

## Energy Sources Decarburization

Energy and Environment  
New Trends and Issues

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In the last years some relevant events have profoundly changed the energy market:

The first: the new standby of the nuclear energy development (“Nuclear Renaissance”) after the Fukushima crisis that undermined any perspective for the coming decades. Even if we can count 434 reactors in operation and some new grid connections (in 2013, February, HongYanhe-1, China, 1 GW, PWR) and 69 NPP in construction, public acceptance and economic compliance with the energy market are still a big issue.

In US, the constraints on the Federal budget with the related cuts to subsidies to Nuclear (and renewables too) and the costs of the upgrades required after Fukushima are forcing many utilities to an anticipated outage for many aging or not easy to refit NPP.

Moreover, the economic disaster of the first EPR NPP of Olkiluoto in Finland (that is now looking at Russian style PWR, the VVVRs) created some additional panic.

The second: the strong development of the shale gas search and extraction in the Central and North-West part of US, that is rapidly changing also many political strategies, allowing f.i. the US to look differently with respect to the past to Arab oil-based power and put themselves on the market as energy exporters.

However, fracking will probably face in the next future some consensus issues due to the still lacking information about the medium-long term environmental consequences of the extraction procedures (water tab pollution, extensive use of chemicals, etc.).

and, as far as today, the planned Keystone XL pipeline linking Alberta oil sands fields and US shale gas resources to the big refineries and ship terminals in the Gulf of Mexico, are still under scrutiny by EPA and the Obama administration.

In spite of that, gas undoubtedly looks as the main energy source for the coming decades (see the fast development of the various pipelines, liquefied gas terminals, etc. all around the world). In EU too, potential shale gas fields have been identified and tested.

All costs are rising in a fast pace, mainly for environmental reasons, for new oil/gas sources (even for oil sands, the Canada Environmental Authorities are establishing stronger carbon content limits for the extracted oil)

The very long term exploitable resources like the Arctic ones, are really investment demanding (and the studies on the potential interest for the methane hydrate ice are still under way).

So, we are again facing the perspective of at least one or two decades with energy production still based mainly on fossil fuels (more coal, perhaps less oil, and more and more gas...): the nuclear phase-out of Germany and delay in the nuclear restart in Japan up to now are simply increasing fossil fuels burning.

In this context, Carbon Capture technology has found his own path to develop, even if all the proposed ideas looks expensive and focused on big plants with potential relevant and dramatic environmental impact in case of failure.

An other main point is the worldwide economical standby that touch also the so called BRICS, that discovered in the last couple of years that economical growth cannot be decoupled from the social one...

Finally, and mainly in OECD Countries, an always more deep consciousness of the environmental issues risen by the exploitation of the energy sources (every kind, renewable or not: even wind farms or PV fields have their issues), and the need of a new attitude with respect to the carbon emissions & global heating and anthropogenic driven climate changes that threatens the Planet...

What is stepping out is an idea (and the search) of a “smart” solution for global networks for production/distribution of the (electric) energy when and where you need it, becoming able to overcome the well-known paradigm of “you can produce it, but you cannot store it”.

This philosophy, that is actually receiving quite a strong support by economical analysts, remove from consideration some facts that are also relevant and worth to mention in a correct picture of the energy problem, i.e.

the return to the strategic idea of an autonomous sustainable energy policy at Country level, that goes in opposite direction with respect to the more appealing “smart” concepts.

the need of plants f.i. for electric energy base load production (hydro or nuclear or coal...) that cannot rely (only) on renewable potential...

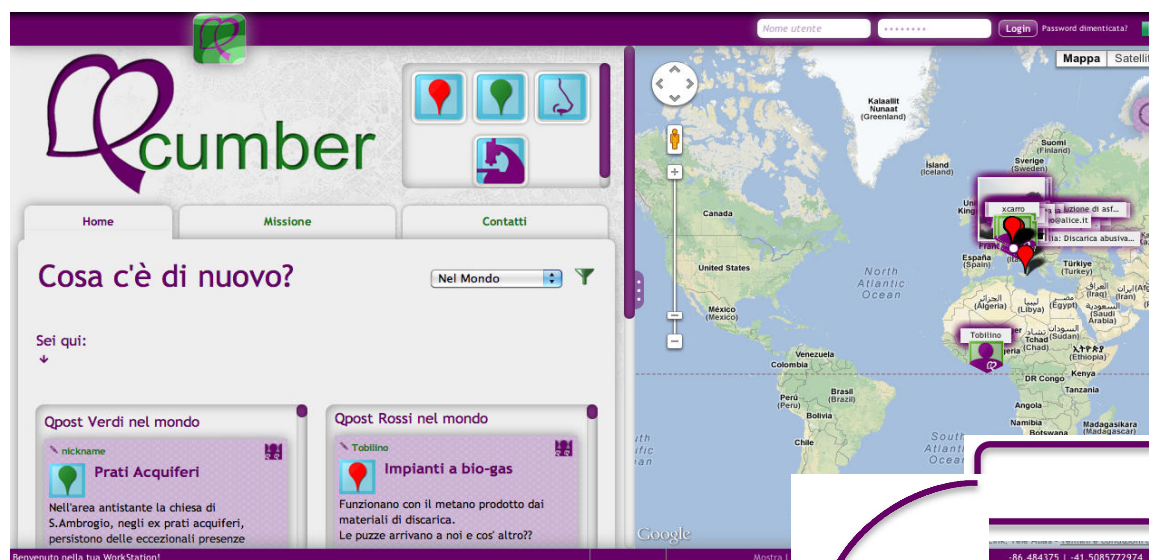


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[info@Q-cumber.org](mailto:info@Q-cumber.org)

O seguici: SuFacebook0  


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Ref: <http://www.q-cumber.org>



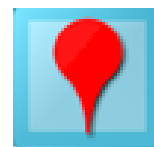
## COSA PUOI FARE CON QCUMBER

### Accedere al Geodatabase

Qcumber offre la possibilità di conoscere il territorio consultando: elementi di stressor (es. cave, discariche, impianti di trattamento rifiuti, ecc.), elementi di vulnerabilità (Comunità umane, ecosistemi e risorse ambientale), e dispositivi di ARPA (centraline meteo, piezometri, ecc..)

### Post Rosso

Qcumber offre la possibilità di segnalare direttamente su mappa eventuali problemi e disagi ambientali (es. rifiuti abbandonati sul territorio, ecc..)



"Post Rosso"!

### Post Verde

Qcumber offre la possibilità di segnalare direttamente su mappa luoghi e/o situazioni di pregio e da tutelare.



"Post Verde"!

### Qalert odori

Qcumber offre la possibilità di segnalare problematiche di molestie olfattive, direttamente su mappa, indicando l'ora della segnalazione, il livello di odore percepito ed eventualmente inserendo fotografie

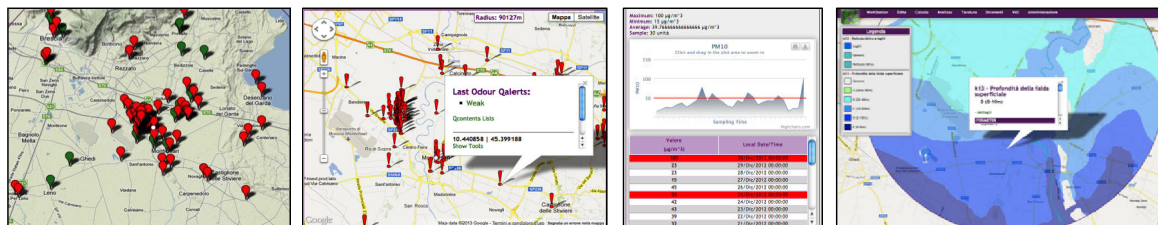


"Qalert Odori"!

