%
7%	0.0%
7% 8%	0.0%
7% 8% 9%	0.0% 0.0% 0.0%
7% 8% 9% 10%	0.0% 0.0% 0.0% 0.0%
7% 8% 9% 10% 11%	0.0% 0.0% 0.0% 0.0% 0.0%
7% 8% 9% 10% 11% 12%	0.0% 0.0% 0.0% 0.0% 0.0% 0.0%
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7% 8% 9% 10% 11% 12% 13% 14%	0.0% 0.0% 0.0% 0.0% 0.0% 0.0% 0.0%

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