

# The Bergey Excel 15 Story

## Developing the Next-Gen Small Wind Turbine

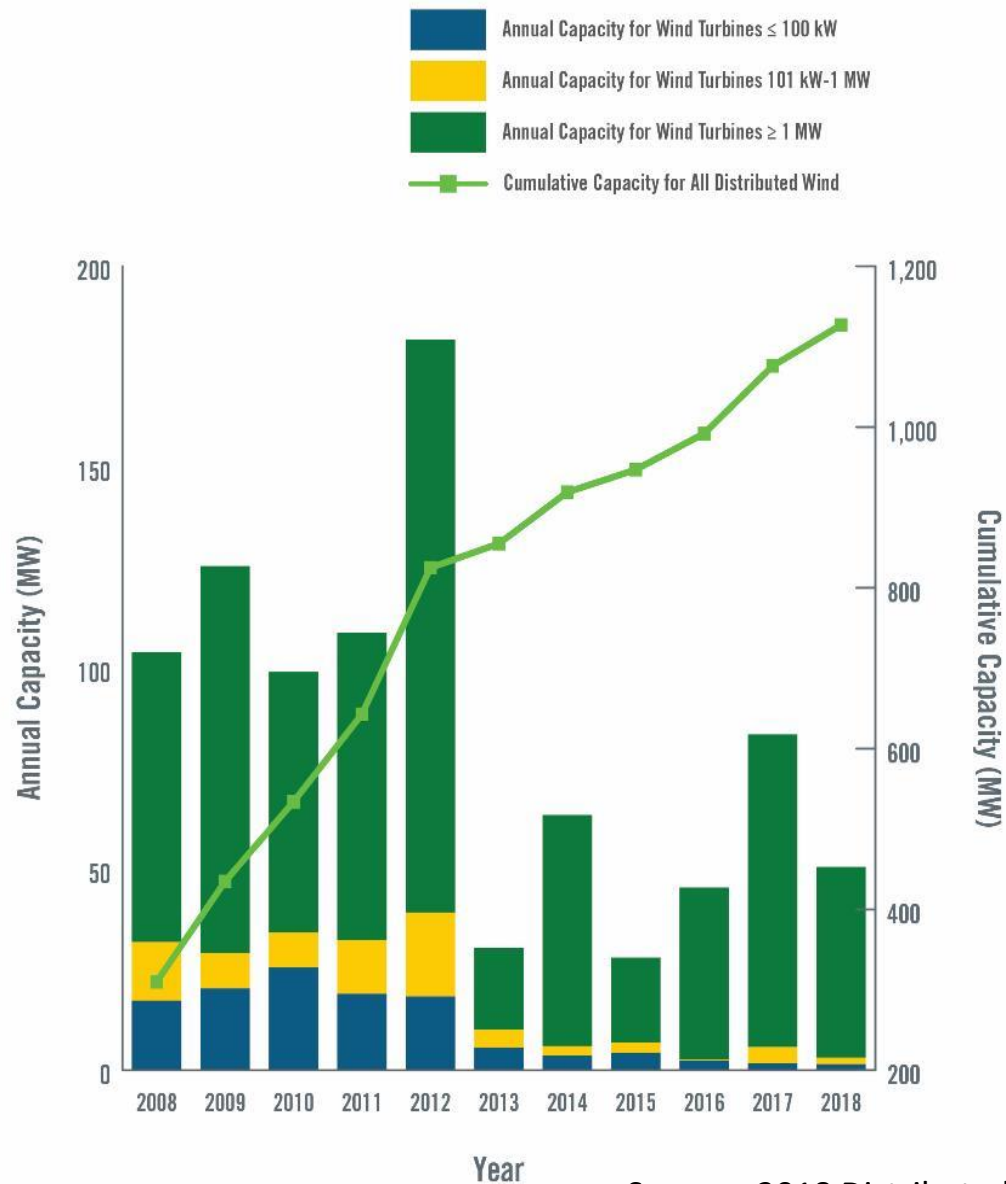
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**Small wind is facing an extreme threat**

