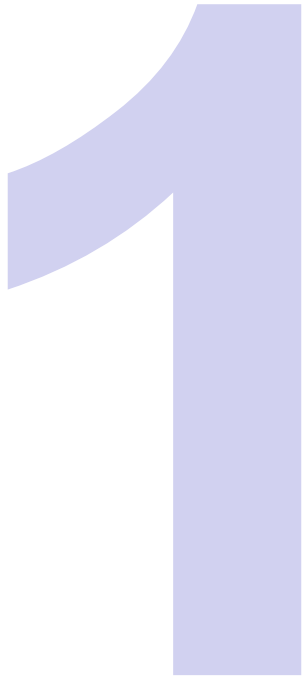


The Renewable Revolution: Power Generation Costs



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COSTING....

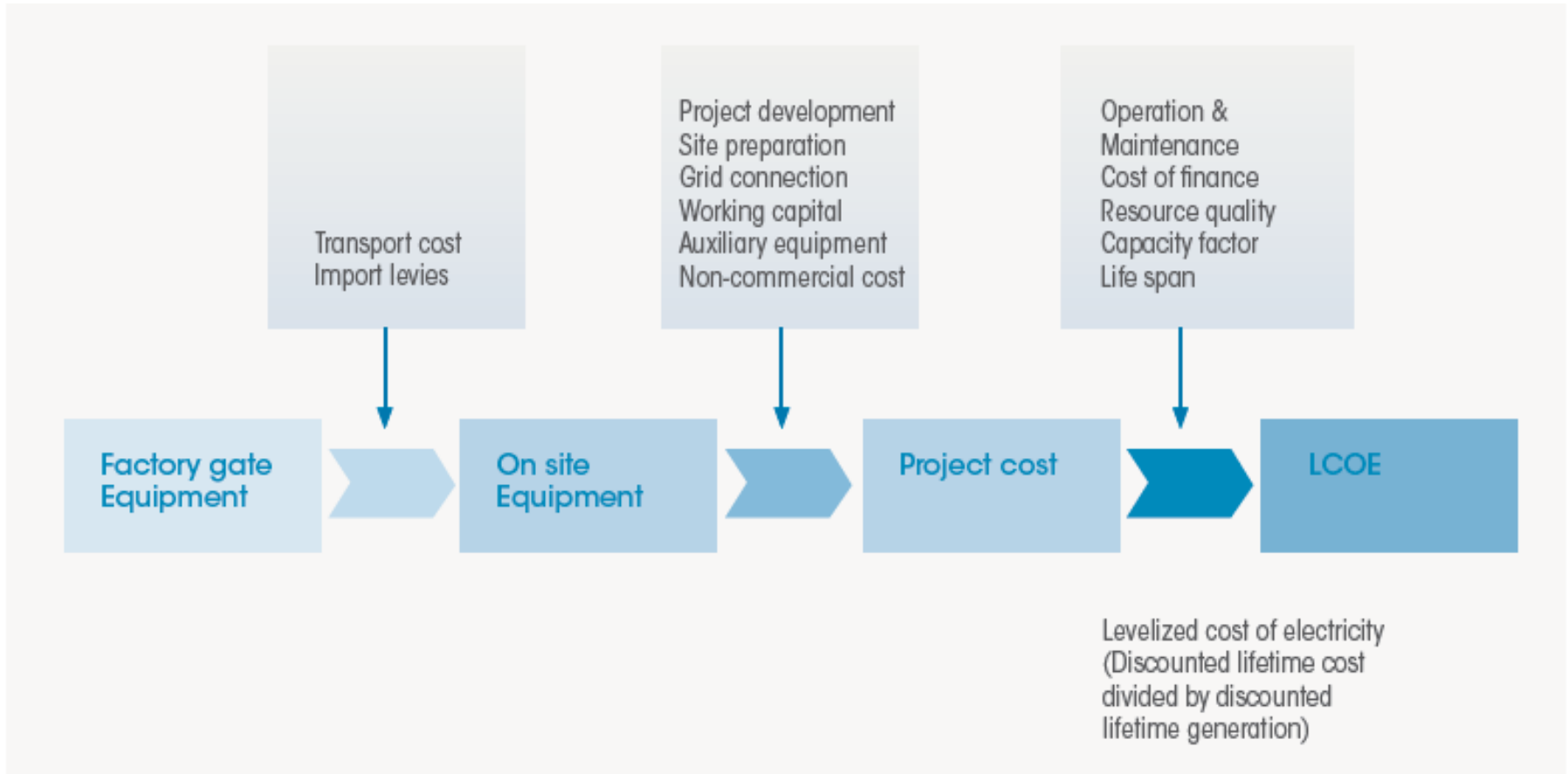
WHY?

HOW?

WITH WHOM?

- Renewable energy can meet countries policy goals for secure, reliable and affordable energy and access.
- Lack of objective and up-to-date data
- Economics are a key decision factor
- Cost declines, rapid for some renewables, occurring
- Decision making is often based on:
 - outdated numbers
 - opinion, not fact based
- IRENA to strive to become THE source for cost data
- Goals are to assist government decision-making, and fill significant information gap

Where to set the boundaries?



Are costs even available? Prices, or price indicators?

Levelised cost of electricity (LCOE)

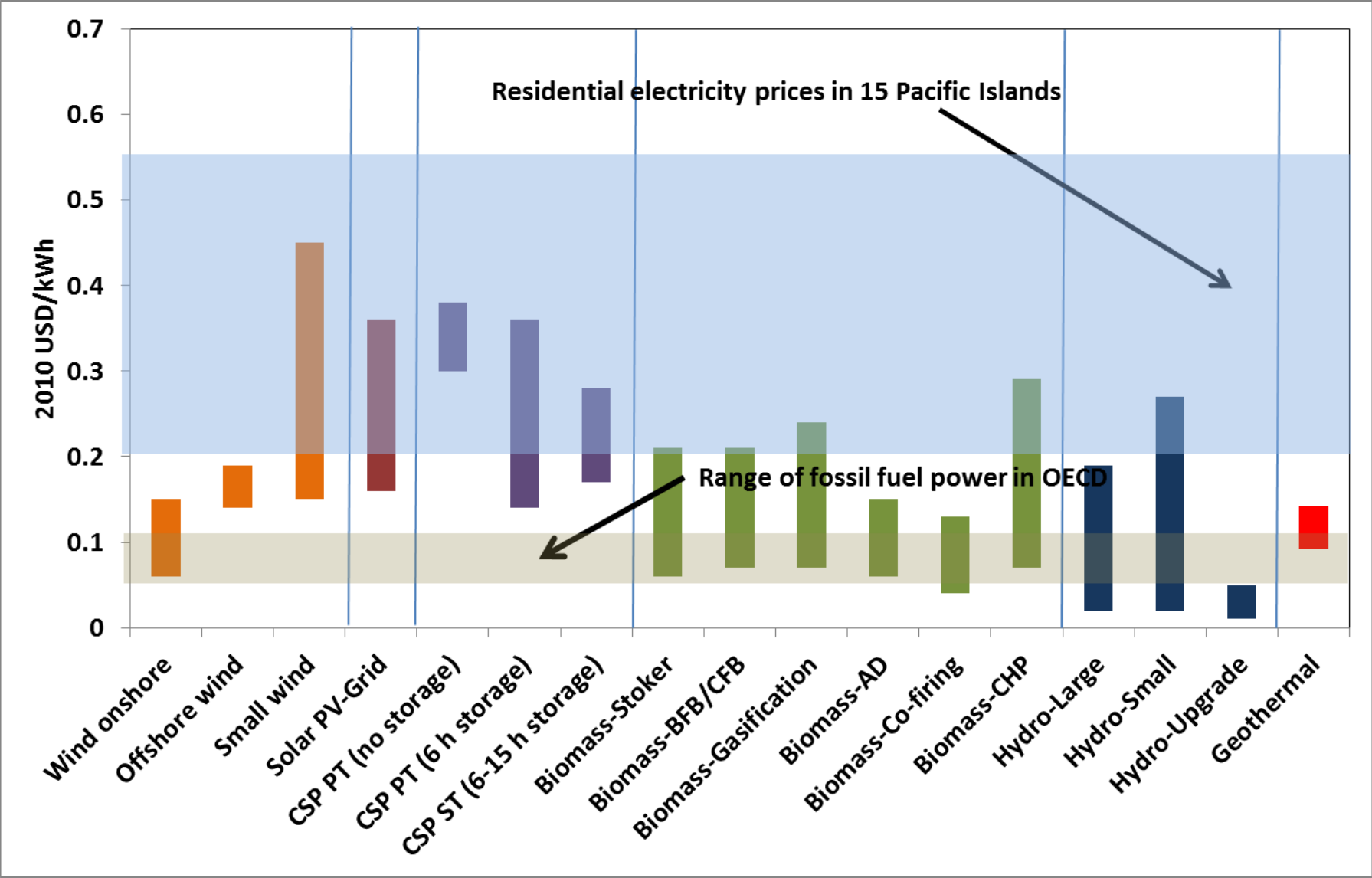
- General information
 - Business journals (eg Photon), consultancies (eg BNEF), industry associations (eg WWEA, ESTELA, etc.), auctions and tenders (eg Brazil), project design studies, development banks (e.g. KfW)
- Questionnaire: real world project data IRENA/GIZ collaboration
 - 79 projects for Asia and Africa (34 PV, 20 hydropower, 11 wind, 8 biomass, 3 hybrid and 3 CSP)
 - 7 submissions unusable!
- Data gaps, some assumptions required. Transportation data difficult to separate out
- Difficult to define what is a “development project“
- Inconsistencies in the allocation of costs

