Seventh Plan Midterm Assessment: Draft Resource Capital Cost Estimates for Wind and Solar

Gillian Charles & Mike Starrett

Power Committee

May 8, 2018

Northwest Power and Conservation Council

Reminder: How the Council develops capital cost estimates

- **Gather** analysis of available cost data from
  - "Raw": manufacturers, developers, PPAs, project-specific publically available reported info, technical handbooks (Gas Turbine World)
  - Secondary sources: Reports from EIA, DOE, national labs, IRPs, state commissions, consultants, etc.
- **Normalize** the cost data to a consistent year dollars, configuration, capacity, heat rate, etc.
- **Review and discuss** tentative estimates with Generating Resources Advisory Committee
- **Bring to Council Members**

Northwest Power and Conservation Council

WIND & SOLAR: FINANCIAL CHANGES SINCE 7TH POWER PLAN

Changes Since 7P

- **Corporate Income Tax Rate:** Lowered from 35% to 21%
- **Interest Rates:** Beginning to rise
- **Investment Tax Credit:** No change
- **Production Tax Credit:** No change

Changes Since 7P

- **Solar Tariff:** 30% on imported solar cells and modules for 4 years, decreasing by 5% per year
  - First 2.5 GW of imported cells are excluded
- **Steel and Aluminum:** 25% on foreign steel, 10% on foreign aluminum

WIND: ON SHORE

7P Reference Plant: Wind

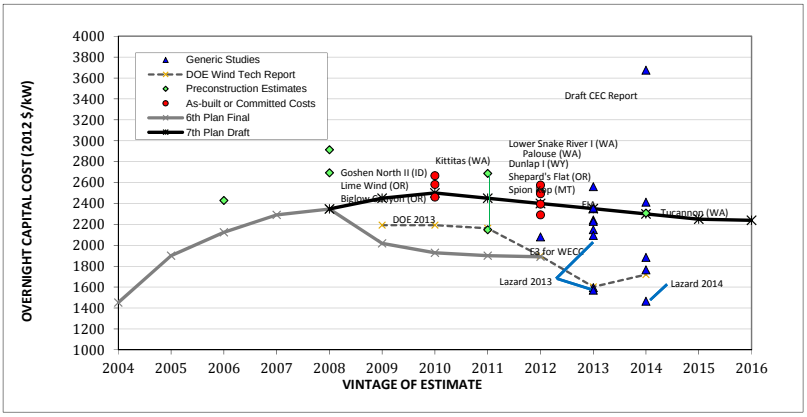
	Wind Columbia Basin	Wind MT w/ Colstrip Transmission
Configuration	40 x 2.5 MW	40 x 2.5 MW
Capacity (MW)	100	100
Capacity Factor	0.32	0.40
Financial Sponsor	IOU	IOU
Transmission	BPA point to point	Colstrip Trans., Montana Intertie, BPA
Economic Life (years)	25	25
Overnight Capital Cost ($/kW)	**2,240**	**2,240**
Fixed O&M Cost ($/kw-yr)	35	35
	In-Service year of 2020	
All-In Capital Cost ($/kW)	2,307	2,307
Levelized Fixed Cost ($/kW-yr)	303.39	322.50
Levelized Cost of Energy ($/MWh)	110.33	94.16

These are two of five reference plants in Appendix H of the 7th Power Plan

All values in 2012$

Northwest Power and Conservation Council

7P Reference Wind Plants



Capital Costs ($/kW) a fundamental part of LCOE, but not the entire story (capacity factor, tax treatment, *etc.*)

Northwest Power and Conservation Council

7P Reference Plant: Wind

- **Production Tax Credit:**

  Wind in the 7th Power Plan did not include the PTC benefit because,

  1. The Plan began development when it looked like PTC would not be renewed after it's 2014 expiration
  2. Even after the PTC was extended, the anticipated need to construct new wind sources appeared to be post-2019

Technology Updates: Wind

- **Production Tax Credit**

Construction Start*	Percent of PTC	Value of PTC ($/MWh)
2015 and 2016	100%	$24.00
2017	80%	$19.20
2018	60%	$14.40
2019	40%	$9.60
2020 and on	0%	-

***Construction Start:** Spending 5% of total cost of project or undertaking significant physical work (excavating turbine sites, building roads, *etc.*)

- Projects must then be operational on Dec. 31 four years after construction start to take safe harbor benefit