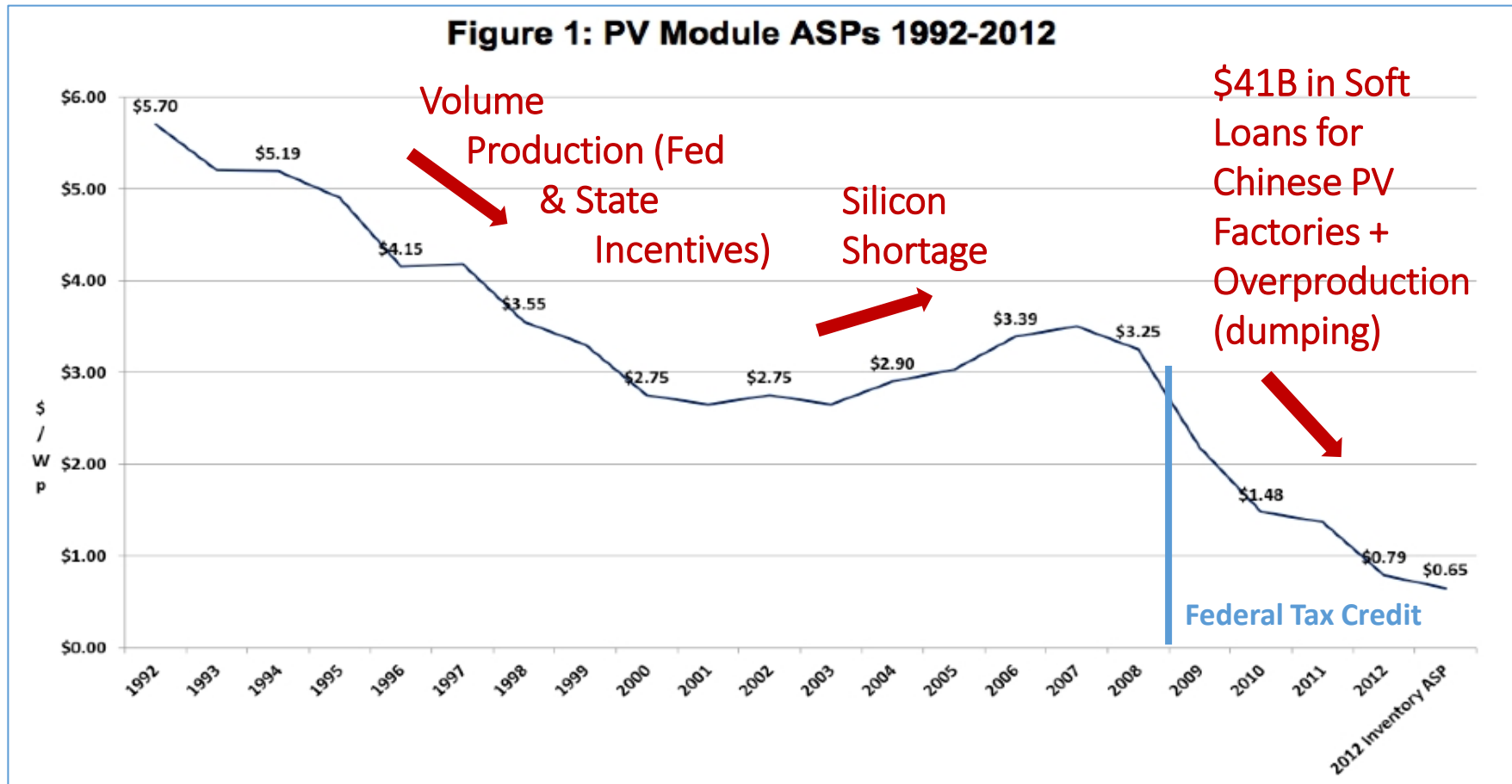
Picture courtesy of Monterey Institute for Research in Astronomy