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TODAY'S COSTS

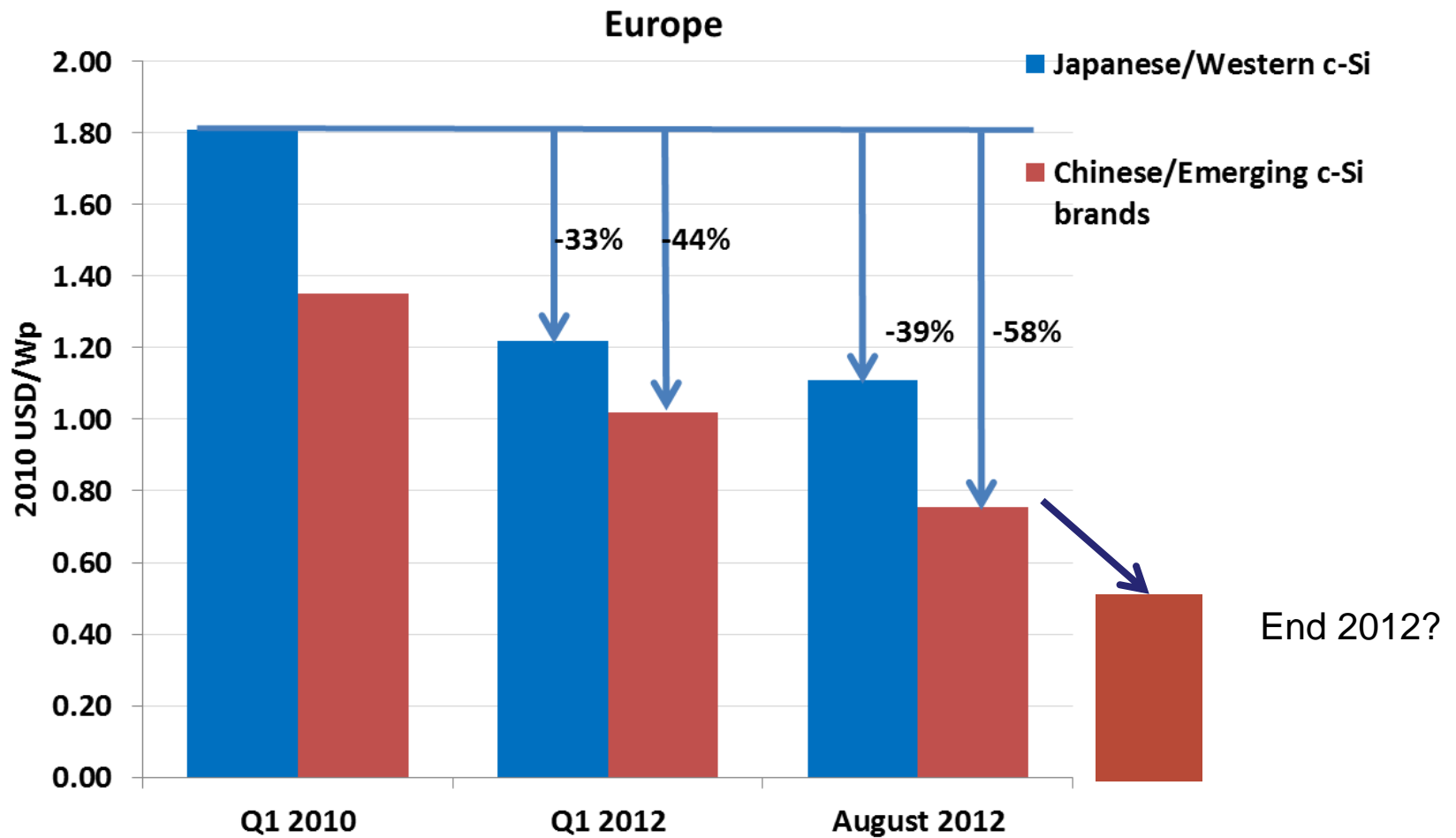
- A renewable revolution is under way
- Dramatic cost reductions for Solar PV, onshore wind competitive at best sites, CSP has great potential, hydropower and biomass more mature
- Unpredictable price variations affect policy efficiency
- Renewables now the economic solution off-grid and for mini-grids
- Data collection poses challenges
- A shift in policy focus will need to come

