Renewables:

The True Costs

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IRENA, Bonn, Germany

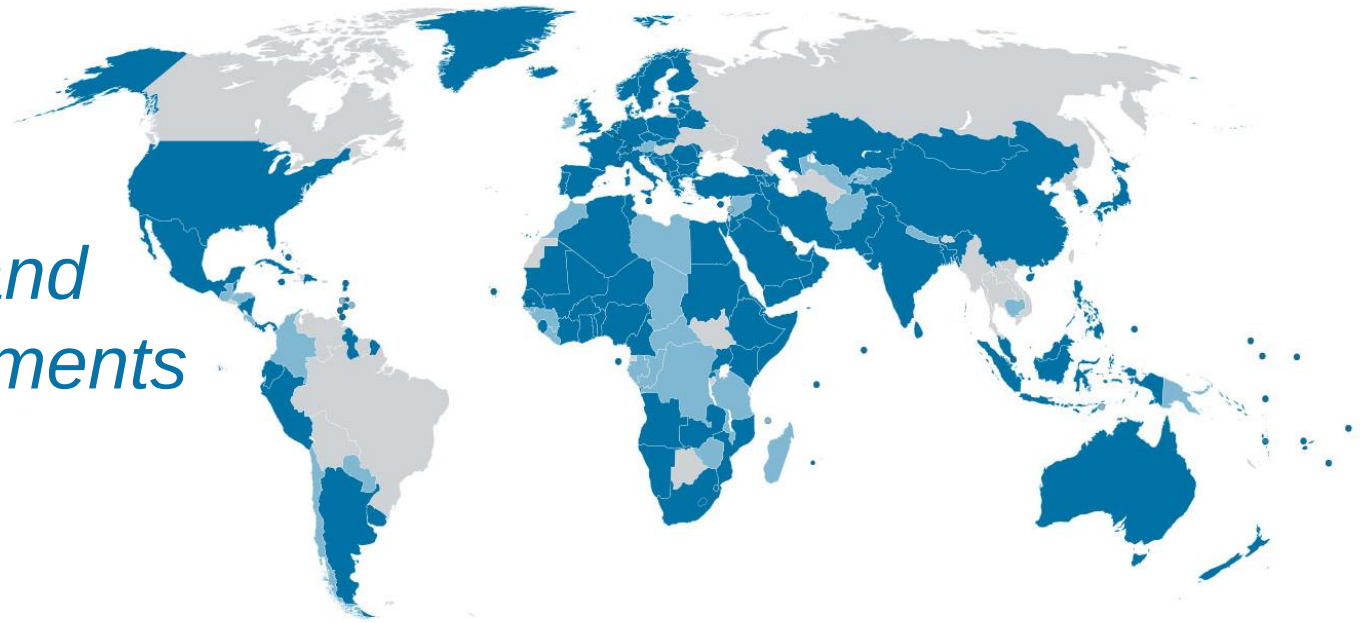
7 May 2015

IRENA introduction

Renewable energy can:

- Meet our goals for ***secure***, ***reliable*** and ***sustainable*** energy
- Provide ***electricity access*** to 1.3 billion people
- Promote ***economic development***
- At an ***affordable cost***

The Voice, Advisory Resource and Knowledge Hub for 170 Governments

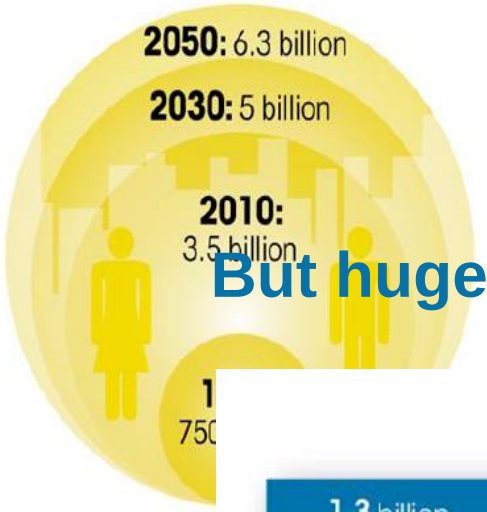


IRENA introduction

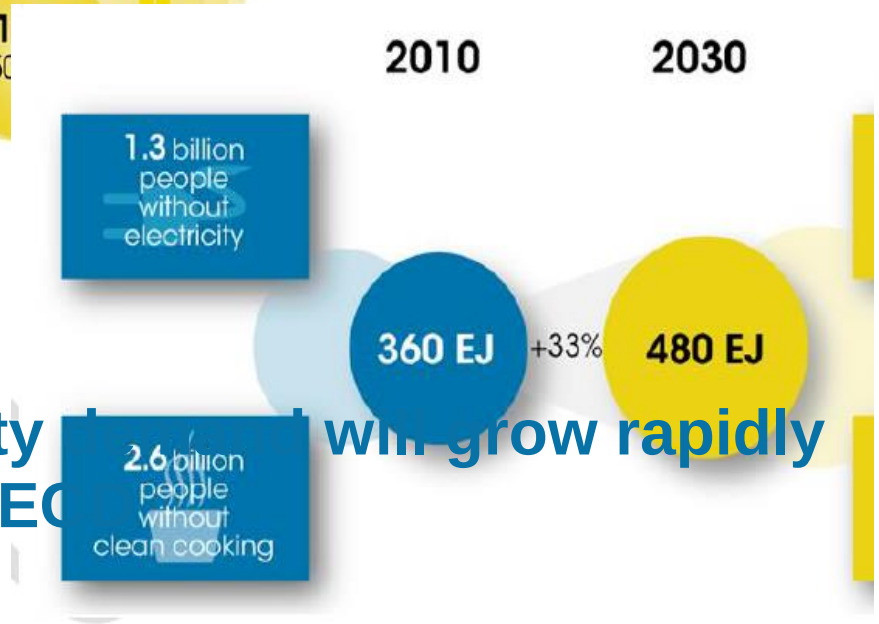
Divisions

- Innovation and technology center **(IITC)** in Bonn
- Country support and partnership **(CSP)** in AD
- Knowledge, policy and finance center **(KPFC)** in AD