### Analizzare il territorio

Qcumber offre la possibilità di analizzare il territorio entro un raggio di 3 km intorno al luogo in cui vive un utente (Analizza area nella tua geolocalizzazione) o intorno ad un punto di interesse definito dall'utente (Analizza area qui).

Le segnalazioni possono essere notificate agli Enti competenti e i cittadini verranno informati sulle attività intraprese e sul livello di risoluzione del problema.!



# Appendix

## data and references

**Current Status:**

**434** NUCLEAR POWER REACTORS  
IN OPERATION

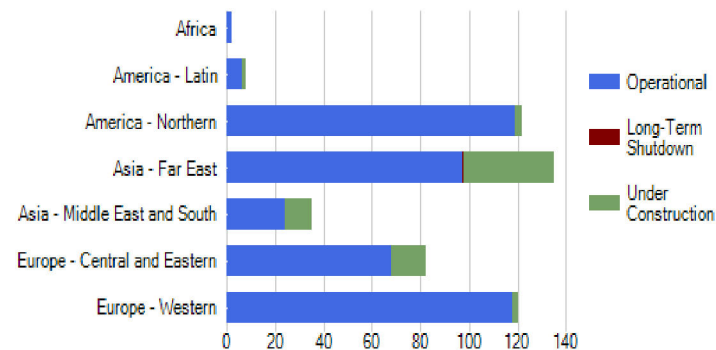
**370 543** MW<sub>e</sub> TOTAL NET INSTALLED  
CAPACITY

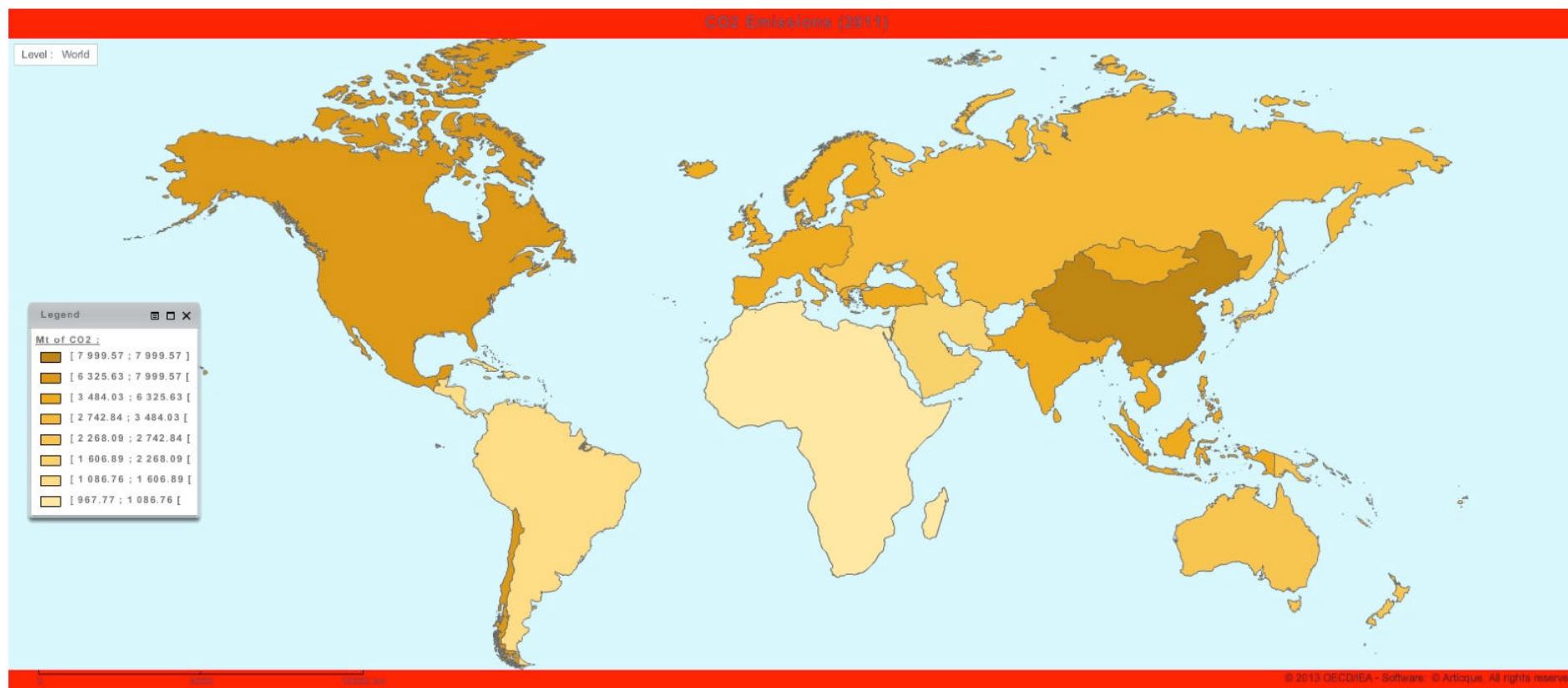
**1** NUCLEAR POWER REACTORS  
IN LONG-TERM SHUTDOWN

**69** NUCLEAR POWER REACTORS  
UNDER CONSTRUCTION

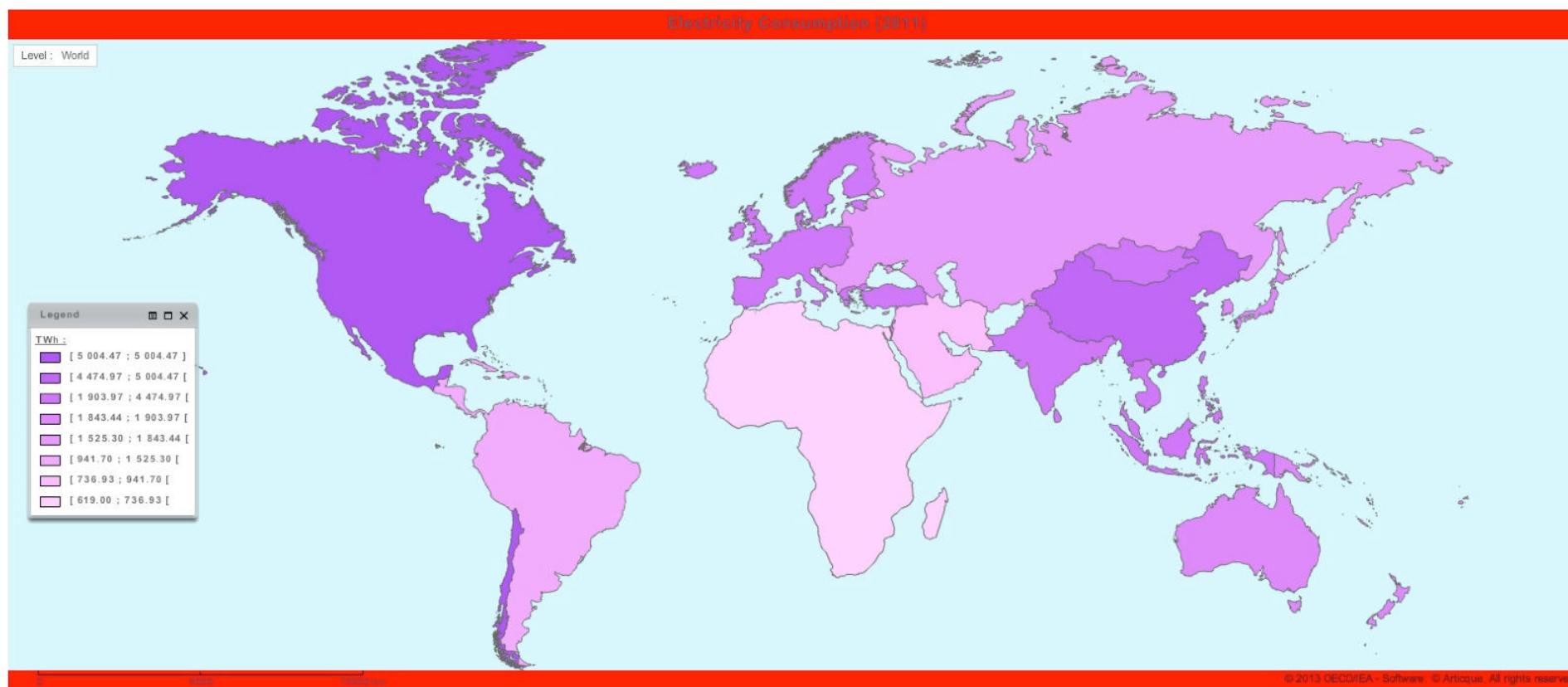
**Regional Distribution of Nuclear Power Plants**