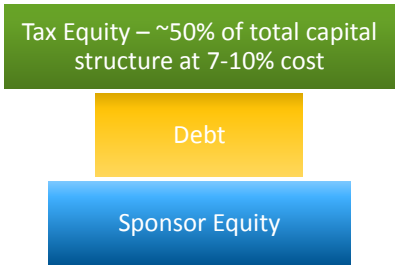
https://www.energy.gov/savings/renewable-electricity-production-tax-credit-ptc
https://www.taxequitytimes.com/2017/10/dramatic-arc-ptc/
https://www.windpowerengineering.com/business-news-projects/ptc-qualifies-start-construction-tax-equity-panel-advises/

Technology Updates: Wind

- **Impact of Production Tax Credit:**
  1. 3rd party cost studies are primarily reporting on projects with PTC benefit
  2. Substantial Safe Harbor equipment with full PTC benefit is still available and being proposed and developed in the region
  3. Tax equity a major part of wind capital stack
  4. Tax reform reduces value of PTC

Technology Updates: Wind

- **Impact of Production Tax Credit:** Drives current capital structure



Access to PTC + Depreciation (MACRS + Bonus)

7th Plan used 50/50 debt-to-equity (IOU) and 60/40 (IPP) based on the assumption that Wind projects in region would begin construction post-PTC

https://www.nrel.gov/docs/fy17osti/68227.pdf & summary at https://www.taxequitytimes.com/2017/09/nrels-wind-finance-report-highlights/
http://www.nortonrosefulbright.com/knowledge/publications/150031/new-trends-in-financing-wind-farms
Note: Lazard's LCOE v. 11 assumed 15% debt at 8.0% interest, 70% tax equity at 10.0% cost, 15% common equity at 12.0% cost

Technology Updates: Wind

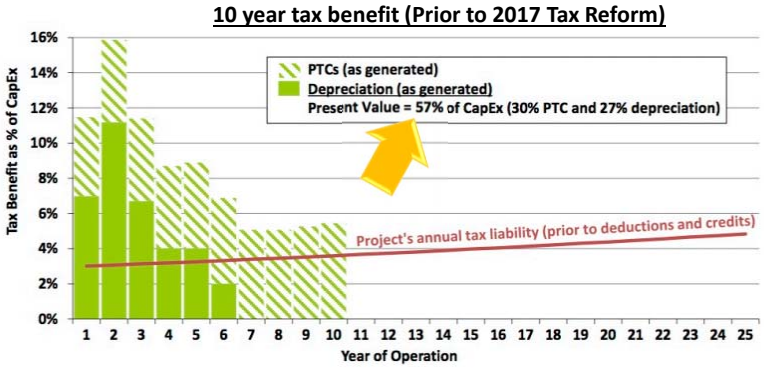


Figure 2. Timing of the federal tax benefits generated by a wind project[14]

Source: Bolinger 2014

https://www.nrel.gov/docs/fy17osti/68227.pdf

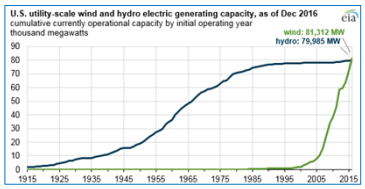
Impact of Tax Reform: Wind

- **Corporate tax rate reduced from 35% to 21%**
  1. Value of depreciation lowered from $0.35 per depreciated dollar to $0.21 per dollar
     - However, the bill increased the optional bonus depreciation (which is additional to the MACRS accelerated schedule) to 100% until Jan 1, 2023 then phasing out 20% per year until Jan 1 2027
  2. Equivalent revenue value of PTC is decreased
     1. Remember, earning $1 of federal income tax results in a larger reduction in revenue requirement based on composite federal + tax rate (Value in $/MWh + Gross Up)
     2. However, capacity factors are generally going up which earns more overall PTCs

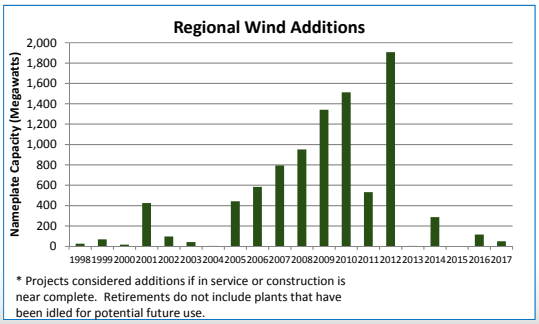
https://www.mcguirewoods.com/Client-Resources/Alerts/2017/12/Tax-Reform-Bills-Impact-Renewable-Energy-Projects.aspx
https://www2.deloitte.com/content/dam/Deloitte/us/Documents/energy-resources/us-er-renewable-energy-project-considerations-when-transacting-with-regulated-utilities.pdf
https://www.taxequitytimes.com/wp-content/uploads/sites/15/2018/03/2018-and-Onward-The-Impact-of-Tax-Reform-Energy-Law-Report-tax-reform.pdf