The Global Context

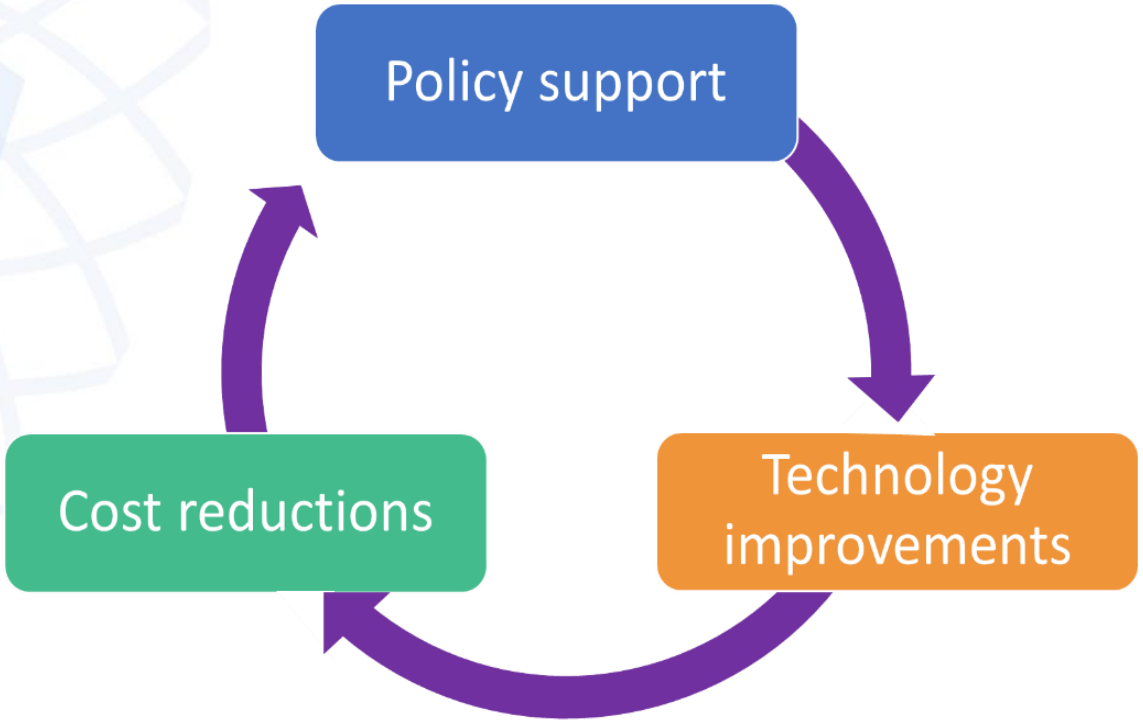


The urban middle class is growing
But huge untapped markets will remain



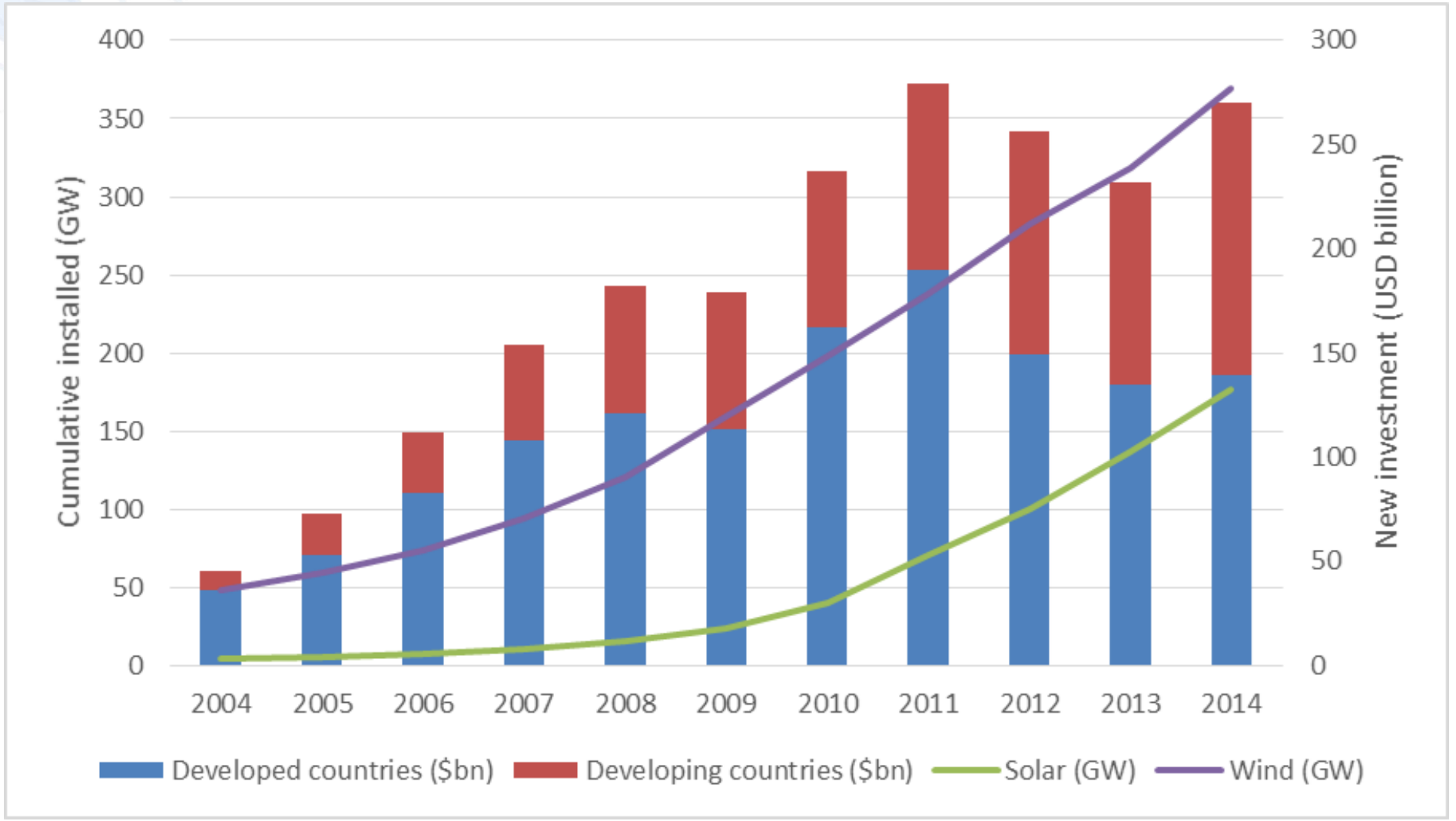
Electricity [illegible] will grow rapidly in non OEC

The Energy Sector is Being Transformed



A ***virtuous cycle*** is unlocking the ***economic***, ***social*** and ***environmental*** benefits of renewables

Global Investment in Renewable Energy



BUT

THE ABSENCE OF UP-TO-DATE COST DATA IS A BARRIER

THAT IS WHY IRENA IS RAMPING UP ITS WORK

Renewable cost analysis at IRENA

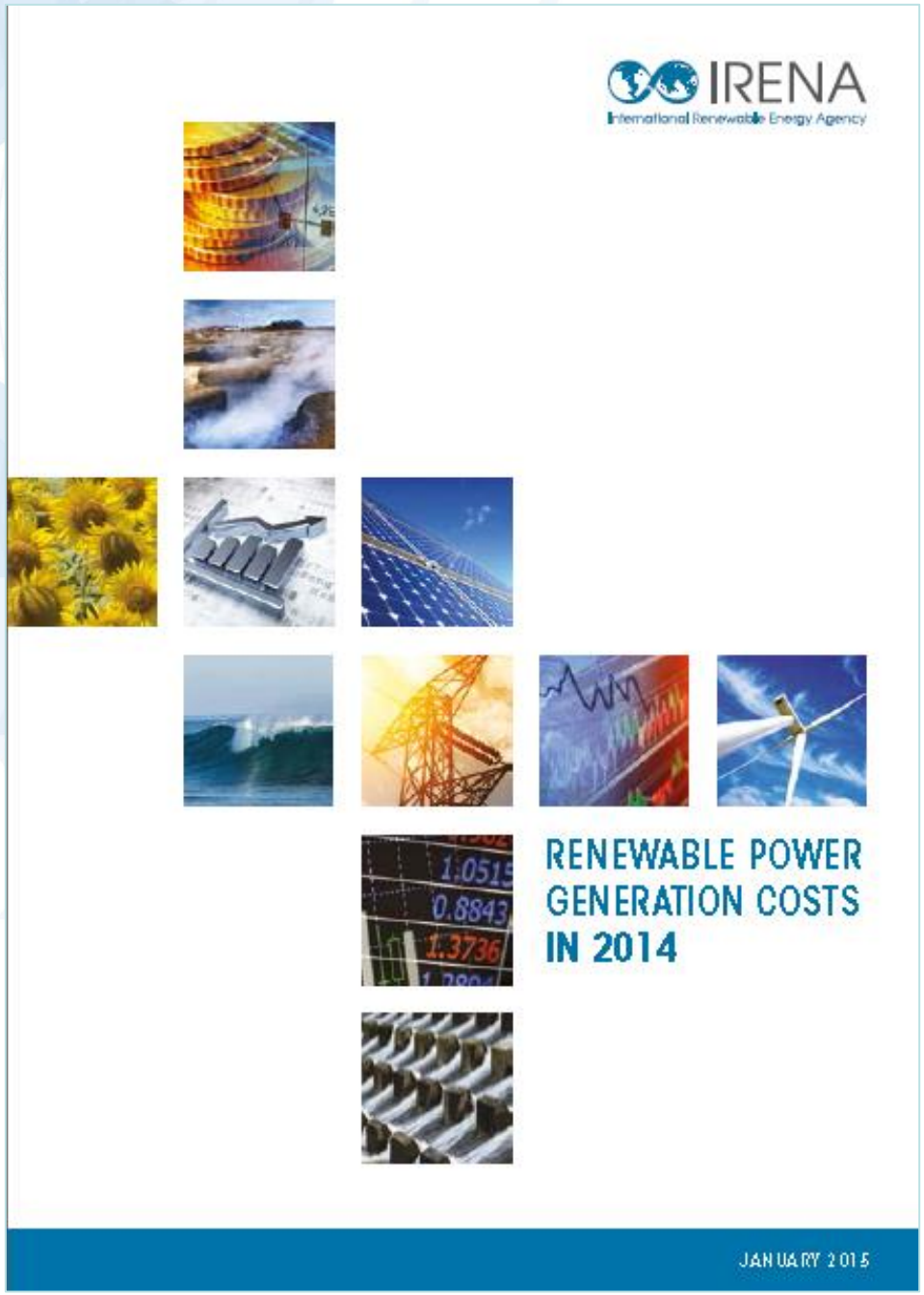
Fills an important gap in knowledge

World-class database of costs

Cutting edge analysis, not just data

More products and analysis coming

Costing Alliance deepens engagement



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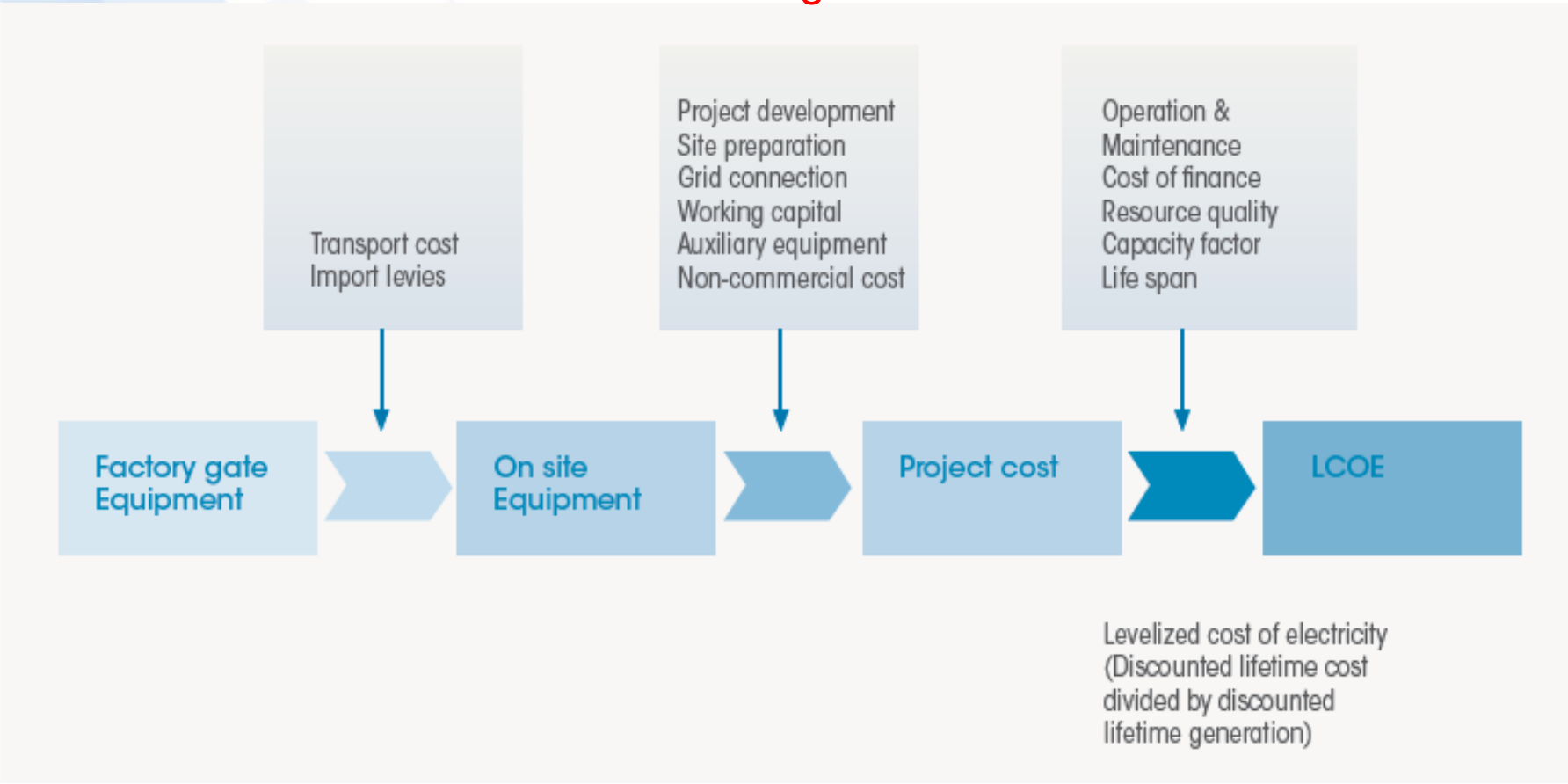
International Renewable Energy Agency