(Click on the chart for more statistics)

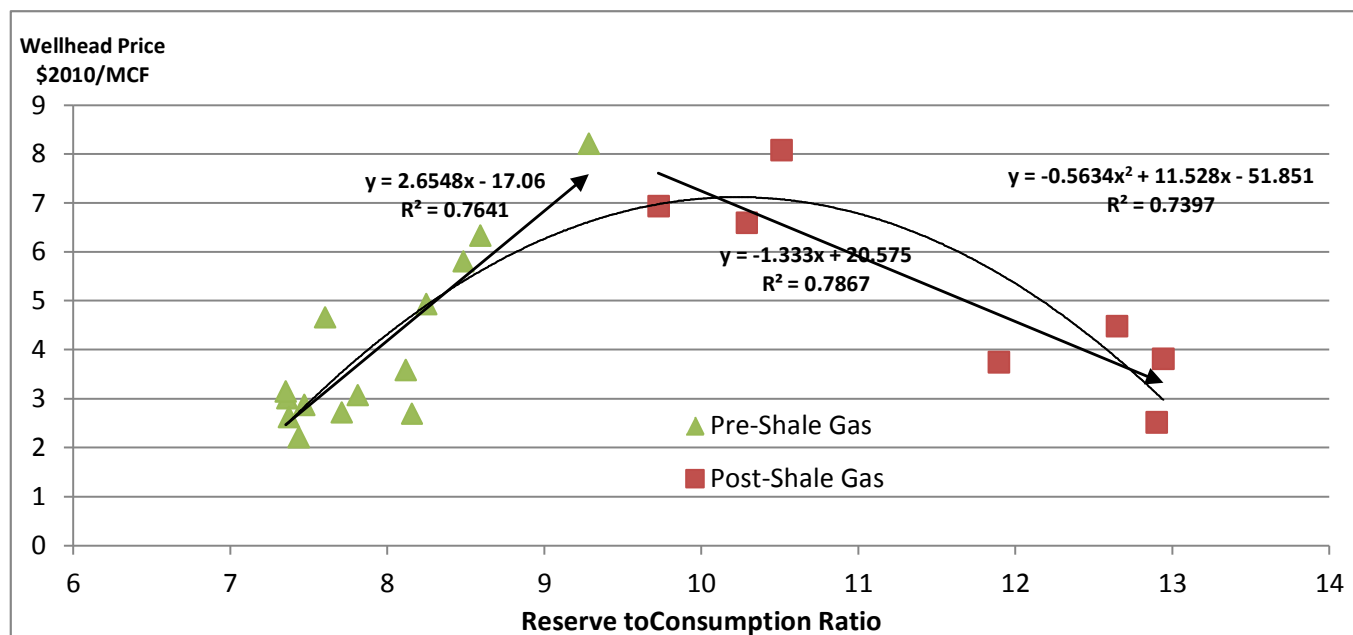








## The Shift in the Natural Gas Supply Curve

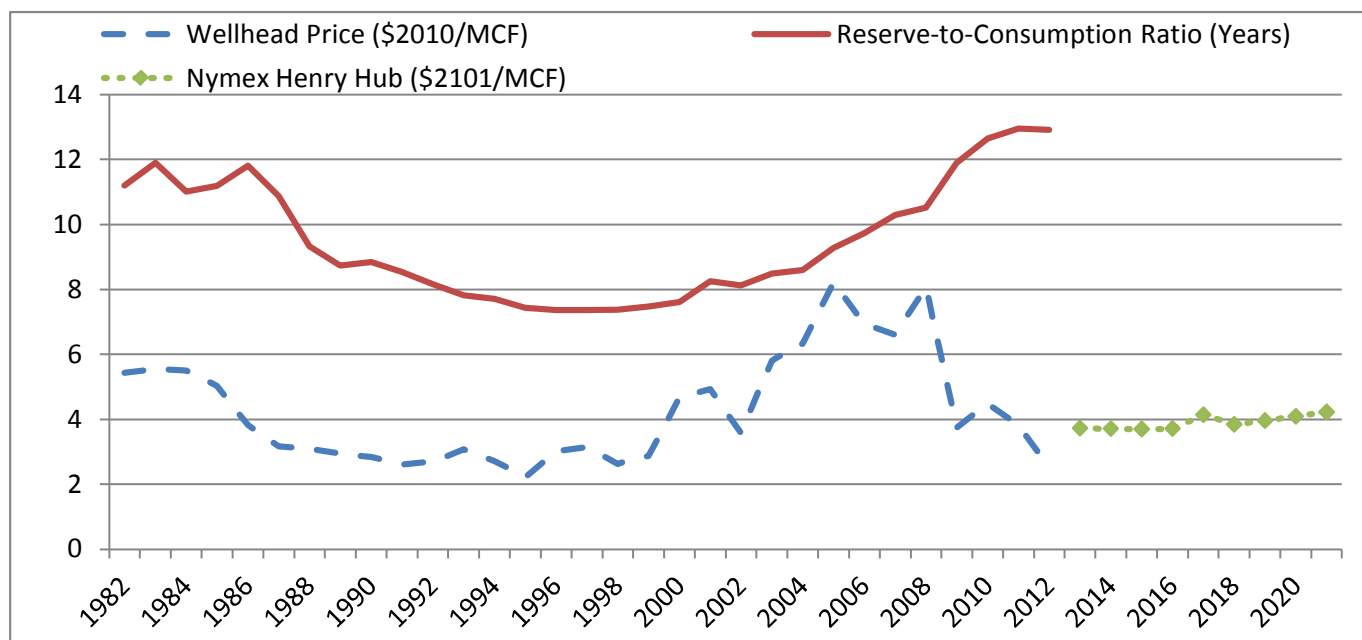


Sources: EIA, Natural Gas Data; Nymex Henry Hub.

Ref: RENAISSANCE IN REVERSE:  
COMPETITION PUSHES AGING U.S. NUCLEAR REACTORS TO THE BRINK OF  
ECONOMIC ABANDONMENT  
MARK COOPER, July 2013.