Trends: Wind

Nationally, wind capacity and energy now exceed hydropower



Regionally, RPS compliance drove early development followed by PURPA + corporate PPAs



Trends: Wind

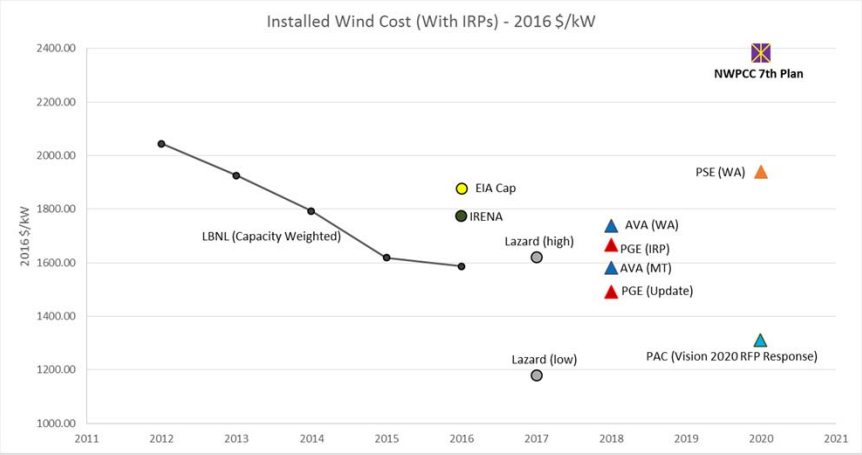
- Trends in region are consistent across U.S.
  - 40% of PPAs across US (~2.2GW) in 2017 were directed to corporate/non-utility off-takers
- Globally, ~75% of all 19GW of global corporate PPA have been signed in the last 3 years
- Corporate PPAs can be more expensive than utility PPAs based on corporate credit worthiness and locational basis risk ownership
  - Locational basis risk: Price spread between bus bar and point of delivery in wholesale markets

https://www.nrel.gov/docs/fy17osti/68227.pdf
https://www.windpowermonthly.com/article/1455220/wind-wins-bulk-corporate-ppas-2017
https://www.awea.org/corporate-purchasers

Recent Wind Costs

- Preface: Important to normalize based on whether or not profit, finance, transmission, *etc.* are included in price summary from 3rd parties
  - Transmission in particular can be a substantial adder to LCOE

Installed Wind Costs



7P Mid-term Draft: Wind

	Wind Columbia Basin	Wind MT w/ Colstrip Transmission
Configuration	40 x 2.5 MW	40 x 2.5 MW
Capacity (MW)	100	100
Capacity Factor	0.32	0.40
Financial Sponsor	IOU	IOU
Transmission	BPA point to point	Colstrip Trans., Montana Intertie, BPA
Economic Life (years)	25	25
Overnight Capital Cost ($/kW)	**1500-1700**	**1500-1700**
Fixed O&M Cost ($/kw-yr)	-	-
	In-Service year of 2020	
All-In Capital Cost ($/kW)	-	-
Levelized Fixed Cost ($/kW-yr)	-	-
Levelized Cost of Energy ($/MWh)	-	-

All values in 2016$

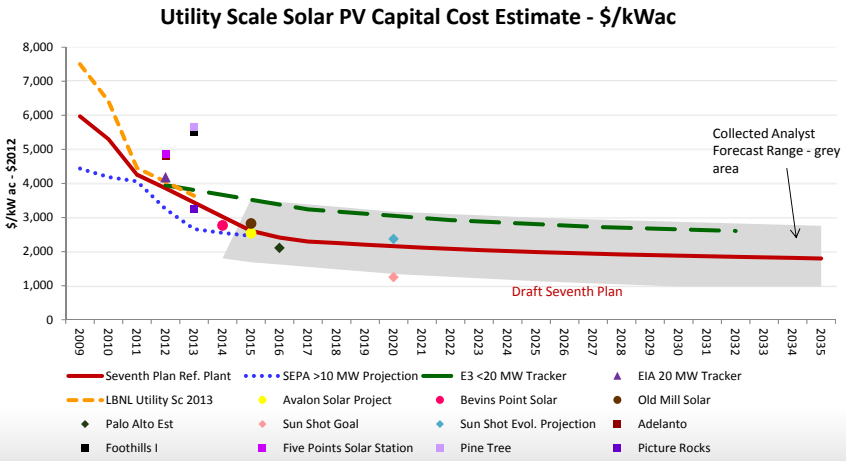
SOLAR PV

7P Reference Plant: Solar PV

	Solar PV S. ID	Solar PV Low Cost S. ID
Configuration	20 Mw_{ac} crystalline silicone with single axis tracker	50 Mw_{ac} crystalline silicone with single axis tracker
Capacity (MW)	17.4	48
Capacity Factor	0.26	0.26
Financial Sponsor	IPP	IPP
Economic Life (years)	30	30
Overnight Capital Cost ($/kW)	2,413	1,685
Fixed O&M Cost ($/kW-yr)	16.63	11.62
	In-Service year of 2020	
All-In Capital Cost ($/kW)	2,238	1,388
Levelized Fixed Cost ($/kW-yr)	204.16	135.28
Levelized Cost of Energy ($/MWh)	91.44	61.43