Renewable Power Generation Costs in 2014

Framework

Where to set the boundaries? How to get data?



Are costs even available? Prices, or price indicators?

Levelised cost of electricity (LCOE)

Highlights

The relentless improvement in competiveness continues

Renewables competing head-to-head with fossil fuels

Integrating variable renewables doesn't change the conclusions

Future cost reductions will be more challenging, policy driven

Renewables competitiveness continues to improve

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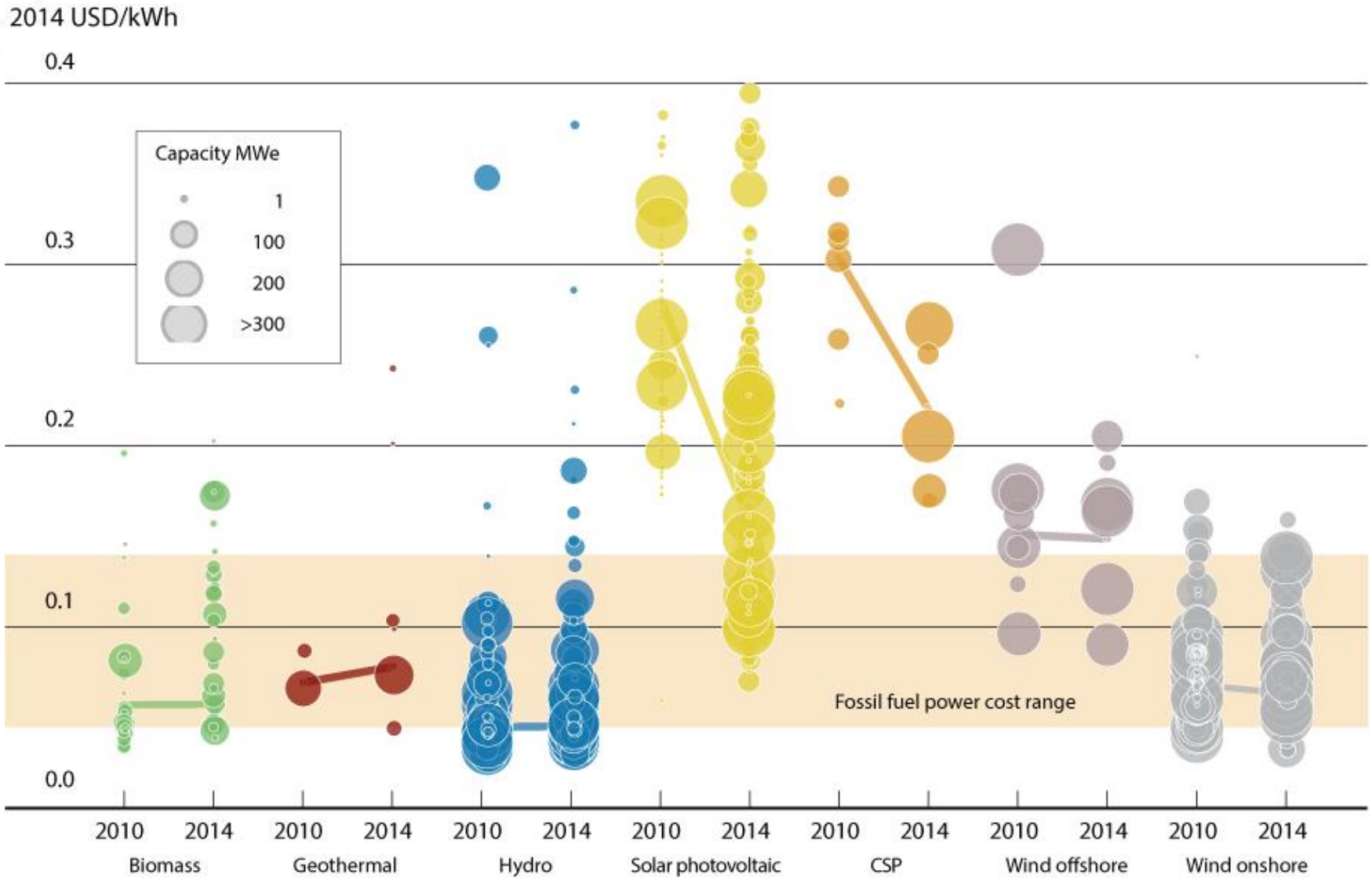