Levelised cost of electricity

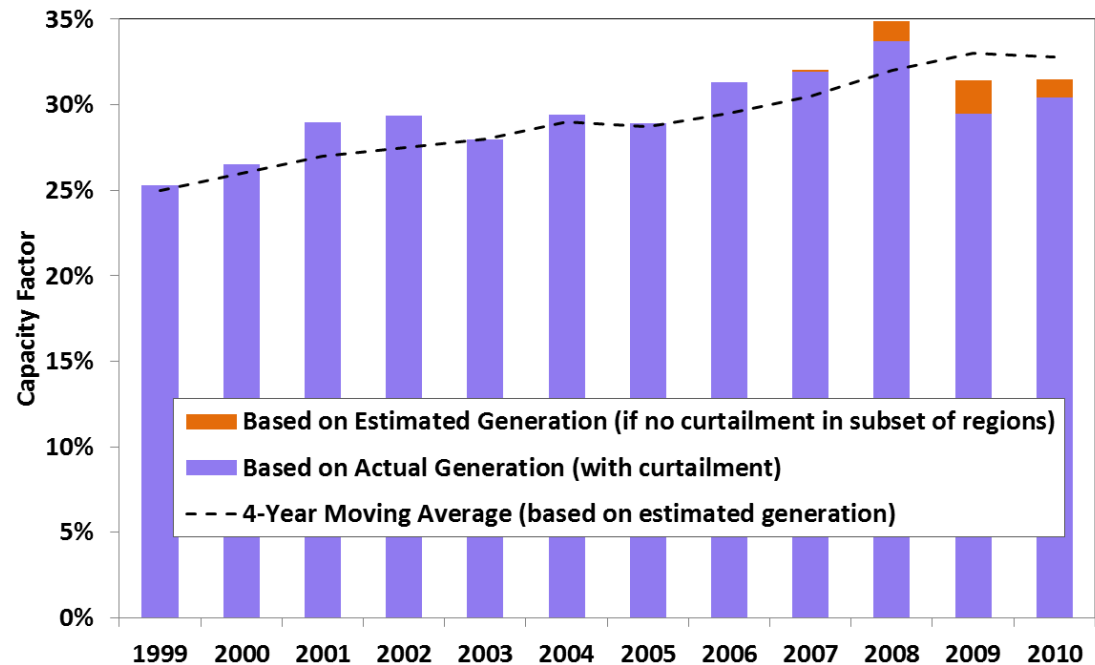


Note: assumes a 10% cost of capital

PV modules prices

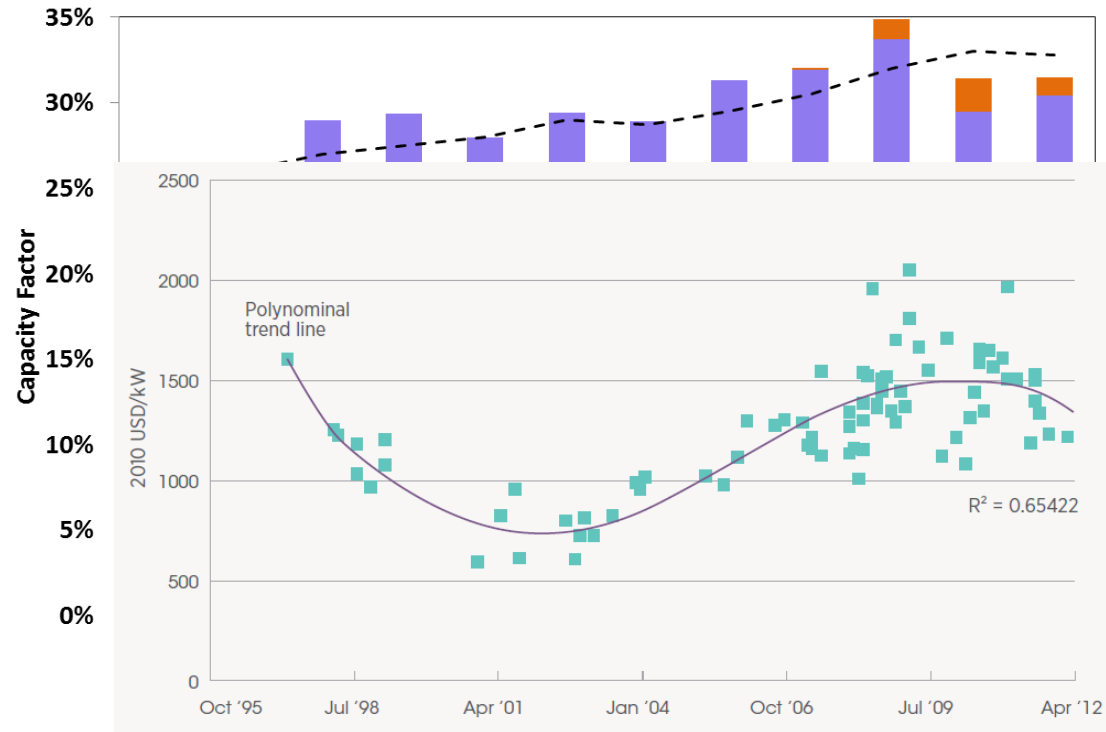


- Capacity factors are increasing
(US example)



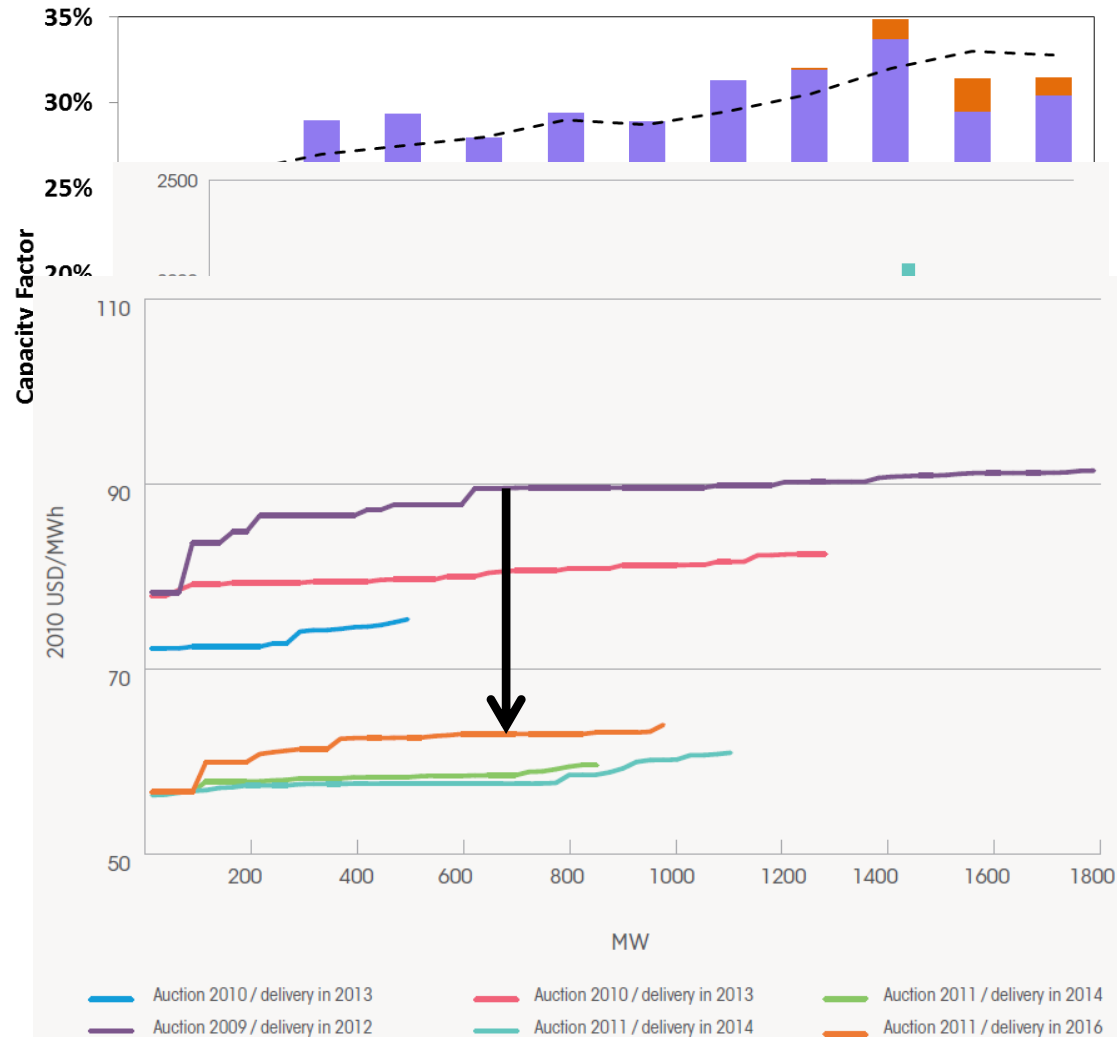
Wind

- Capacity factors are increasing (US example)
- Wind turbine prices declining (US example)



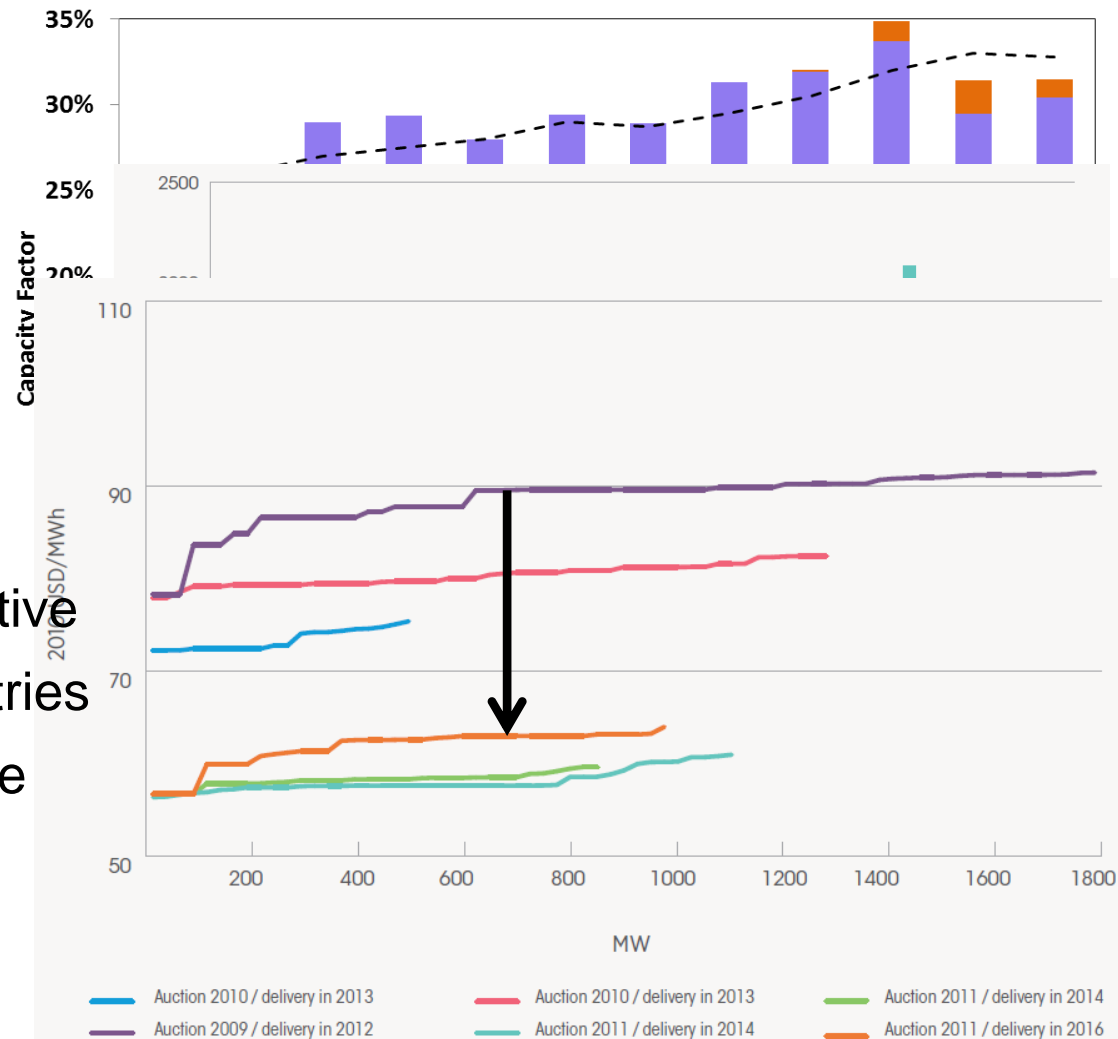
Wind

- Capacity factors are increasing (US example)
- Wind turbine prices declining (US example)
- The LCOE is coming down (Brazilian Auctions)