All values in 2012$

7P Reference Plant: Solar PV



Technology Updates: Solar PV

- **Investment Tax Credit**
  - Costs ($/kW) often reported without ITC

Construction Start	Value of ITC
2016 – 2019	30%
2020	26%
2021	22%
2022 and on	10%

Technology Updates: Solar

- **Steel and Aluminum Tariffs:** Impact anticipated to be $20-40/kW$_{dc}$ *via* increased racking costs
- **Solar Tariff:** Expected to have modest impact, perhaps close to $100/kW$_{dc}$ in the first year (translates to a few dollars/MWh)

https://www.greentechmedia.com/articles/read/steel-aluminum-tariffs-could-add-2-cents-per-watt-to-utility-scale-solar#gs.aUXETnQ

Trends: Solar

- **Growth:** Solar growth contracted somewhat between 2016 and 2017 but has overall been very strong
  - 2016 was an exceptional year due to uncertainty about ITC, and 2017 showed some slowing growth due to PURPA changes, for example

Trends: Solar

- **Costs:**

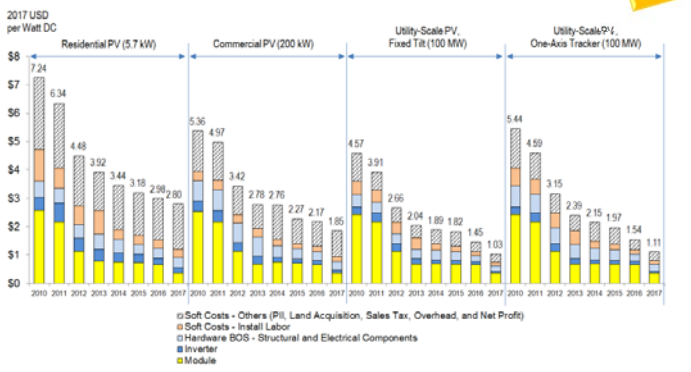
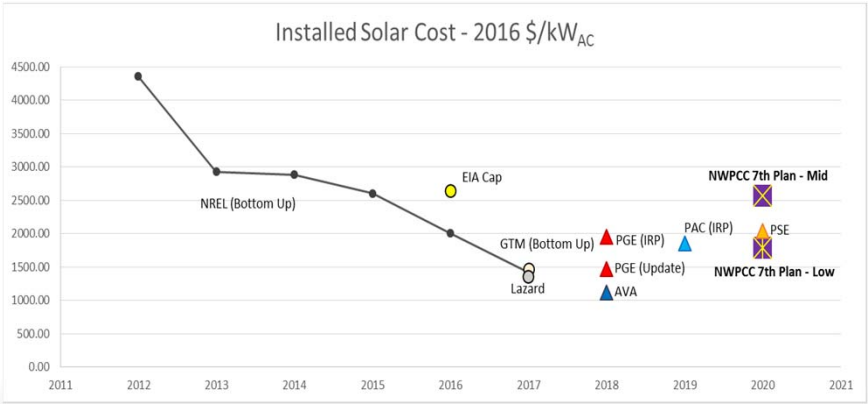


Figure ES-1. NREL PV system cost benchmark summary (inflation adjusted), 2010–2017

https://www.nrel.gov/docs/fy17osti/68925.pdf

Installed Solar Costs



7P Mid-term Draft: Solar

	Solar PV S. ID	Solar PV Low Cost S. ID
Configuration	20 Mw_{ac} crystalline silicone with single axis tracker	50 Mw_{ac} crystalline silicone with single axis tracker
Capacity (MW)	17.4	48
Capacity Factor	0.26	0.26
Financial Sponsor	IPP	IPP
Economic Life (years)	30	30
Overnight Capital Cost ($/kW)	**1350-1500**	**1350-1500**
Fixed O&M Cost ($/kW-yr)		
	In-Service year of 2020	
All-In Capital Cost ($/kW)		
Levelized Fixed Cost ($/kW-yr)		
Levelized Cost of Energy ($/MWh)		

All values in 2016$


Northwest Power and Conservation Council
29