# Small Wind Sales have Plummeted



Source: 2018 Distributed Wind Market Report, US-DOE

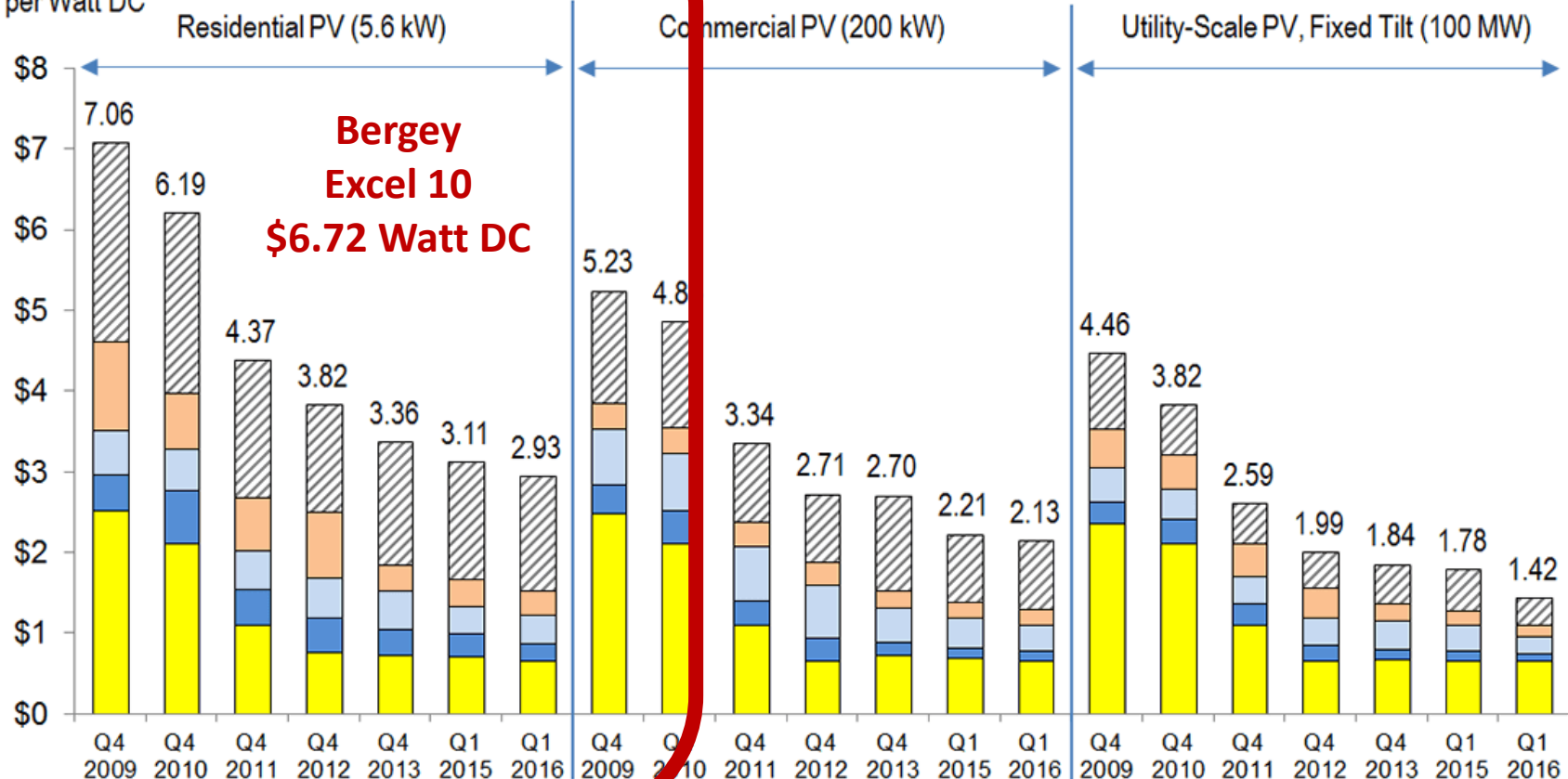
# Due to Plummeting Solar Module Prices



**Chinese manufacturers now command  
~ 80% of the worldwide solar market**

# Small Scale Solar Costs Less!

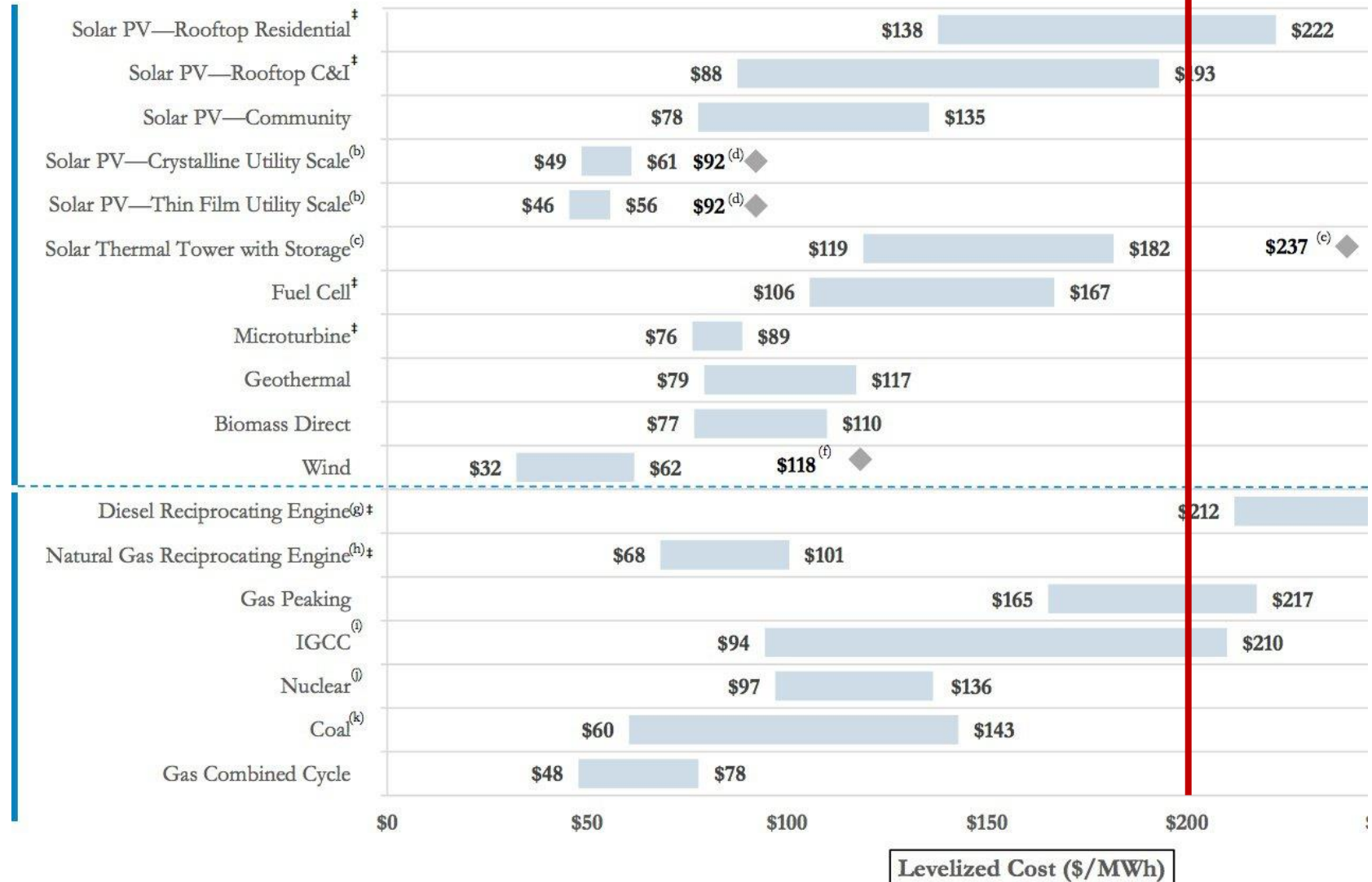
2016 USD  
per Watt DC



- ▨ Soft Costs - Others (PIL, Land Acquisition, Sales Tax, Overhead, and Net Profit)
- ▤ Soft Costs - Install Labor
- ▥ Hardware BOS - Structural and Electrical Components
- ▦ Inverter
- ▧ Module

# Levelized Cost of Energy (LCOE)

Excel 10, 30m SSL (\$200)