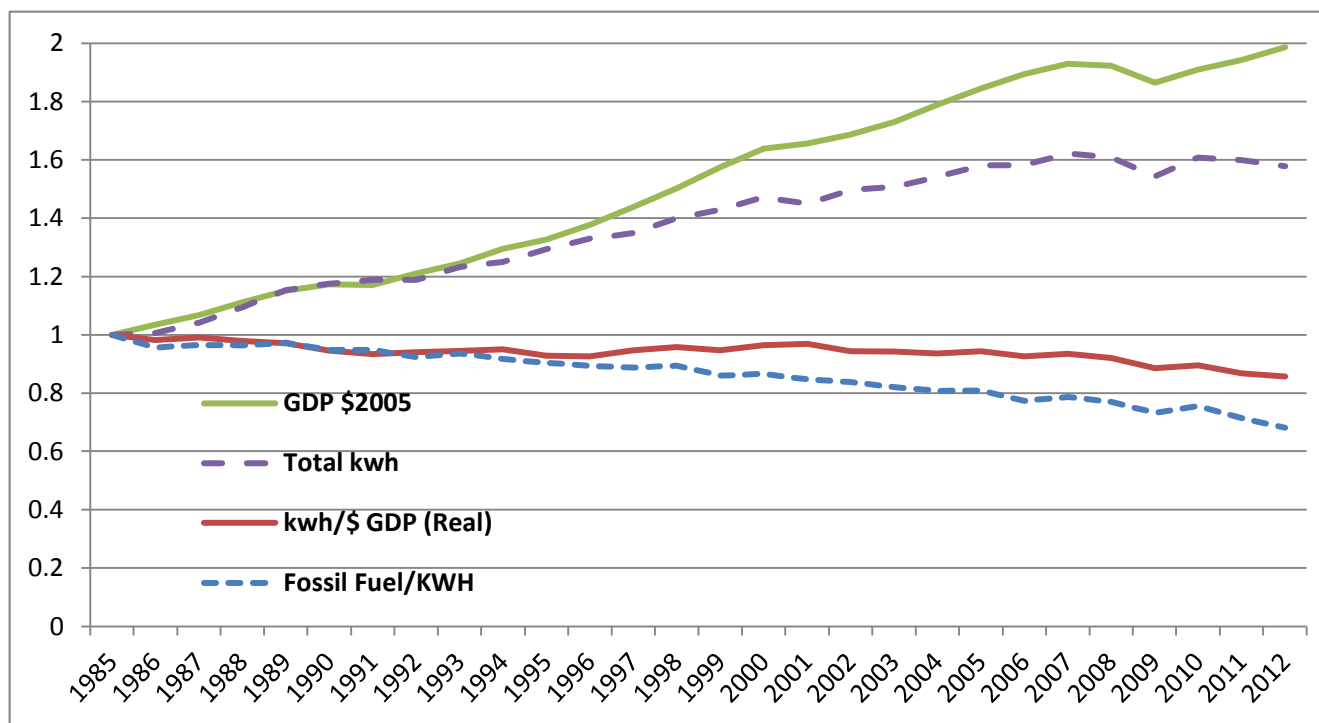
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## Reserves Drive Prices on a Forward Looking Basis



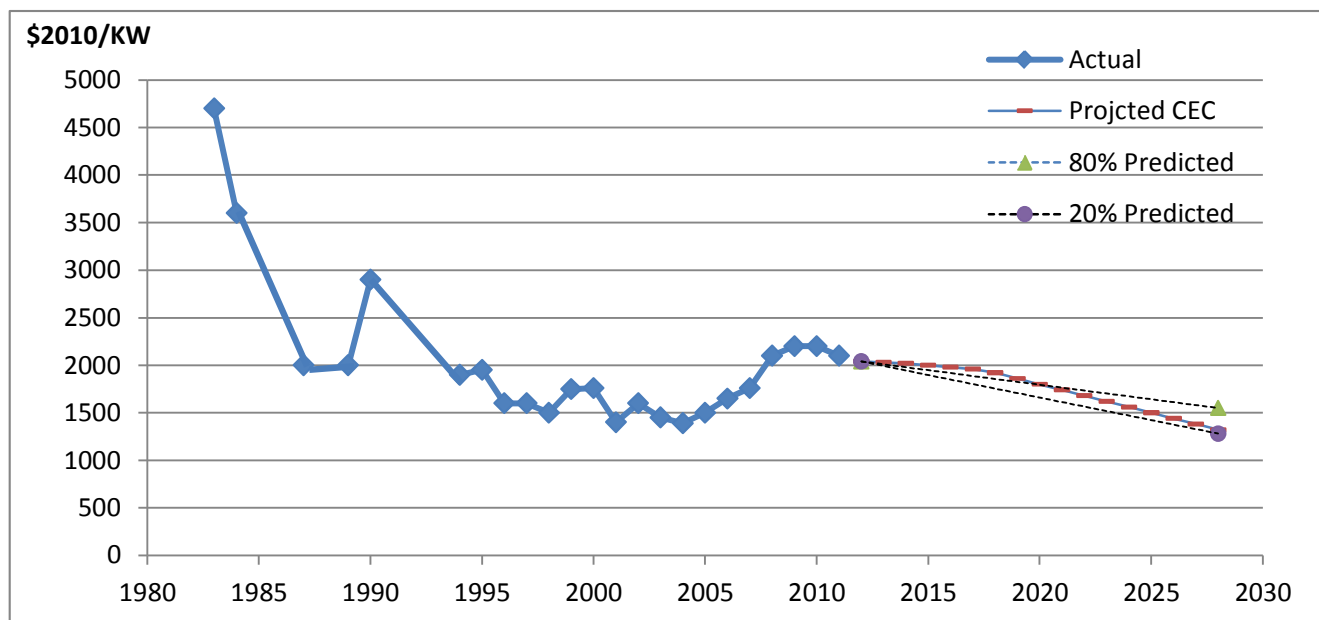
# EXHIBIT III-10: DEMAND FOR FOSSIL FUEL GENERATING CAPACITY:

1985 = 1



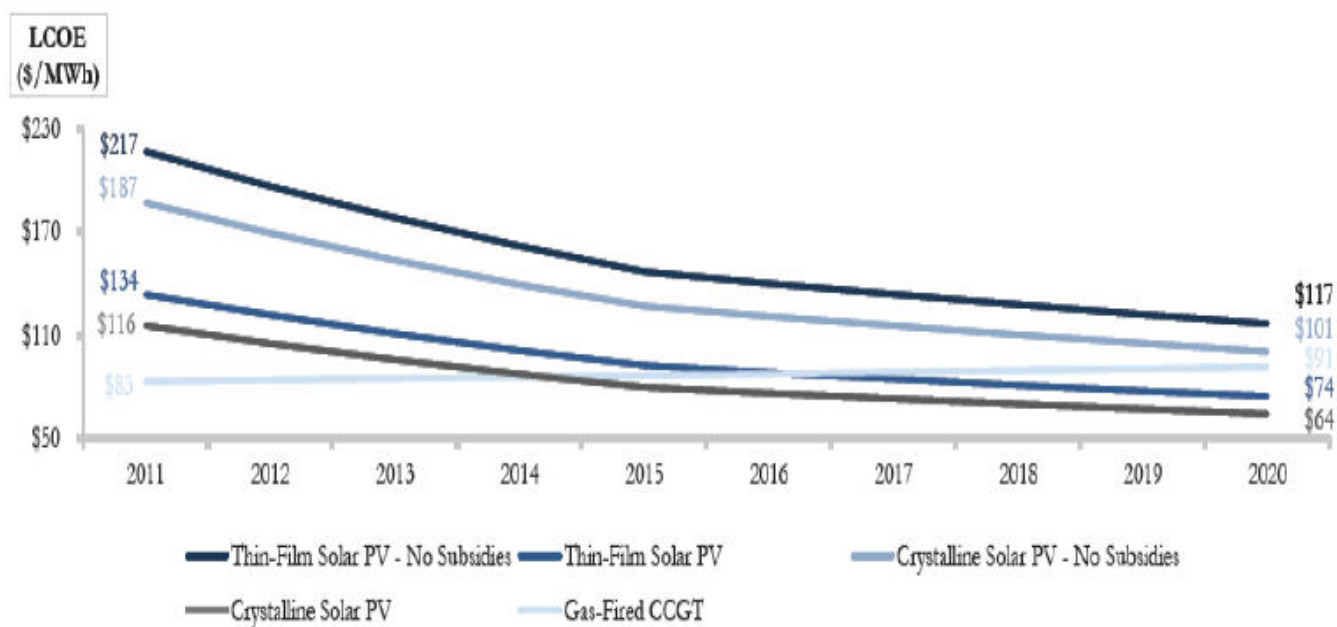
Source: Energy Information Administration, *Monthly energy Review* data tables.