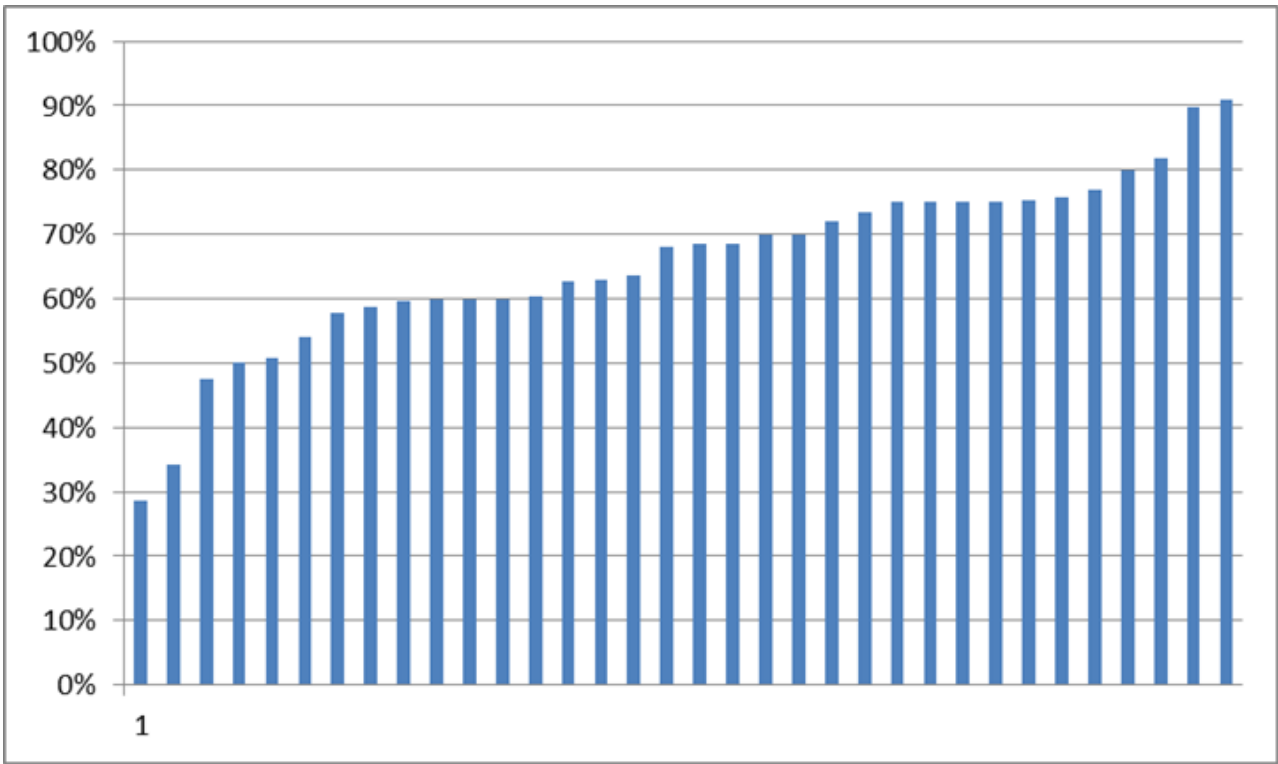


Wind

- Capacity factors are increasing (US example)
- Wind turbine prices declining (US example)
- The LCOE is coming down (Brazilian Auctions)
- Onshore wind is now competitive with fossil fuels in many countries
- Offshore wind is still expensive

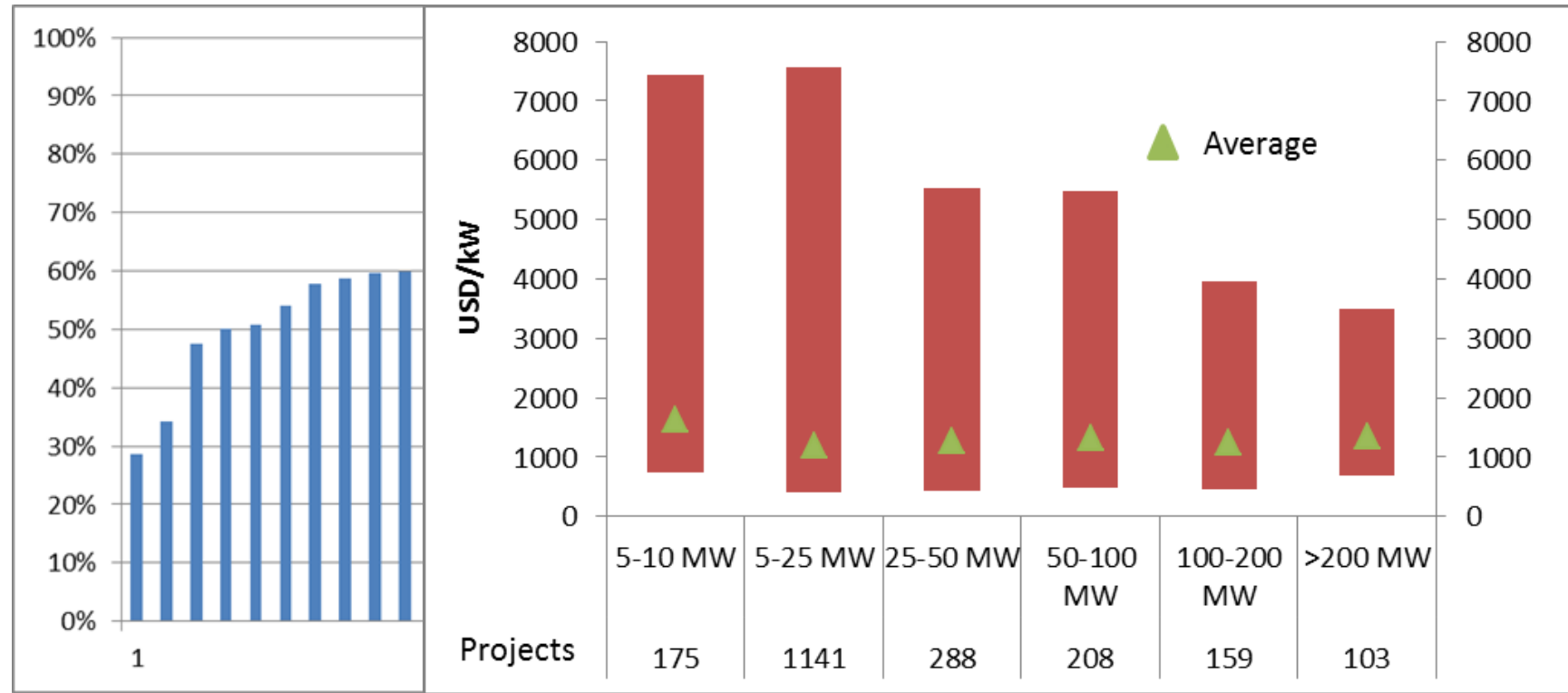


- Mature technology, flexibility in design in many cases.
- Importance will grow with penetration of variable RE
- Often provides the lowest cost electricity available