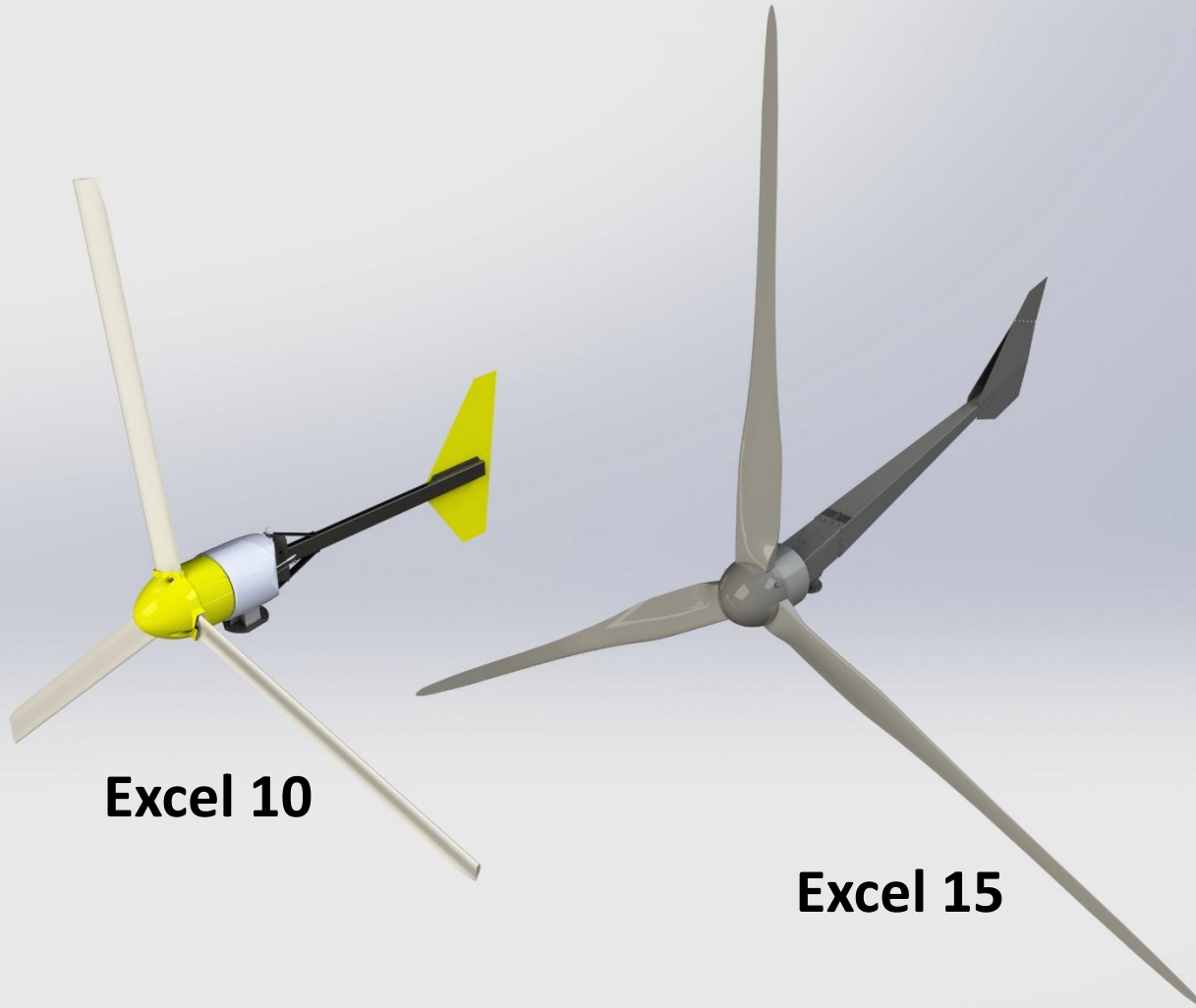
# LCOE Imperative: Innovate or Die!



- Upgrades to Excel 10 evaluated, but proved insufficient to catch imported solar
- BWC forced to start with the proverbial “clean sheet of paper”
- Led us down a different technology path; similar to the larger rotors path of megawatt-scale wind turbines



# Next-Gen Turbine: Excel 15



**Excel 10**

**Excel 15**

R&D supported by US-DOE

# Excel 15 - Advanced Technology



- Tailored Aerodynamics
- Carbon Fiber Blades
- Variable Speed with Stall Control
- 2 Moving Parts (Rotor & Yaw)
- No maintenance; 5 Year Inspection Interval; 30 – 75 Year Predicted Operational Life
- 25 kW Advanced Intergrid Silicon Carbide Inverter, with 8.8 kW dump load