## EXHIBIT IV-7: TRENDS & PROJECTIONS FOR ONSHORE OVERNIGHT WIND COSTS

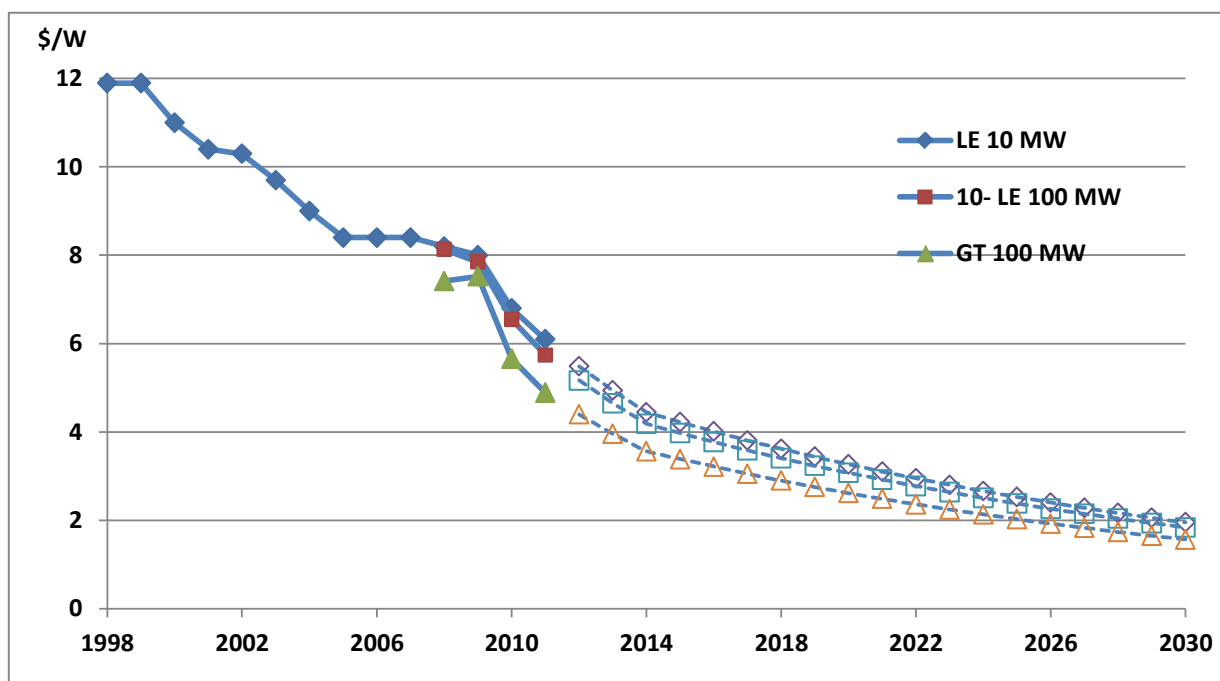


Sources: Ryan Wiser, et al., *Recent Developments in the Levelized cost of Energy From U.S. Wind Power Projects*, NREL, February 2012; Eric Lantz, Maureen Hand and Ryan Wiser, *The Past and Future cost of Wind Energy*, NREL, August 2012; California Energy Commission, *Cost of Central Station Generation*, January 2012.

# EXHIBIT IV-8: KEY COST TRENDS FOR SOLAR POWER: LAZARD LEVELIZED COST FOR SOLAR AND COMBINED CYCLE



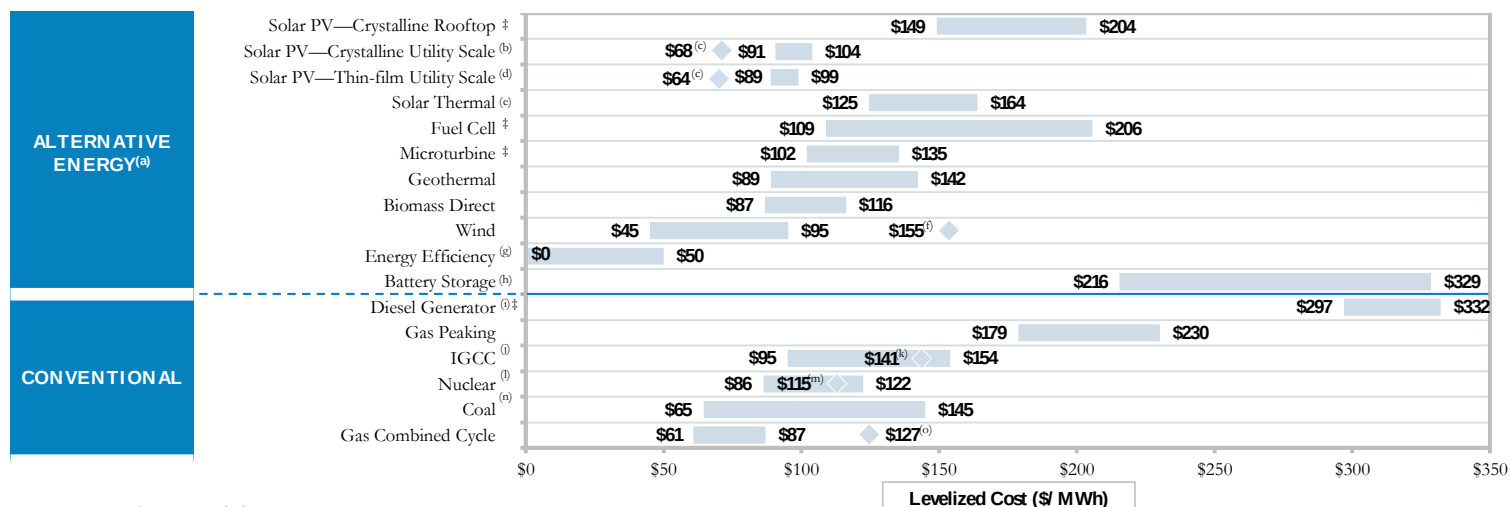
## EXHIBIT IV-9: TRENDS & PROJECTIONS FOR SOLAR



Source: Lazard, *Levelized Cost of Energy Analysis – Version 5.0*, June 2011; Galen Barbose, et al., *Photovoltaic (PV) Pricing Trends: Historical, Recent, and Near-Term Projections*, LBL and NREL, November 2012,

## Unsubsidized Levelized Cost of Energy Comparison

Certain Alternative Energy generation technologies are cost-competitive with conventional generation technologies under some scenarios, before factoring in environmental and other externalities (e.g., RECs, transmission and back-up generation/ system reliability costs) as well as construction and fuel cost dynamics affecting conventional generation technologies



Source: Lazard estimates

Note: Assumes 60% debt at 8% interest rate and 40% equity at 12% cost for conventional and Alternative Energy generation technologies. Assumes Powder River Basin coal price of \$1.99 per MMBtu and natural gas price of \$4.50 per MMBtu. As many have argued, current solar pricing trends may be masking material differences between the inherent economics of certain types of thin-film technologies and crystalline silicon.

‡ Denotes distributed generation technology.

(a) Analysis excludes integration costs for intermittent technologies. A variety of studies suggest integration costs ranging from \$2.00 to \$10.00 per MWh.

(b) Low end represents single-axis tracking. High end represents fixed-tilt installation. Assumes 10 MW system in high insolation jurisdiction (e.g., Southwest U.S.). Not directly comparable for baseload.

(c) Diamonds represent estimated implied levelized cost of energy in 2015, assuming \$1.50 per watt for a crystalline single-axis tracking system and \$1.50 per watt for a thin-film single-axis tracking system.

(d) Low end represents single-axis tracking. High end represents fixed-tilt installation. Assumes 10 MW fixed-tilt installation in high insolation jurisdiction (e.g., Southwest U.S.).