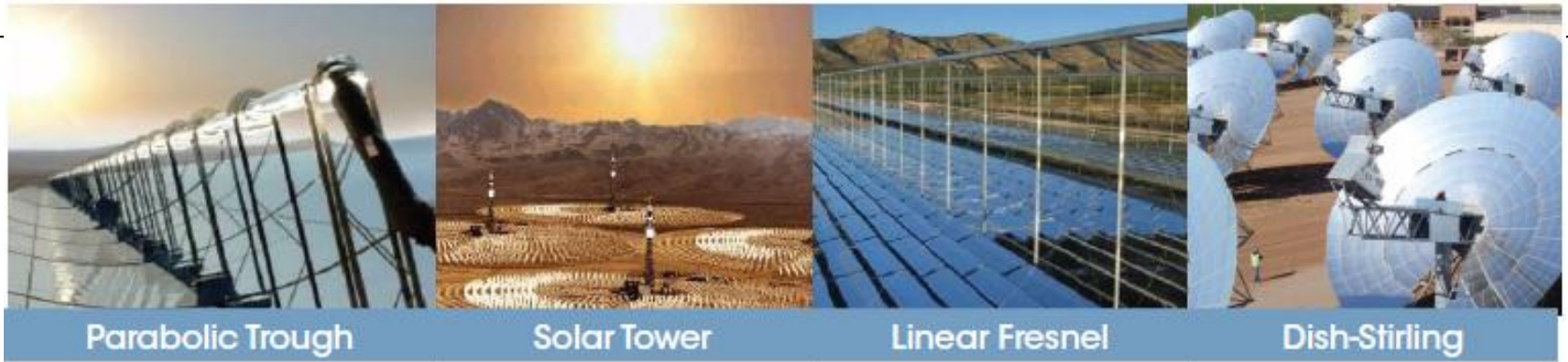


Hydropower

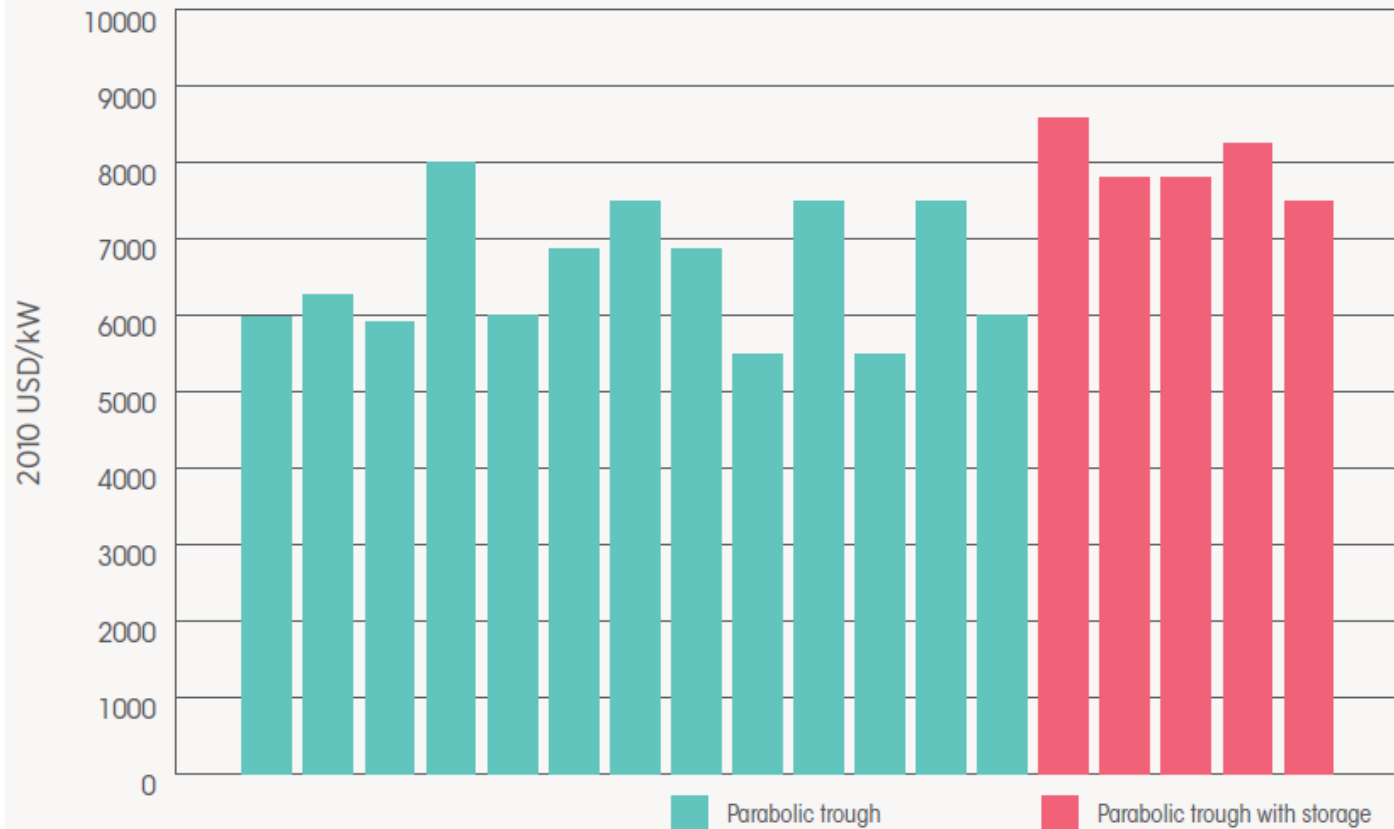
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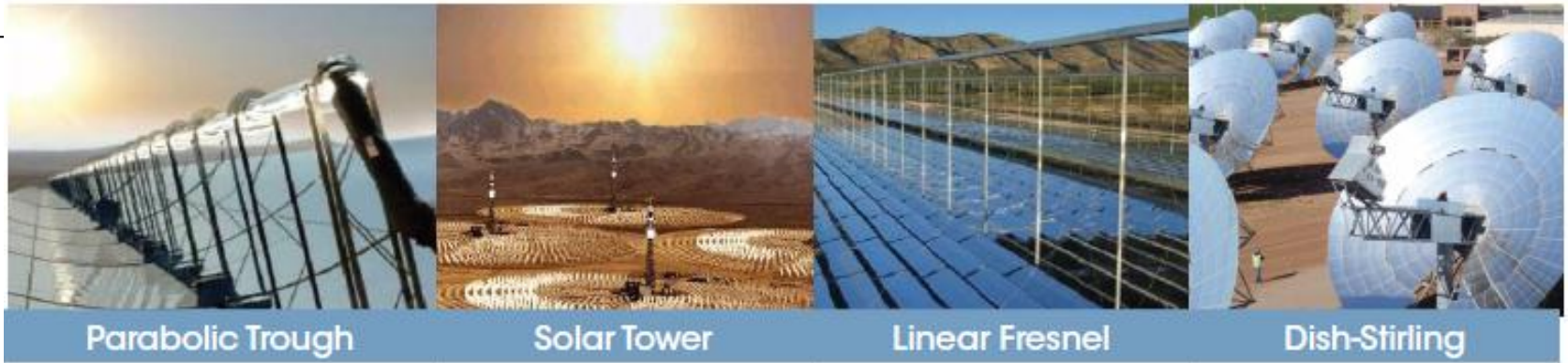
CSP: a set of technologies