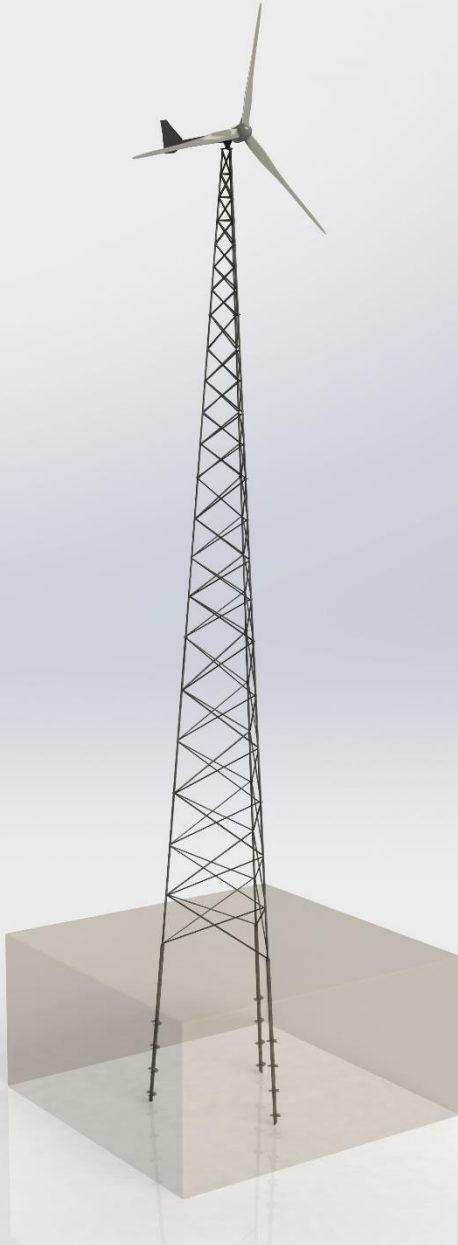


# Excel 15 – Better Economics

	Excel 10	Excel 15	Change
<b>Rotor Diameter</b>	7m (23 ft)	9.6m (31.5 ft)	<b>+ 37%</b>
<b>Rotor Area</b>	38.5m <sup>2</sup>	72.4m <sup>2</sup>	<b>+ 88%</b>
<b>Ref. Power (11 m/s)</b>	8.9 kW	15.6 kW	<b>+ 75%</b>
<b>Max. Cp</b>	0.30	0.40	<b>+ 33%</b>
<b>Max. RPM</b>	450	140	<b>- 69%</b>
<b>AEO at 6 m/s (NREL LCOE)</b>	18,825 kWh	44,950 kWh	<b>+ 139%</b>
<b>MSRP, with inverter</b>	\$31,770	\$37,500	<b>+ 18%</b>
<b>CAPEX, 30m SSL Tower</b>	\$77,000 (\$6.13/Wp)	\$82,500 (\$3.30/Wp)	<b>+ 7%</b>
<b>LCOE*, 30m SSL Tower</b>	21.4¢	9.5¢	<b>- 56%</b>

\* LCOE does not include tax credits, depreciation and other incentives

# 100 ft. Towers with Helical Anchors



- Height works for most sites
- Small foot-print
- High reliability
- No maintenance
- Helical anchors to replace concrete foundations



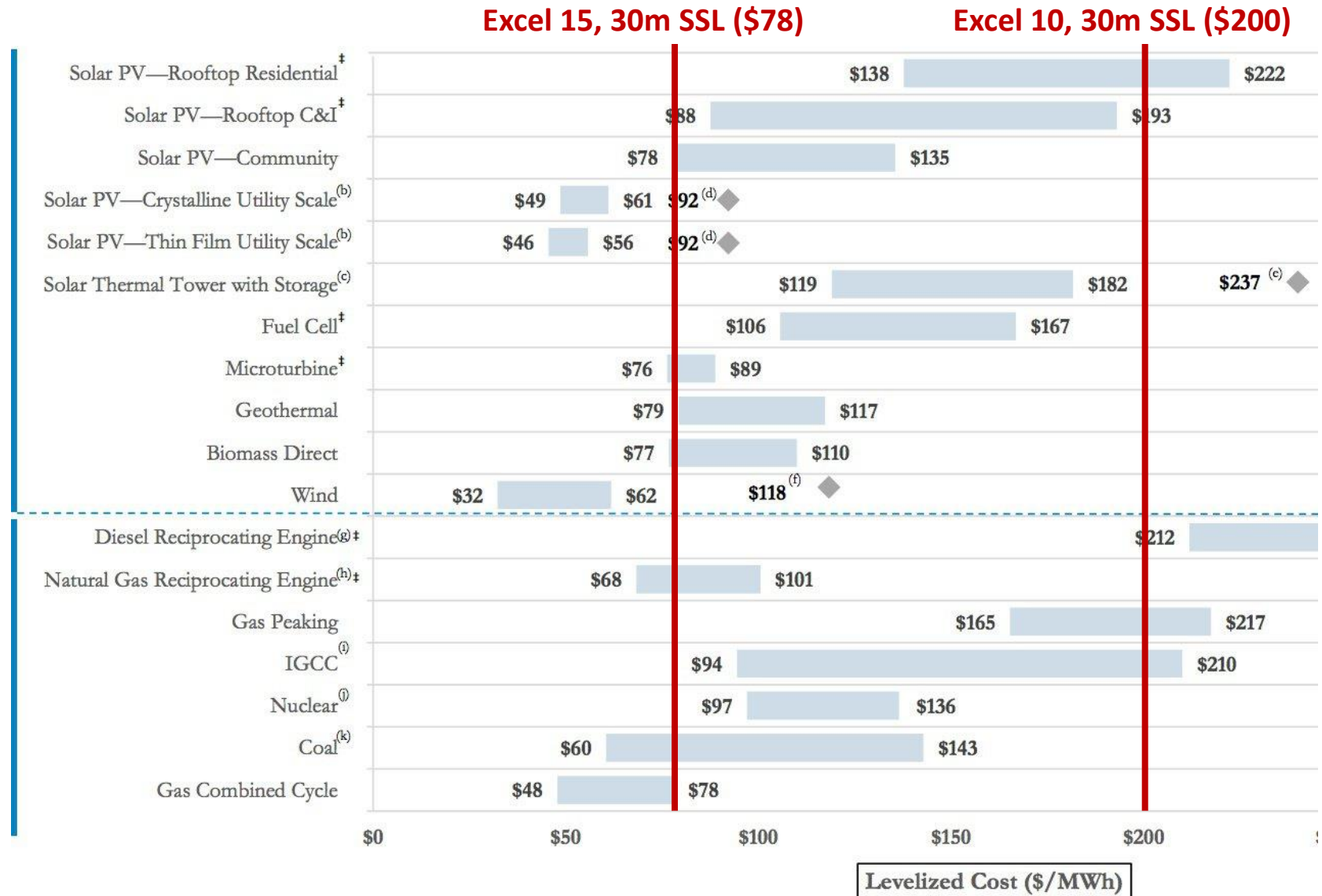
# Excel 15 – Including Advanced Installation