Competing head-to-head with fossil fuels

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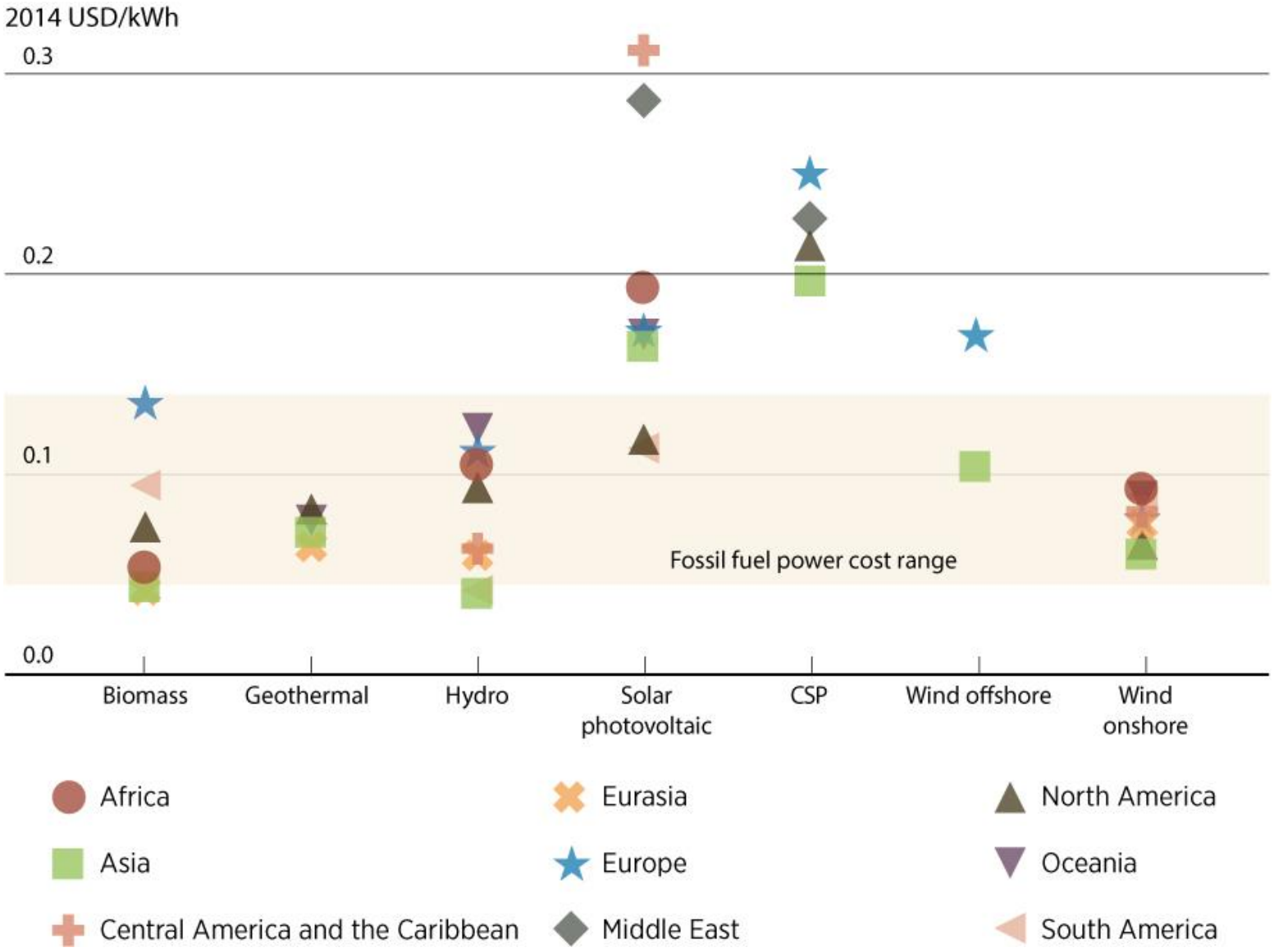
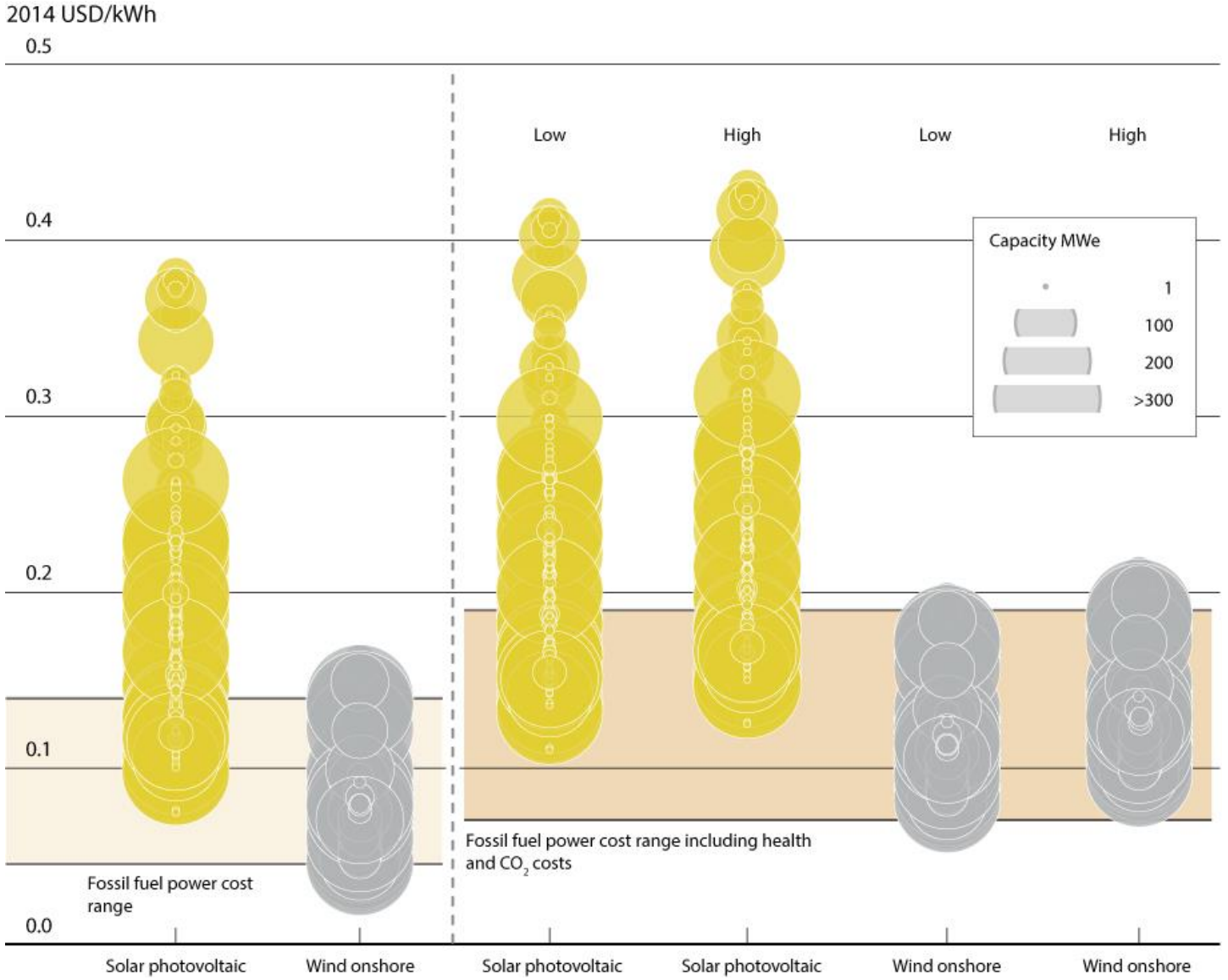