(e) Low end represents solar tower without storage. High end represents solar tower with storage capability.

(f) Represents estimated midpoint of levelized cost of energy for offshore wind, assuming a range of \$3.10 – \$5.00 per watt.

(g) Estimates per National Action Plan for Energy Efficiency; actual cost for various initiatives varies widely. Estimates involving demand response may fail to account for opportunity cost of foregone consumption.

(h) Indicative range based on current and future stationary storage technologies; assumes capital costs of \$400 – \$750/KWh for 6 hours of storage capacity, \$60/MWh cost to charge, one full cycle per day (full charge and discharge), efficiency of 66% – 75% and fixed O&M costs of \$5 to \$20 per KWh installed per year.

(i) Low end represents continuous operation. High end represents intermittent operation. Assumes diesel price of \$4.00 per gallon.

(j) High end incorporates 90% carbon capture and compression. Does not include cost of transportation and storage.

(k) Represents estimate of current U.S. new IGCC construction with carbon capture and compression. Does not include cost of transportation and storage.

(l) Does not reflect decommissioning costs or potential economic impact of federal loan guarantees or other subsidies.

(m) Represents estimate of current U.S. new nuclear construction.

(n) Based on advanced supercritical pulverized coal. High end incorporates 90% carbon capture and compression. Does not include cost of transportation and storage.

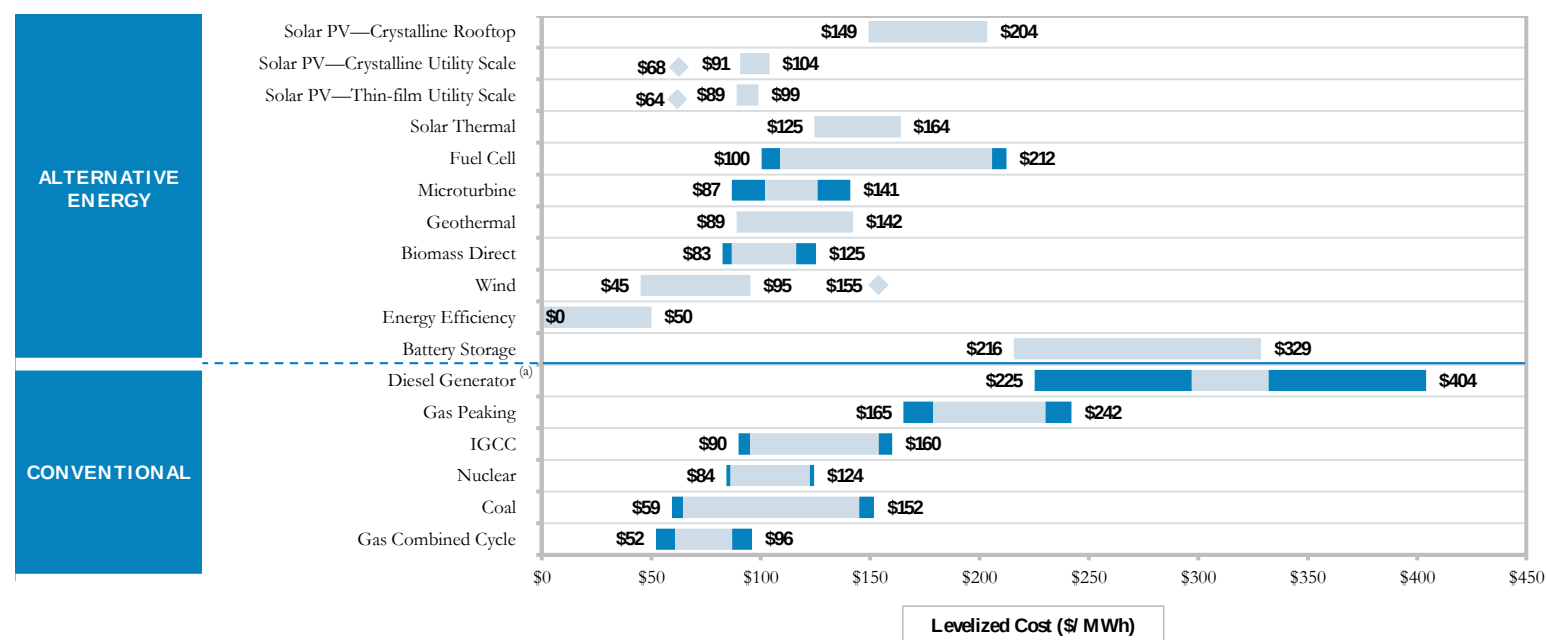
(o) Incorporates 90% carbon capture and compression. Does not include cost of transportation and storage.

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## Levelized Cost of Energy Comparison—Sensitivity to Fuel Prices

Variations in fuel prices can materially affect the levelized cost of energy for conventional generation technologies, but direct comparisons against “competing” Alternative Energy generation technologies must take into account issues such as dispatch characteristics (e.g., baseload and/ or dispatchable intermediate load vs. peaking or intermittent technologies)



Source: Lazard estimates

Note: Darkened areas in horizontal bars represent low end and high end levelized cost of energy corresponding with  $\pm 25\%$  fuel price fluctuations.

(a) Low end represents continuous operation. High end represents intermittent operation.

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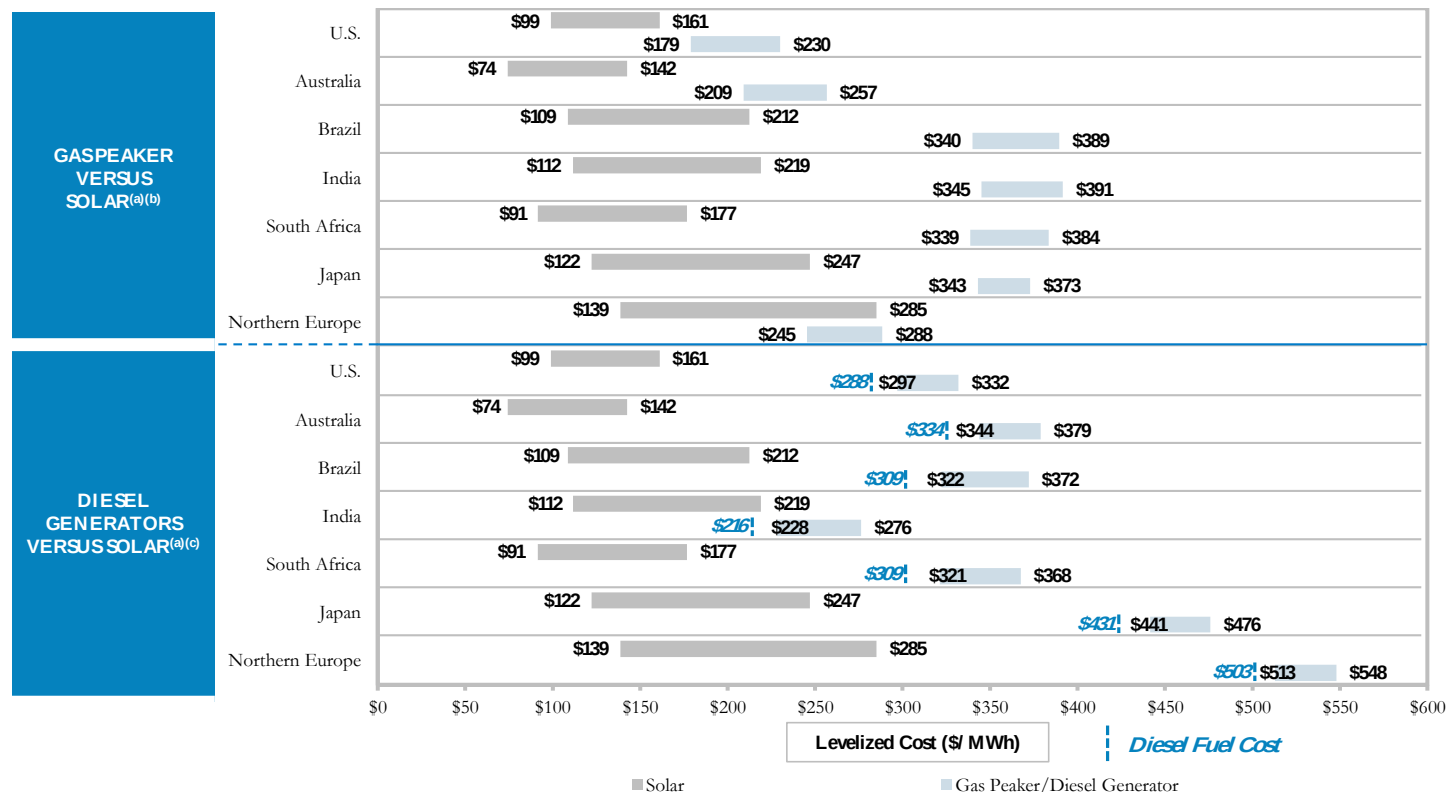
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Ref: Lazard's Levelized Cost of Energy  
Analysis—Version 7.0, Sept. 2103