	Excel 10	Excel 15	Change
MSRP, with inverter	\$31,770	\$37,500	+ 18%
CAPEX, 30m SSL Tower	\$77,000 (\$6.13/Wp)	\$67,500 (\$2.70/Wp)	- 12%
LCOE*, 30m SSL Tower	21.4¢	7.8¢	- 64%

**Result: LCOE for Small Scale Wind Reduced by 64%!**

\* LCOE does not include tax credits, depreciation and other incentives

# Levelized Cost of Energy (LCOE)



# Increasing Value – Utility Perspective



15 kW Electric  
Plenum Heater



Tesla Model 3



- At 25-50,000 kWh/year, Excel 15 suitable for conversion to total electric (decarbonizing heating) and/or electric car
- Seasonally complements solar in many places
- Electronics, and emerging storage, allow grid support capabilities and peak shaving



# Next: Affordable Microgrids



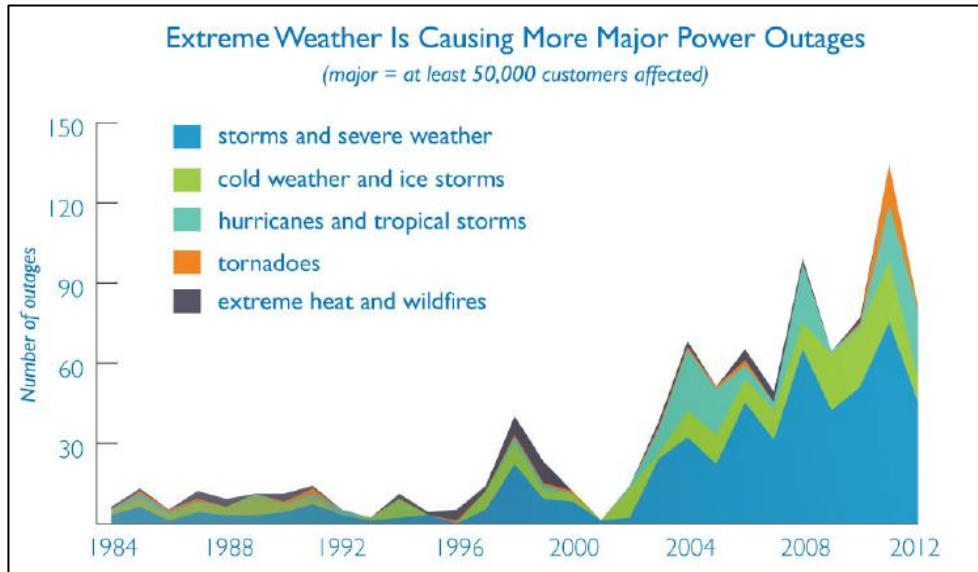
**Rural  
Residences  
& Farms**

**Military &  
Disaster  
Response**



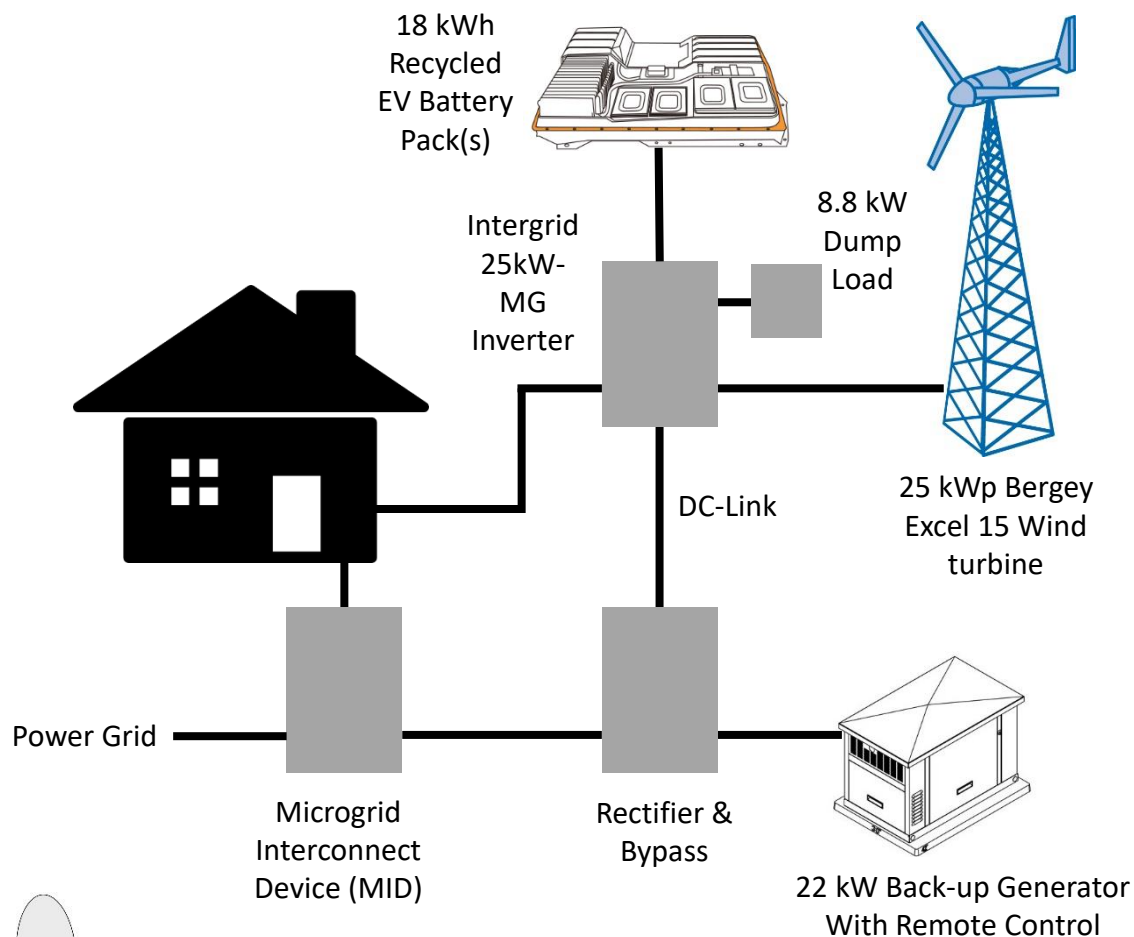


# The Increasing Value of Resiliency



- Increasing risk of extended power outages due to weather
- Resiliency – “The killer app for DER”
- Small microgrids are like village/telecom remote power
  - BWC has 35+ years experience
- New DOE CIP-supported R&D project at Bergey Windpower
  - Home Micro-Grids
  - New REC business models for DER ownership