But 94% of installed capacity is parabolic trough and has the most recent data

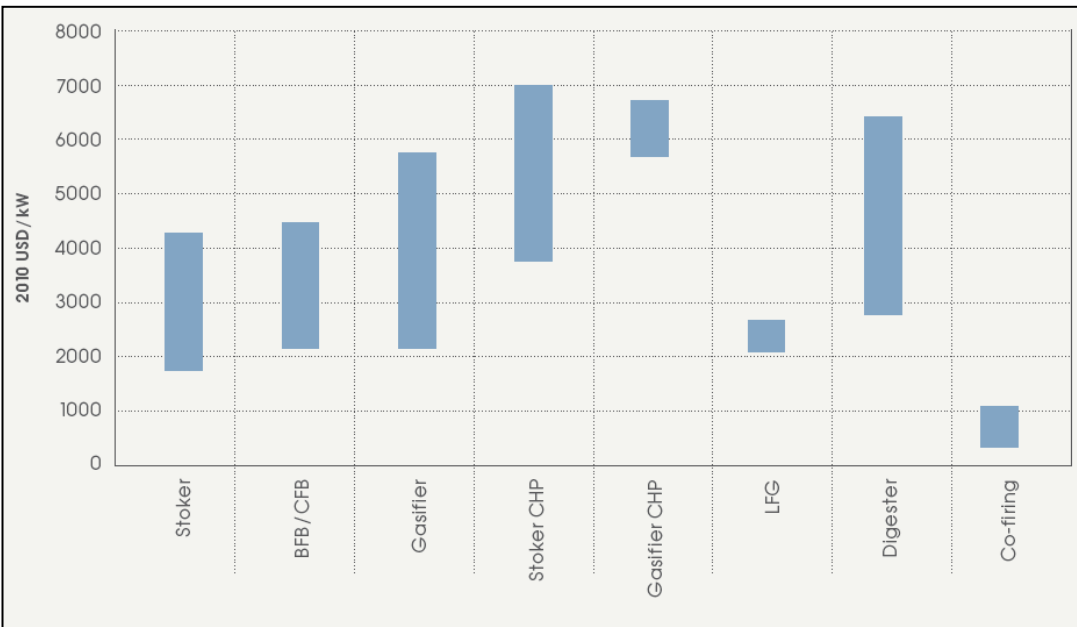


CSP: a set of technologies

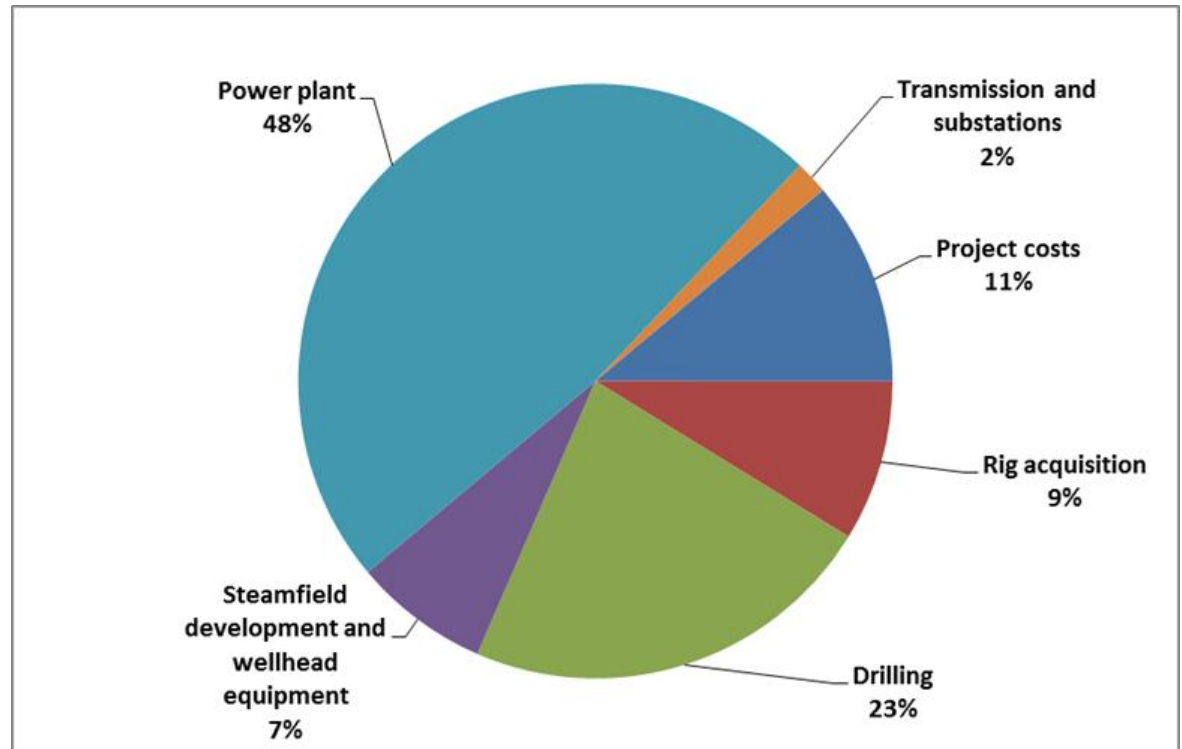


- Deployment is in its infancy (2 GW)
- Cost reduction potential is good
- Solar towers have greater cost reduction potential with higher operating temperatures and lower cost thermal energy storage
- The ability to incorporate cheap thermal energy storage and provide dispatchable power will raise value of CSP in high RE scenarios

- Range of technologies at different maturities
- Feedstock cost a large share
 - Prices depend on quality, quantity, availability, moisture content, regulation
 - Feedstock handling costs can be high
- Emerging market for pellets and woodchips
- Long term contracts for feedstock supply to be bankable
- Biomass co-generation systems often linked to industrial processes



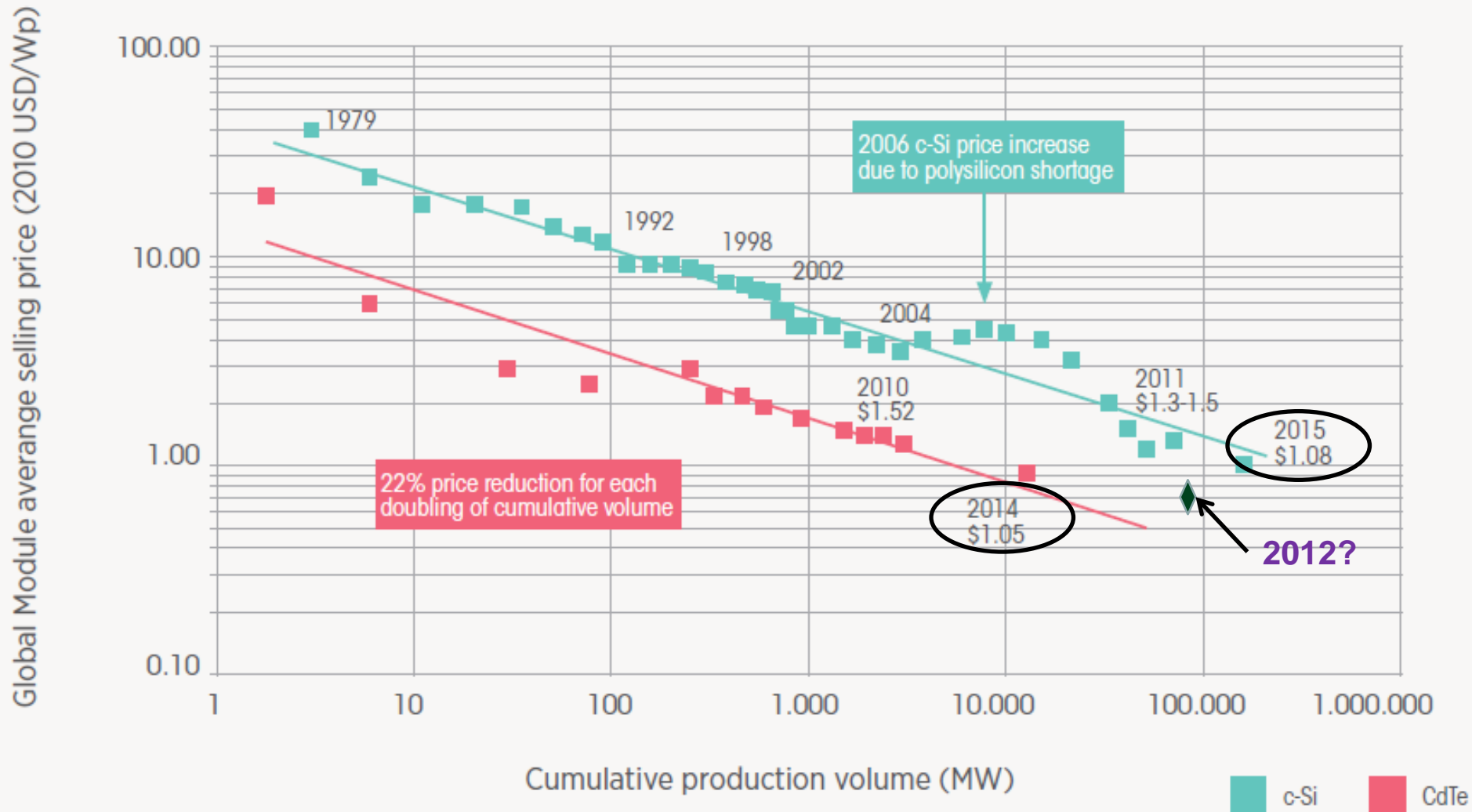
- Mature, baseload technology.
- Very competitive for a high quality resource
- Costs for greenfield developments can be high (USD 4000/kW)
- Development of adjacent resources, where infrastructure is in place and resource well characterised, can be much cheaper (as low as USD 1700/kW)