## Solar versus Peaking Capacity—Global Markets

Solar PV can be an attractive resource relative to gas and diesel-fired peaking in many parts of the world due to high fuel costs; without storage, however, solar lacks the dispatch characteristics of conventional peaking technologies

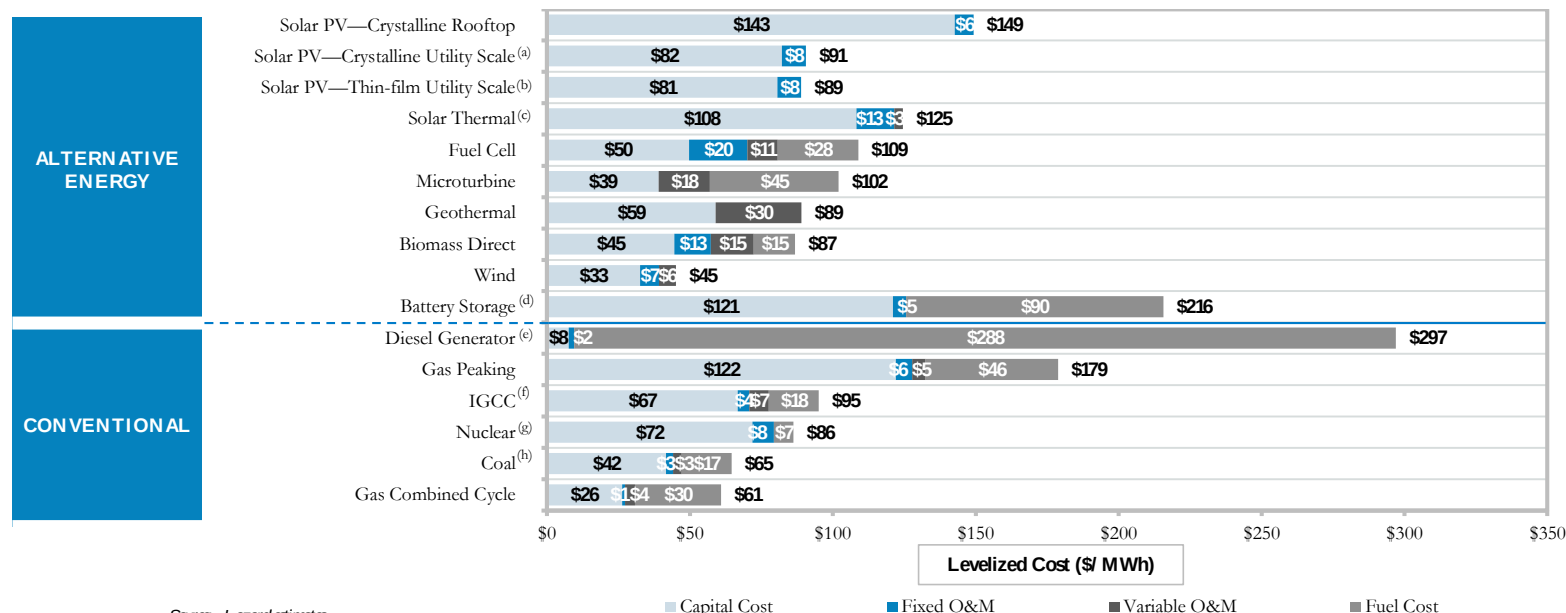


Source: World Bank, Waterborne Energy, Department of Energy of South Africa, Sydney and Brisbane Hub Trading Prices and Lazard estimates

- (a) Low end assumes a solar fixed-tilt thin-film utility scale system with per watt capital costs of \$3.25. Solar projects assume capacity factors of 26% – 28% for Australia, 25% – 27% for Brazil, 23% – 25% for India, 27% – 29% for South Africa, 15% – 17% for Japan and 13% – 15% for Northern Europe. Equity IRRs of 12% are assumed for Australia, Japan and Northern Europe and 18% for Brazil, India and South Africa; assumes cost of debt of 8% for Australia, Japan and Northern Europe, 14.5% for Brazil, 13% for India and 11.5% for South Africa.
- (b) Assumes natural gas prices of \$7 for Australia, \$14 for Brazil, \$15 for India, \$15 for South Africa, \$18 for Japan and \$10 for Northern Europe (all in U.S.\$ per MMBtu). Assumes a capacity factor of 10%.
- (c) Diesel assumes high end capacity factor of 30% representing intermittent utilization and low end capacity factor of 95% representing baseload utilization, O&M cost of \$15 per KW/year, heat rate of 10,000 Btu/KWh and total capital costs of \$500 to \$800 per KW of capacity. Assumes diesel prices of \$4.65 for Australia, \$4.30 for Brazil, \$3.00 for India, \$4.30 for South Africa, \$6.00 for Japan and \$7.00 for Northern Europe (all in U.S.\$ per gallon).

## Levelized Cost of Energy Components—Low End

Certain Alternative Energy generation technologies are already cost-competitive with conventional generation technologies; a key factor regarding the long-term competitiveness of currently more expensive Alternative Energy technologies is the ability of technological development and increased production volumes to materially lower the capital costs of certain Alternative Energy technologies, and their levelized cost of energy, over time (e.g., as has been the case with solar PV and wind technologies)