Integrating high levels of variable renewables is competitive



Cost reduction drivers are changing

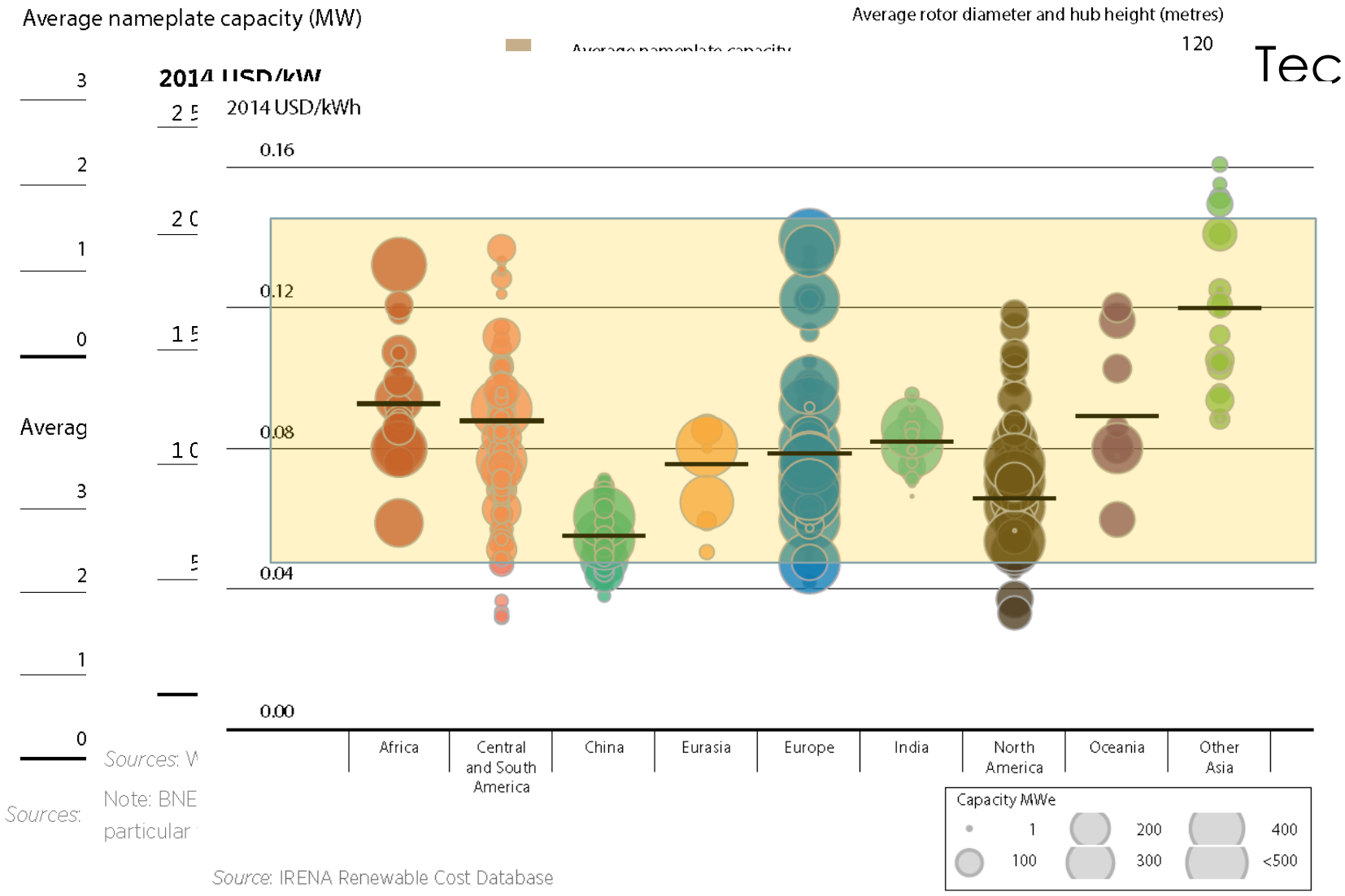
Low equipment costs change the dynamics

Balance of project costs, O&M, financing will grow in importance

In some cases more challenging to unlock

But cost differentials are large and the policy levers exist

Wind power



Technology improvements

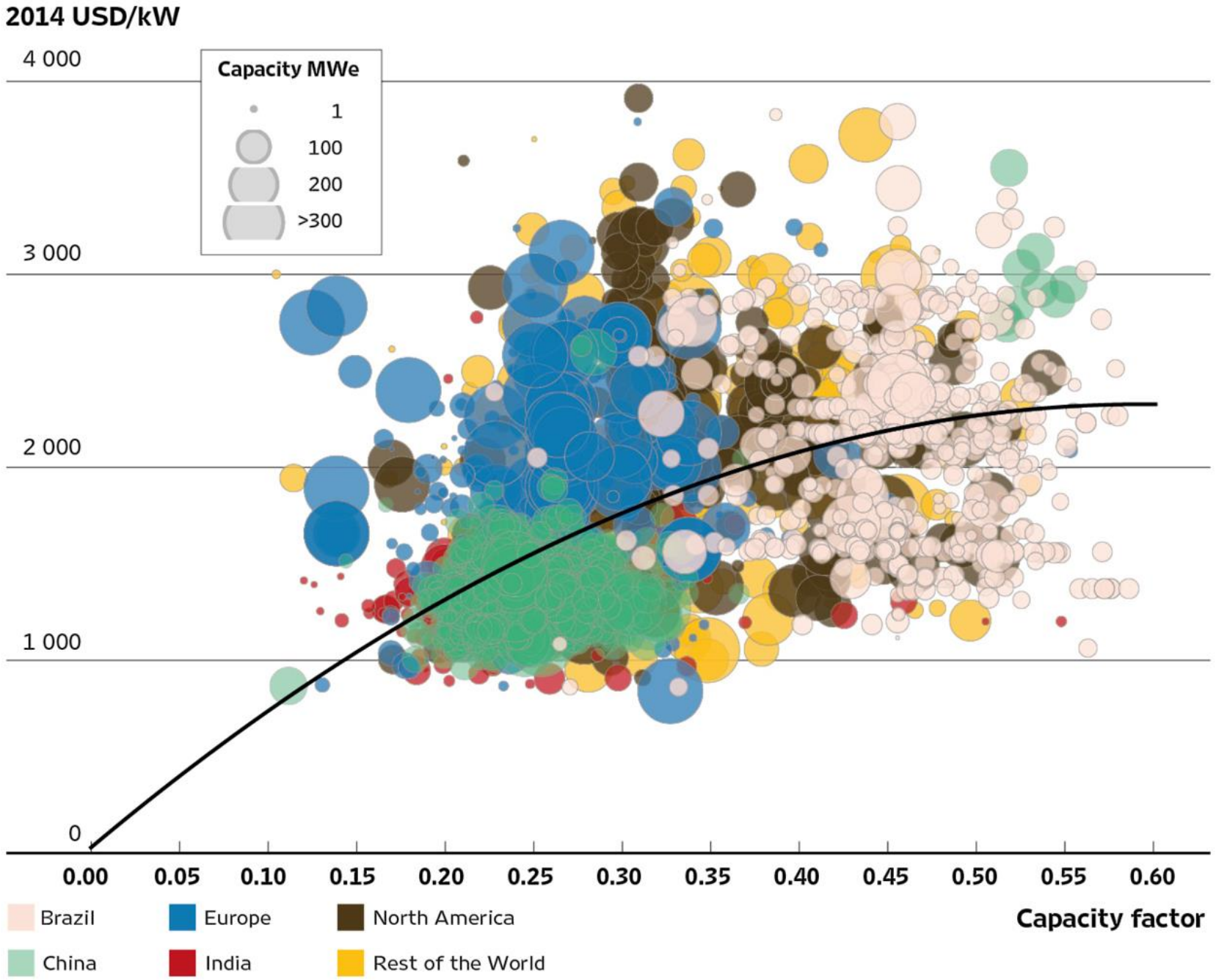
+

Capital cost declines

=

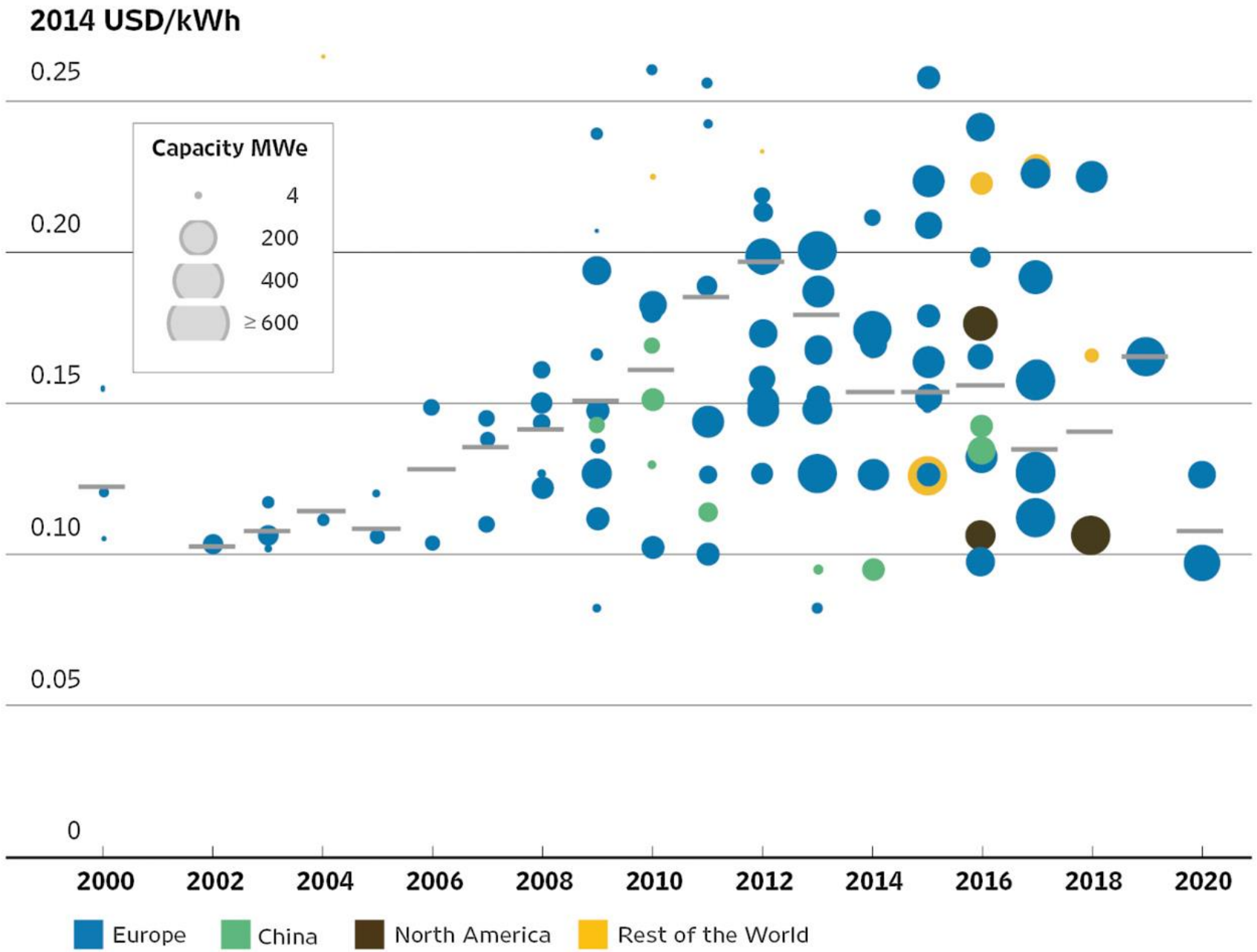
Falling LCOEs

Source: IRENA Renewable Cost Database



Source: IRENA Renewable Cost Database.

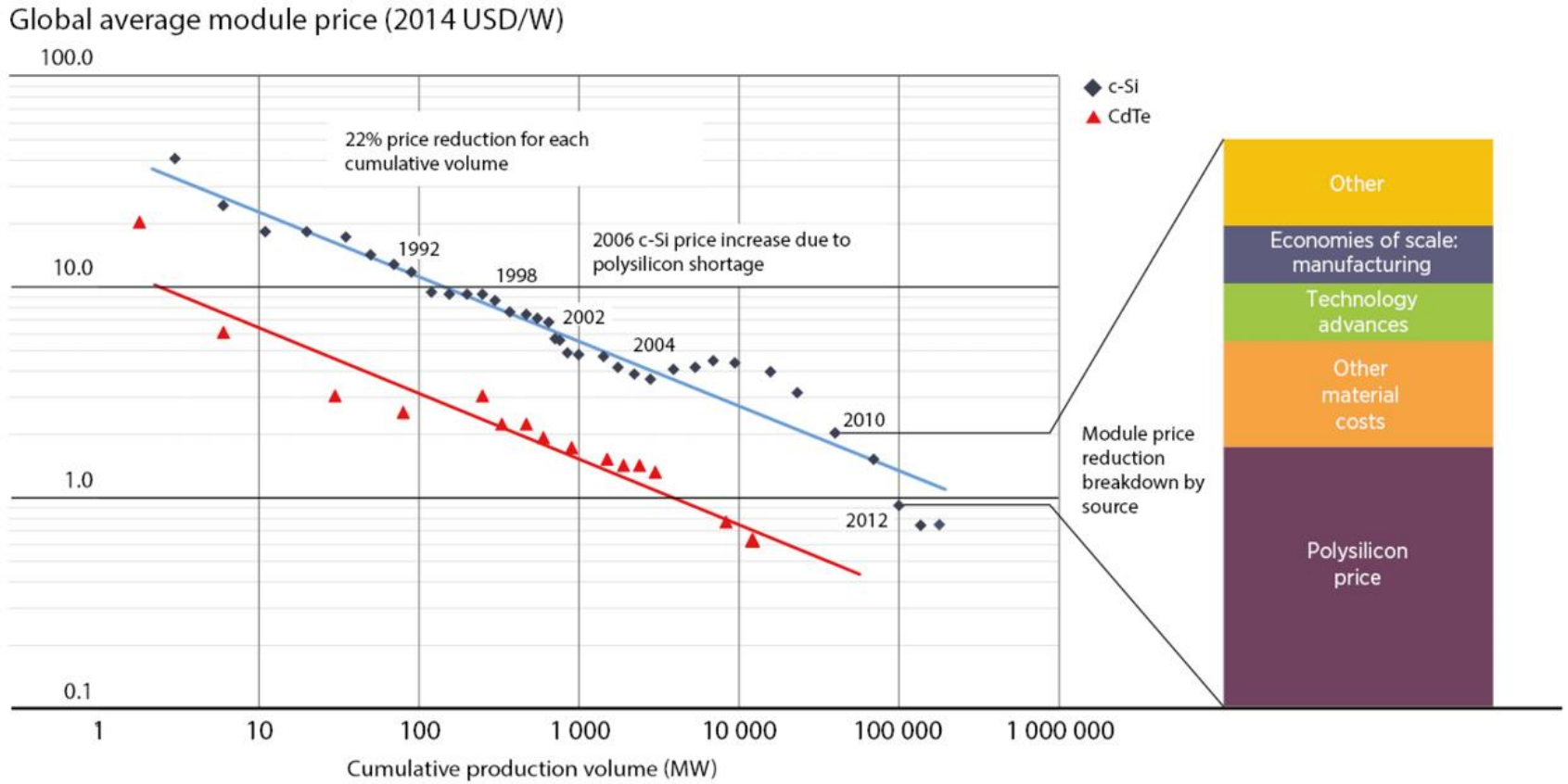
FIGURE 4.19: THE LCOE AND WEIGHTED AVERAGES OF COMMISSIONED AND PROPOSED OFFSHORE WIND PROJECTS, 2000 TO 2020