3

COST REDUCTION POTENTIAL

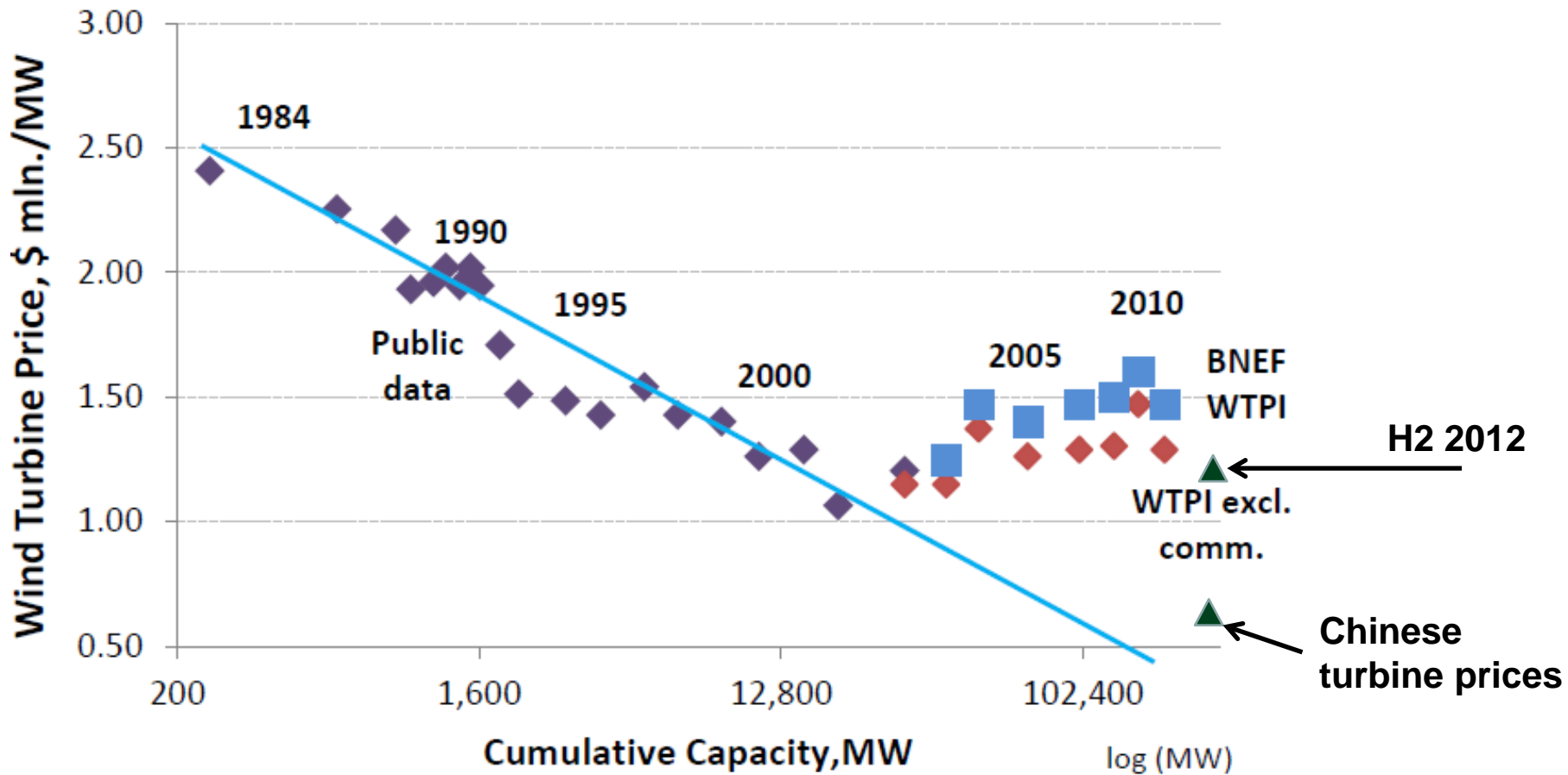
Solar PV Module costs



Will we slower rate of cost reduction to 2015? Probably

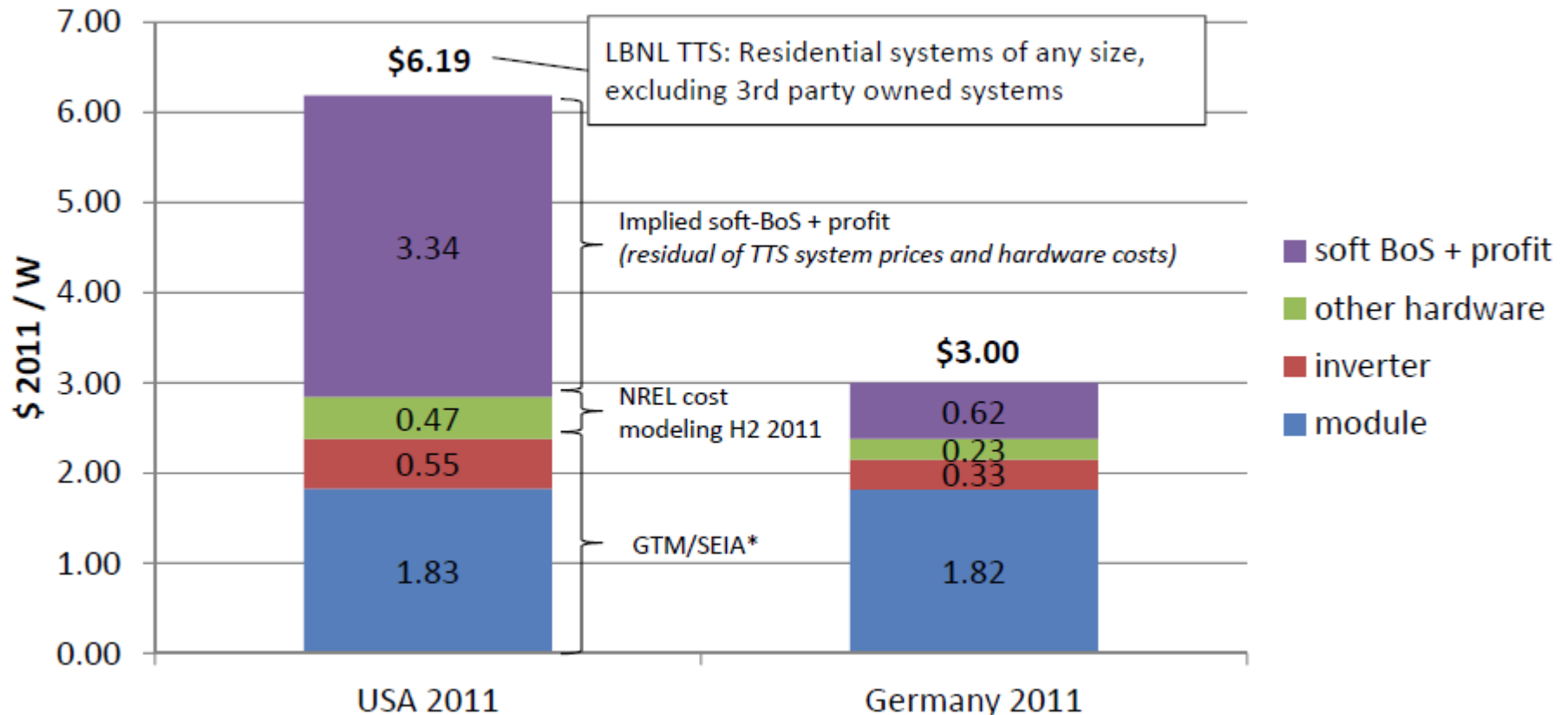
Learning curve for turbines

Strong anomalies in recent years; further analysis needed



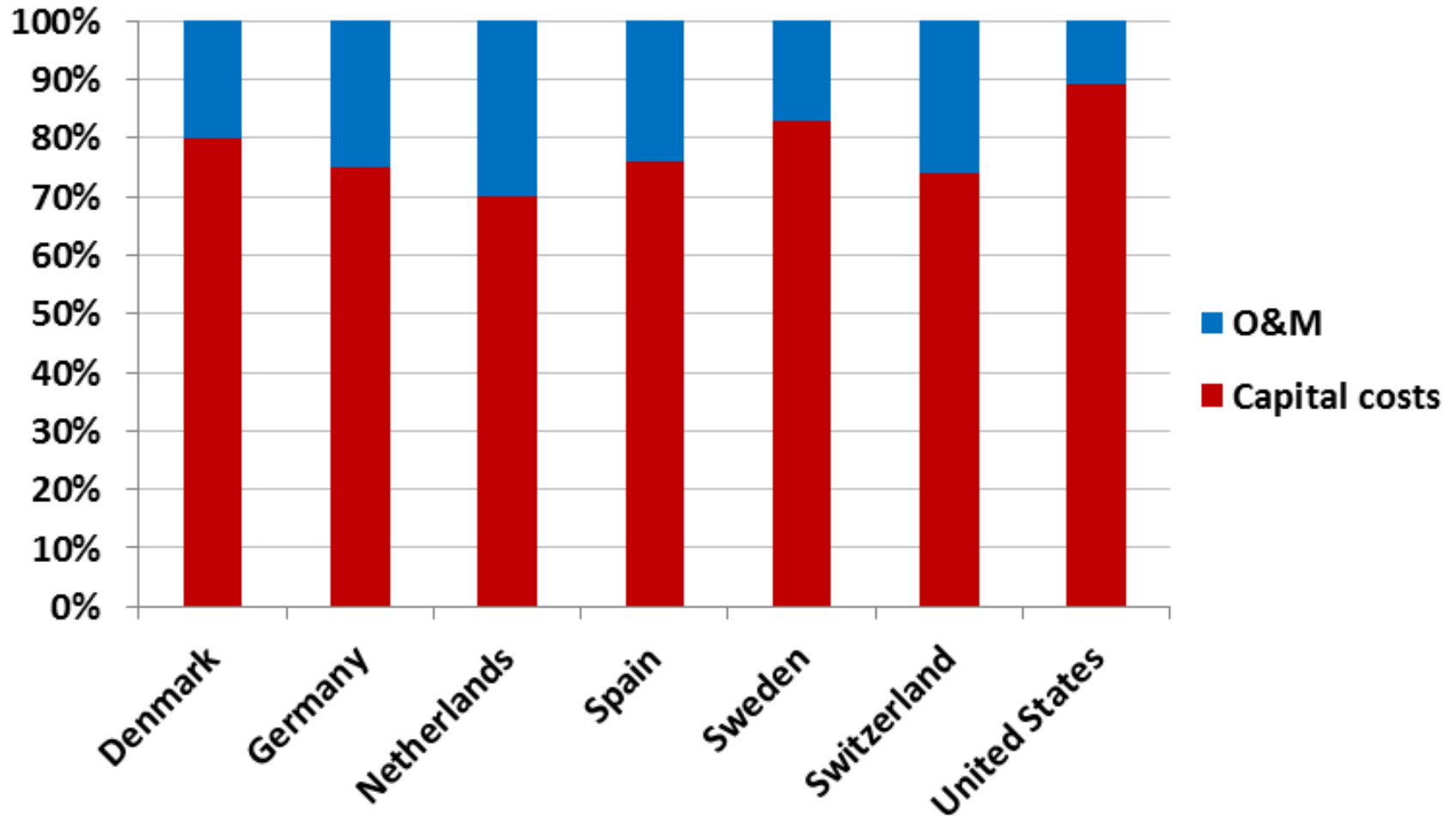
Source: Bloomberg New Energy Finance, February, 2011

Residential PV costs in Germany and the United States



Cost reduction pass-through will be strongly tied to success in reducing BoS costs

The share of O&M in the LCOE of wind power



Summary of cost reduction potentials

- Solar PV module cost reductions to slow? Installed cost declines will depend on market. BoS is the key. Grid parity (residential) increasingly the norm, at utility-scale timeline will be longer
- CSP costs could come down rapidly, but difficult period. Trend to solar towers for lower costs, dispatchability and higher capacity factors
- Wind is often the most competitive non-hydro RE, LCOE will continue to decline. Will global market prices for turbines converge like PV modules?
- Hydropower: large untapped low-cost potential, but little room for cost reductions. Sustainability issues very important
- Biomass: many mature solutions, but more innovative technologies will see cost reductions. Key is sustainable feedstock supply at reasonable cost
- Geothermal a mature, low-cost option where good resources exist. Limited cost reduction potential