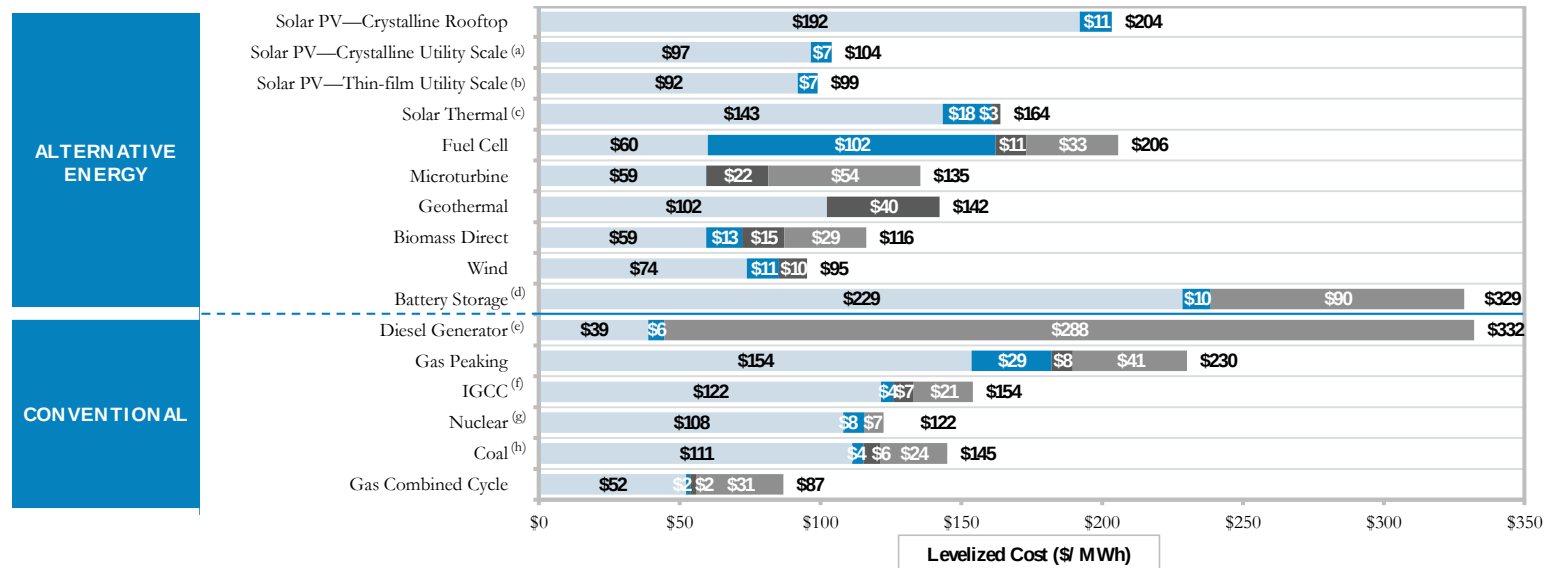
Source: Lazard estimates

Note: Assumes 60% debt at 8% interest rate and 40% equity at 12% cost for conventional and Alternative Energy generation technologies. Assumes Powder River Basin coal price of \$1.99 per MMBtu and natural gas price of \$4.50 per MMBtu.

- (a) Low end represents single-axis tracking.
- (b) Low end represents single-axis tracking.
- (c) Low end represents solar tower without storage capability.
- (d) Low end represents flow battery.
- (e) Low end represents continuous operation.
- (f) Does not incorporate carbon capture and compression.
- (g) Does not reflect decommissioning costs or potential economic impact of federal loan guarantees or other subsidies.
- (h) Based on advanced supercritical pulverized coal. Does not incorporate carbon capture and compression.

## Levelized Cost of Energy Components—High End

Certain Alternative Energy generation technologies are already cost-competitive with conventional generation technologies; a key factor regarding the long-term competitiveness of currently more expensive Alternative Energy technologies is the ability of technological development and increased production volumes to materially lower the capital costs of certain Alternative Energy technologies, and their levelized cost of energy, over time (e.g., as has been the case with solar PV and wind technologies)



Source: Lazard estimates

Note: Assumes 60% debt at 8% interest rate and 40% equity at 12% cost for conventional and Alternative Energy generation technologies. Assumes Powder River Basin coal price of \$1.99 per MMBtu and natural gas price of \$4.50 per MMBtu.

- (a) High end represents fixed-tilt installation.
- (b) High end represents fixed-tilt installation.
- (c) High end represents solar tower with storage capability.
- (d) High end represents NaS technology.
- (e) High end represents intermittent operation.
- (f) High end incorporates 90% carbon capture and compression. Does not include cost of transportation and storage.
- (g) Does not reflect decommissioning costs or potential economic impact of federal loan guarantees or other subsidies.
- (h) Based on advanced supercritical pulverized coal. High end incorporates 90% carbon capture and compression. Does not include cost of transportation and storage.

## Energy Resources: Matrix of Applications

While the levelized cost of energy for Alternative Energy generation technologies is becoming increasingly competitive with conventional generation technologies, direct comparisons must take into account issues such as location (e.g., central station vs. customer-located) and dispatch characteristics (e.g., baseload and/ or dispatchable intermediate load vs. peaking or intermittent technologies). This analysis also does not address the potential stranded cost aspects of distributed generation solutions in respect of existing electric utility systems, nor does it account for the social costs or other externalities of the rate consequences for those who cannot afford distributed generation solutions

|                       |                          | LEVELIZED<br>COST OF<br>ENERGY | CARBON<br>NEUTRAL/<br>REC<br>POTENTIAL | STATE<br>OF<br>TECHNOLOGY | LOCATION            |                    |                          | DISPATCH     |         |                    |               |
|-----------------------|--------------------------|--------------------------------|----------------------------------------|---------------------------|---------------------|--------------------|--------------------------|--------------|---------|--------------------|---------------|
|                       |                          |                                |                                        |                           | CUSTOMER<br>LOCATED | CENTRAL<br>STATION | GEOGRAPHY                | INTERMITTENT | PEAKING | LOAD-<br>FOLLOWING | BASE-<br>LOAD |
| ALTERNATIVE<br>ENERGY | SOLAR PV                 | \$89 – 204                     | ✓                                      | Commercial                | ✓                   | ✓                  | Universal <sup>(a)</sup> | ✓            | ✓       |                    |               |
|                       | SOLAR<br>THERMAL         | \$125 – 164                    | ✓                                      | Commercial                |                     | ✓                  | Southwest                | ✓            | ✓       | ✓                  |               |
|                       | FUEL CELL                | \$109 – 206                    | ?(b)                                   | Emerging/<br>Commercial   | ✓                   |                    | Universal                |              |         |                    | ✓             |
|                       | MICROTURBINE             | \$102 – 135                    | ?(b)                                   | Emerging/<br>Commercial   | ✓                   |                    | Universal                |              |         |                    | ✓             |
|                       | GEOTHERMAL               | \$89 – 142                     | ✓                                      | Mature                    |                     | ✓                  | Varies                   |              |         |                    | ✓             |
|                       | BIOMASS<br>DIRECT        | \$87 – 116                     | ✓                                      | Mature                    |                     | ✓                  | Universal                |              |         | ✓                  | ✓             |
|                       | ONSHORE<br>WIND          | \$45 – 95                      | ✓                                      | Mature                    |                     | ✓                  | Varies                   | ✓            |         |                    |               |
|                       | BATTERY<br>STORAGE       | \$216 – 329                    | ✓                                      | Emerging                  | ✓                   | ✓                  | Varies                   |              | ✓       | ✓                  |               |
| CONVENTIONAL          | DIESEL<br>GENERATOR      | \$297 – 332                    | ✗                                      | Mature                    | ✓                   |                    | Universal                | ✓            | ✓       | ✓                  | ✓             |
|                       | GASPEAKING               | \$179 – 230                    | ✗                                      | Mature                    | ✓                   | ✓                  | Universal                |              | ✓       | ✓                  |               |
|                       | IGCC                     | \$95 – 154                     | ✗ <sup>(c)</sup>                       | Emerging <sup>(d)</sup>   |                     | ✓                  | Co-located or<br>rural   |              |         |                    | ✓             |
|                       | NUCLEAR                  | \$86 – 122                     | ✓                                      | Mature/<br>Emerging       |                     | ✓                  | Co-located or<br>rural   |              |         |                    | ✓             |
|                       | COAL                     | \$65 – 145                     | ✗ <sup>(c)</sup>                       | Mature <sup>(d)</sup>     |                     | ✓                  | Co-located or<br>rural   |              |         |                    | ✓             |
|                       | GAS<br>COMBINED<br>CYCLE | \$61 – 87                      | ✗                                      | Mature                    | ✓                   | ✓                  | Universal                |              |         | ✓                  | ✓             |

Source: Lazard estimates

- (a) Qualification for RPS requirements varies by location.  
 (b) LCOE study capacity factor assumes Southwest location.  
 (c) Could be considered carbon neutral technology, assuming carbon capture and compression.  
 (d) Carbon capture and compression technologies are in emerging stage.