Solar PV module prices

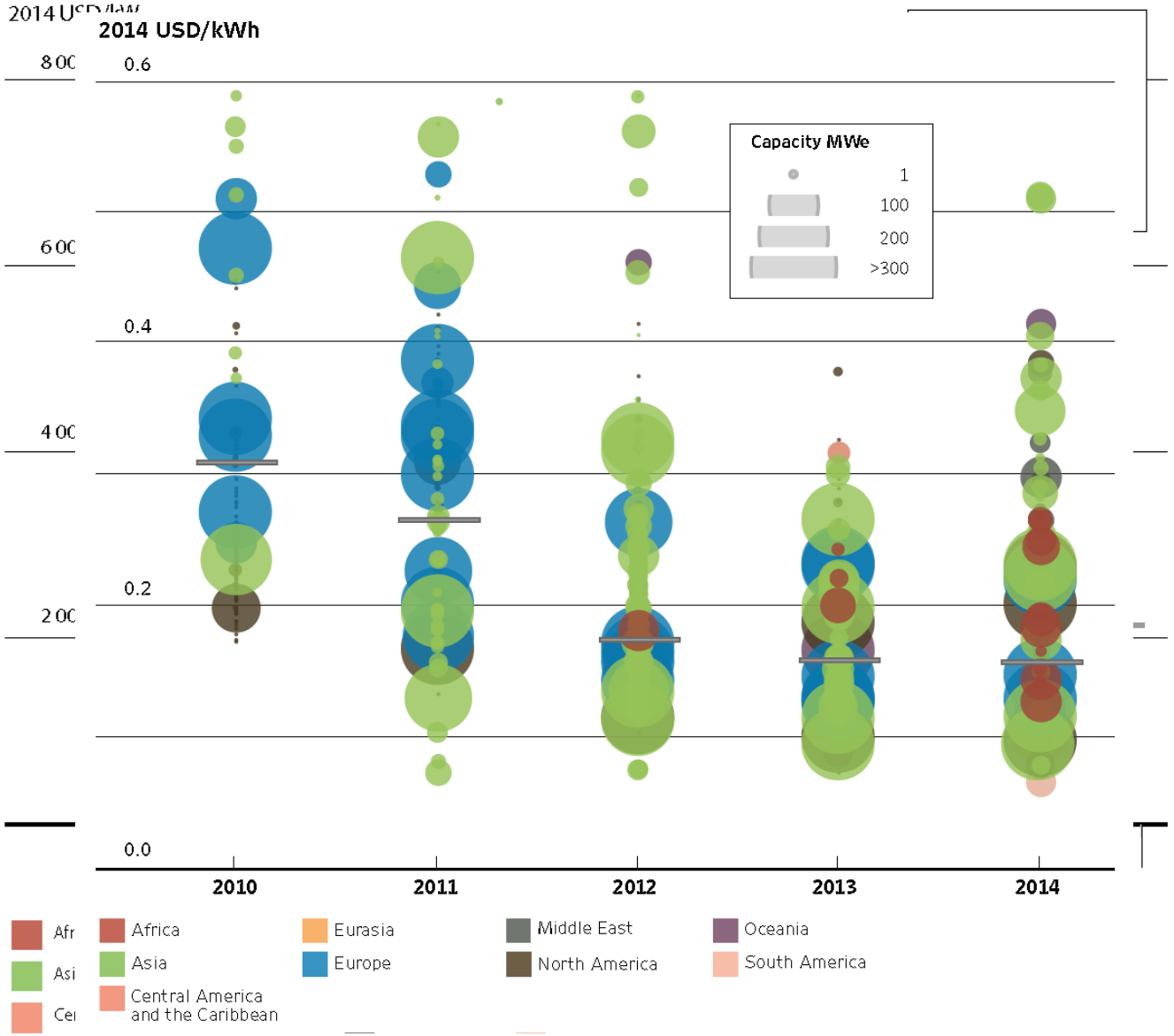
RENEWABLE POWER GENERATION COSTS IN 2014

FIGURE 5.4: SOLAR PV CRYSTALLINE SILICON AND THIN-FILM MODULE COST LEARNING CURVE



Sources: Based on data from EPIA and the Photovoltaic Technology Platform, 2011; GlobalData, 2014; GTM Research, 2014; Liebreich, 2011; pvXchange, 2014 and IRENA analysis.