4 CONCLUSIONS

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- Rapid, unexpected, cost reductions pose challenges
 - Efficient support policies still needed
 - An integrated strategy is required
 - Policy focus will need to shift, depending on country, in the near future. Few countries “get” this!

To Conclude

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- A renewable revolution underway driven by a virtuous circle of increased deployment and cost reductions, particularly for PV
 - Renewables are THE economic solution for off-grid and mini-grid electricity projects (PV and small-scale wind, biomass and hydro)
 - Renewables are increasingly competitive without assistance against incumbent technologies. But this needs to expand from best resources to average resources
 - Renewables will increasingly have to work together as their penetration increases, analysis will have to shift from LCOE to electricity system costs. Demand-side is the forgotten resource!
 - The quest for better cost data and understanding of differences continues. Regular updates for PV, CSP and wind will be needed²⁸



Renewables are increasingly competitive, but more needs to be done to fulfill their potential...

IRENA is part of the solution

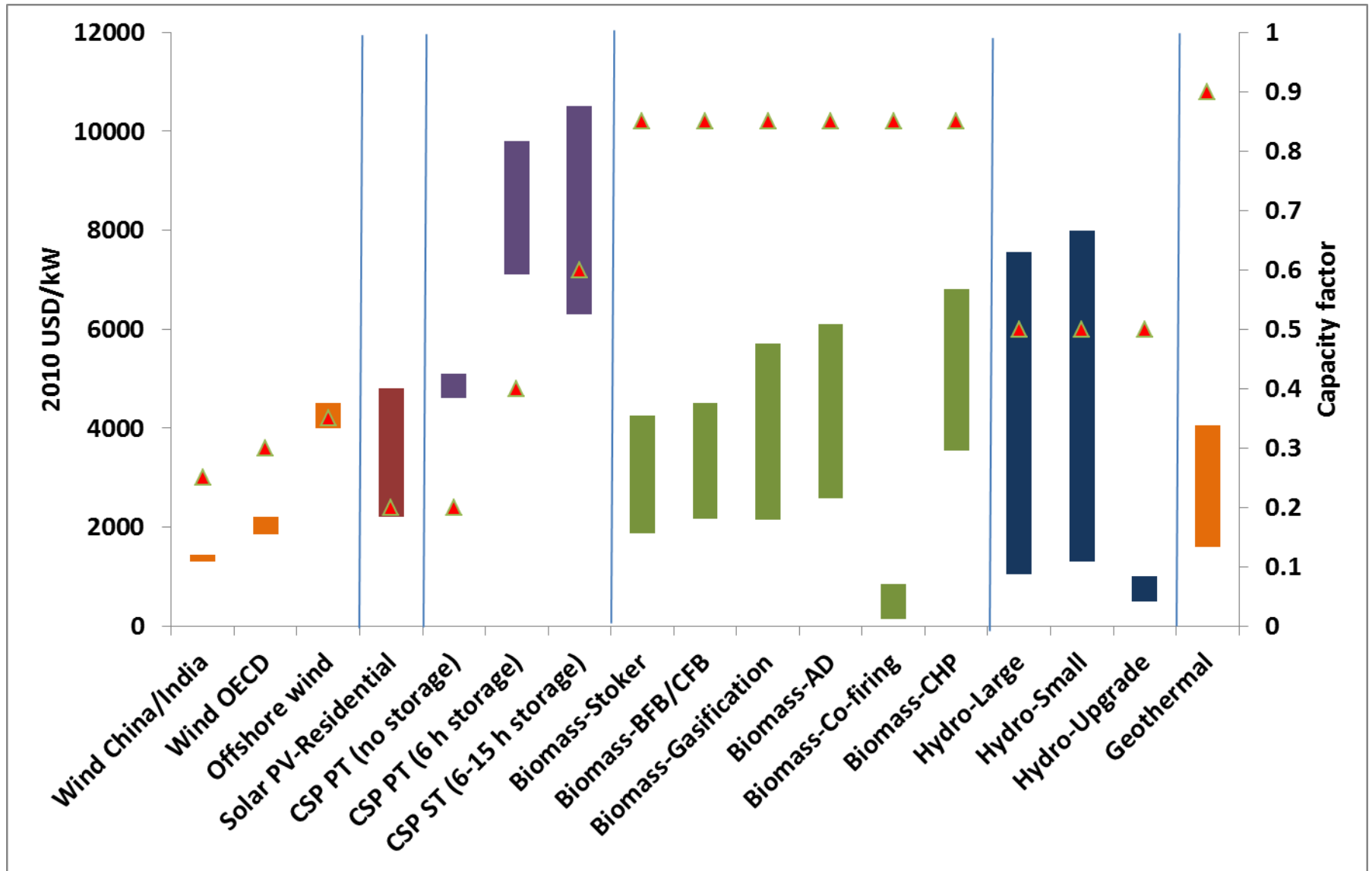
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Additional slides

Typical installed capital costs and capacity factors



Regional variations can be large: Wind turbines