# Excel 15 Home Microgrid System



## Mode 1: Normal Operation

- Grid on
- MID switched to grid
- Generator off
- Turbine & inverter on
- Wind turbine reduces home's consumption of grid energy
- Excess energy maintains battery

## Mode 2: Back-up (Grid Failure)

- Grid off
- MID switched to inverter, home islanded
- Wind turbine + storage supply home through inverter
- Generator provides back-up through DC-Link
- Generator + wind recharge battery

## Mode 3: Peak Shaving/Voltage Support

- Utility dispatched (Virtual Power Plant), firm 25 kW capacity
- Grid on
- MID switched to grid
- Wind turbine + storage supply home + grid through inverter
- Generator provides back-up through DC-Link (EPA regulations)

# Deployable Advanced Renewable Power System (DARPS)

## Microgrid Technology Demonstrator



- 31 kW Wind
- 25-40 kW Inverter, grid-following or grid-forming
- 64-80 kWh Battery (2<sup>nd</sup> Life EV Battery Packs)
- Ships as 40' CFS
- Set-up in < 4 hours
- 3-Phase 240/480 VAC
- Wind: 70-170 kWh/day
- Integrates with military AMMPS generators
- Cost Target: \$300K
- LCOE Target: 60¢/kWh
- Partners/Advisors: INL, Sandia, Cummins Power Sys.
- Funded by US-DOE



Norman, OK

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