Solar PV



Technology improvements
and
cost reductions

=

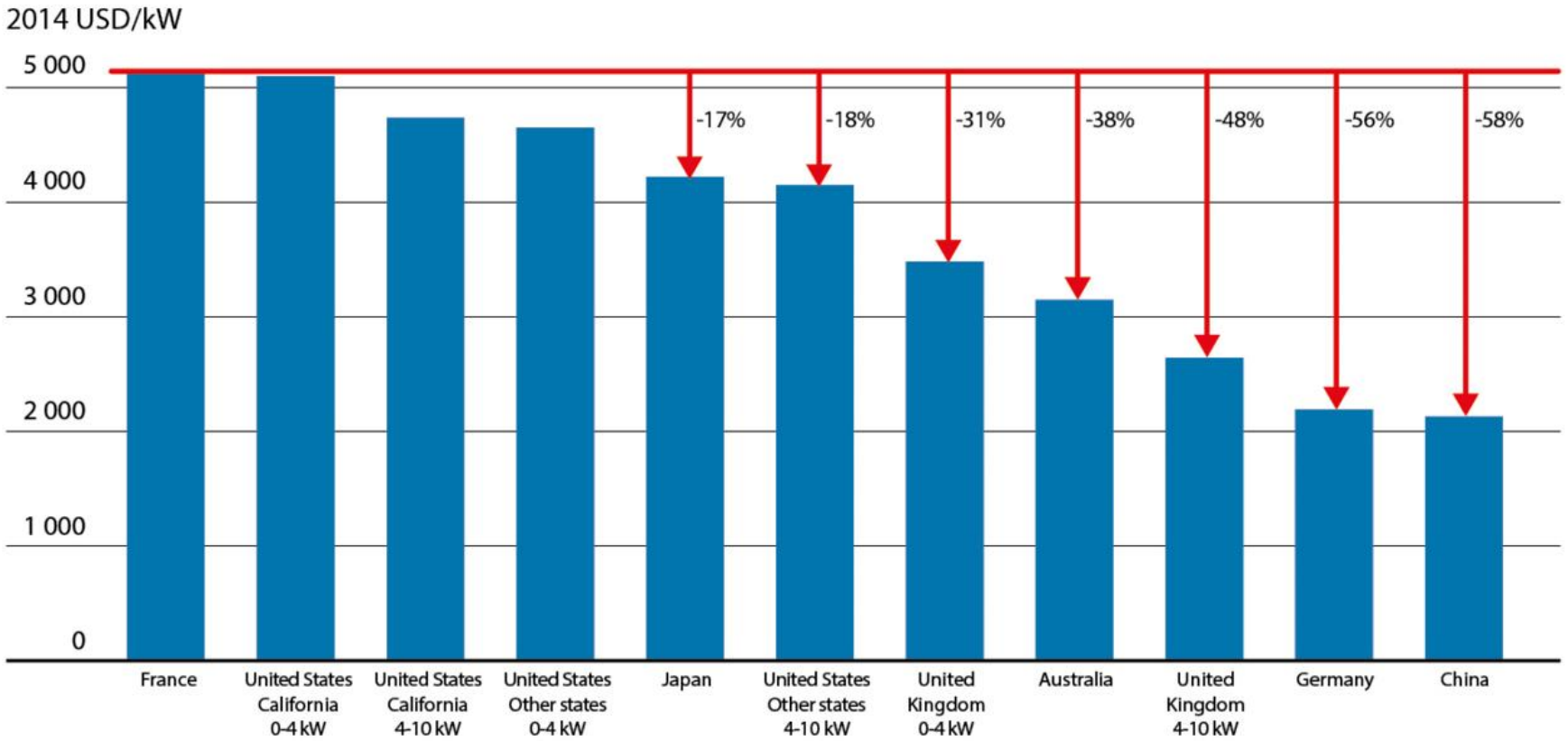
Falling LCOEs

Residential Solar PV

RENEWABLE POWER GENERATION COSTS IN 2014

IRENA International Renewable Energy Agency

FIGURE 5.11: ESTIMATED AVERAGE TOTAL INSTALLED PV SYSTEM COSTS IN THE RESIDENTIAL SECTOR BY COUNTRY, 2014

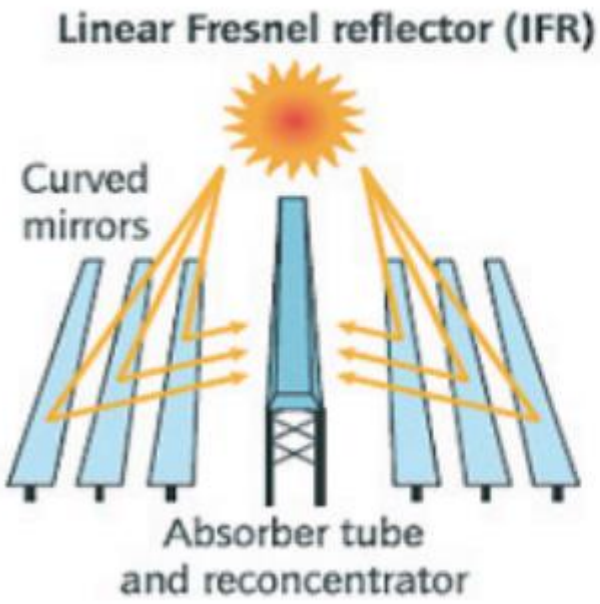


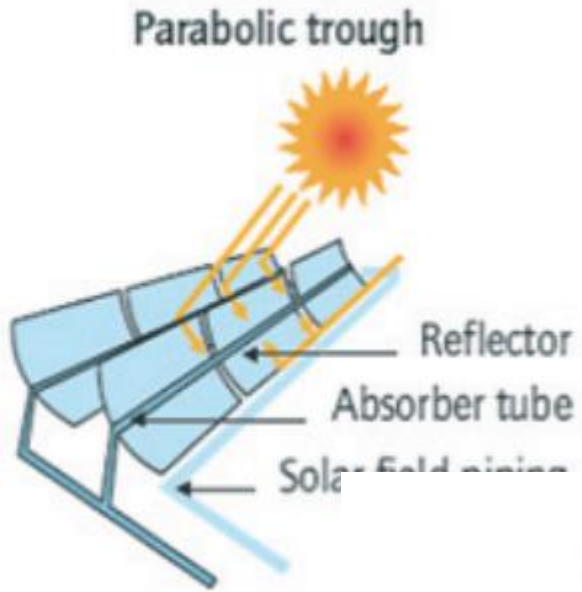
Source: IRENA Renewable Cost Database; DECC, 2014; GSE, 2014; IEA PVPS, 2014; and Photon Consulting, 2014.

CSP: a set of technologies

- Deployment is in its infancy (~5 GW)
- Cost reduction potential is good
- Solar towers have greater cost reduction potential with higher operating temperatures and lower cost thermal energy storage
- Cheap thermal energy storage allows dispatchable power -> more valuable generation (particularly in high RE scenarios)

CSP technologies





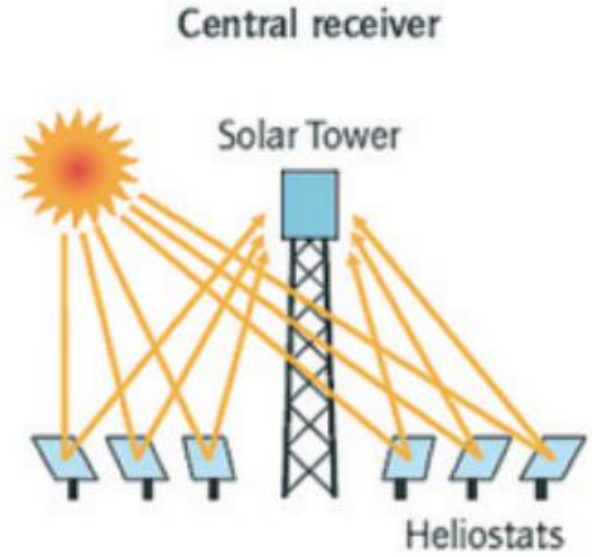
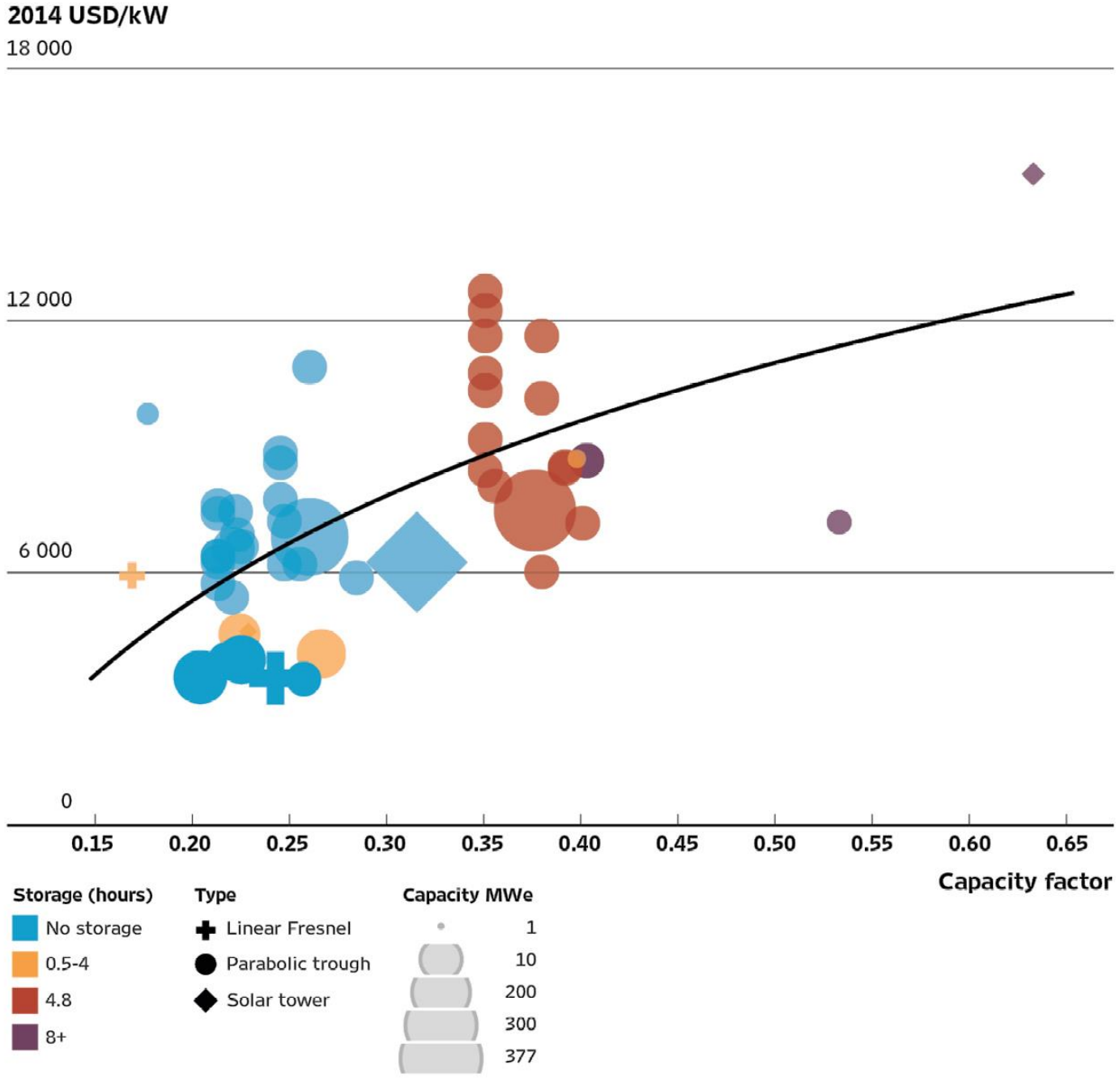
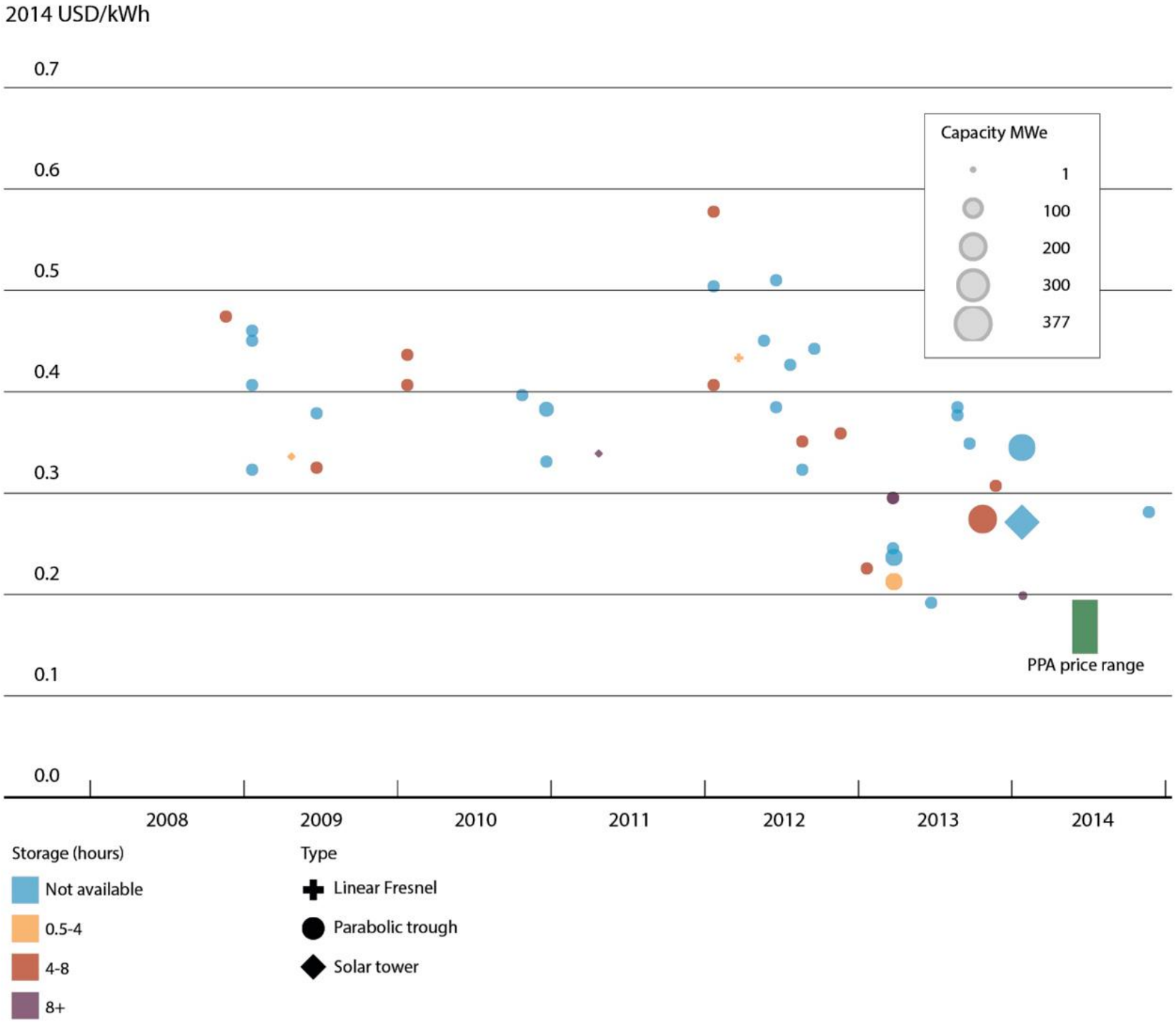


FIGURE 6.1: INSTALLED COSTS AND CAPACITY FACTORS OF CSP PROJECTS BY THEIR QUANTITY OF STORAGE



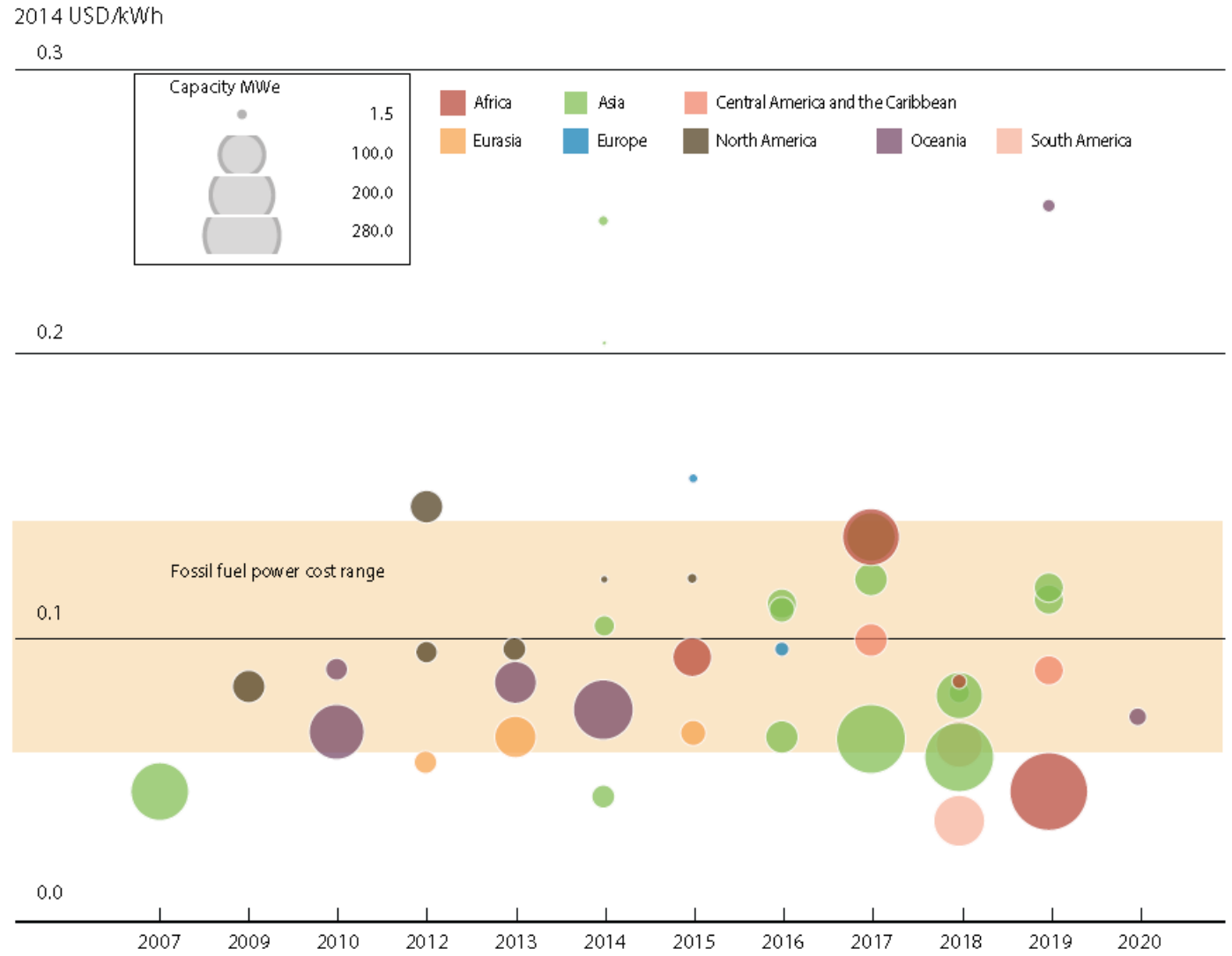

2014 USD/kWh
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
2008
2009
2010
2011
2012
2013
2014
Capacity MWe
1
100
200
300
377
PPA price range
Storage (hours)
Not available
0.5-4
4-8
8+
Type
Linear Fresnel
Parabolic trough
Solar tower

Don’t forget, biomass, hydropower and geothermal

Hydropower

Biomass

Geothermal



Source: IRENA Renewable Cost Database and Global Data, 2014

PV costs and markets in Africa

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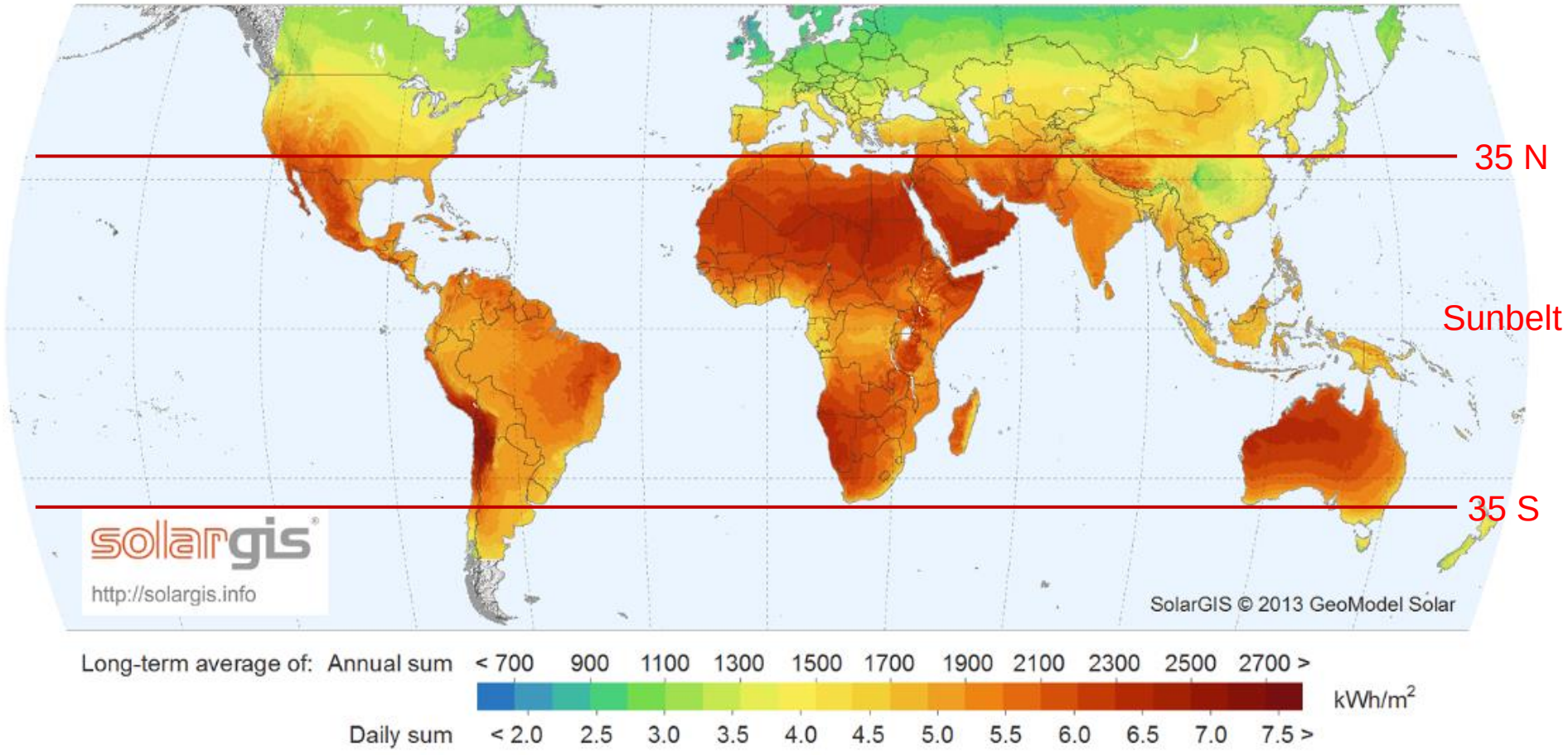
Irradiation distribution



Solar PV in Africa

- Abundant solar resource
- Energy demand growth in Africa
- Poor energy supply by utilities

- **Leapfrogging the development pathway of OECD countries by using RE with mature technology**
- **Solar PV is mature and modular solution with competitive costs today (down to USD 6 cents/ kWh)**

Accelerating PV cost reductions in Africa

- Joint project with GIZ/BMZ
- Focus on collecting up-to-date data on current costs of PV projects (SHS, mini-grids and utility-scale projects) to provide source for an evidence based decision making

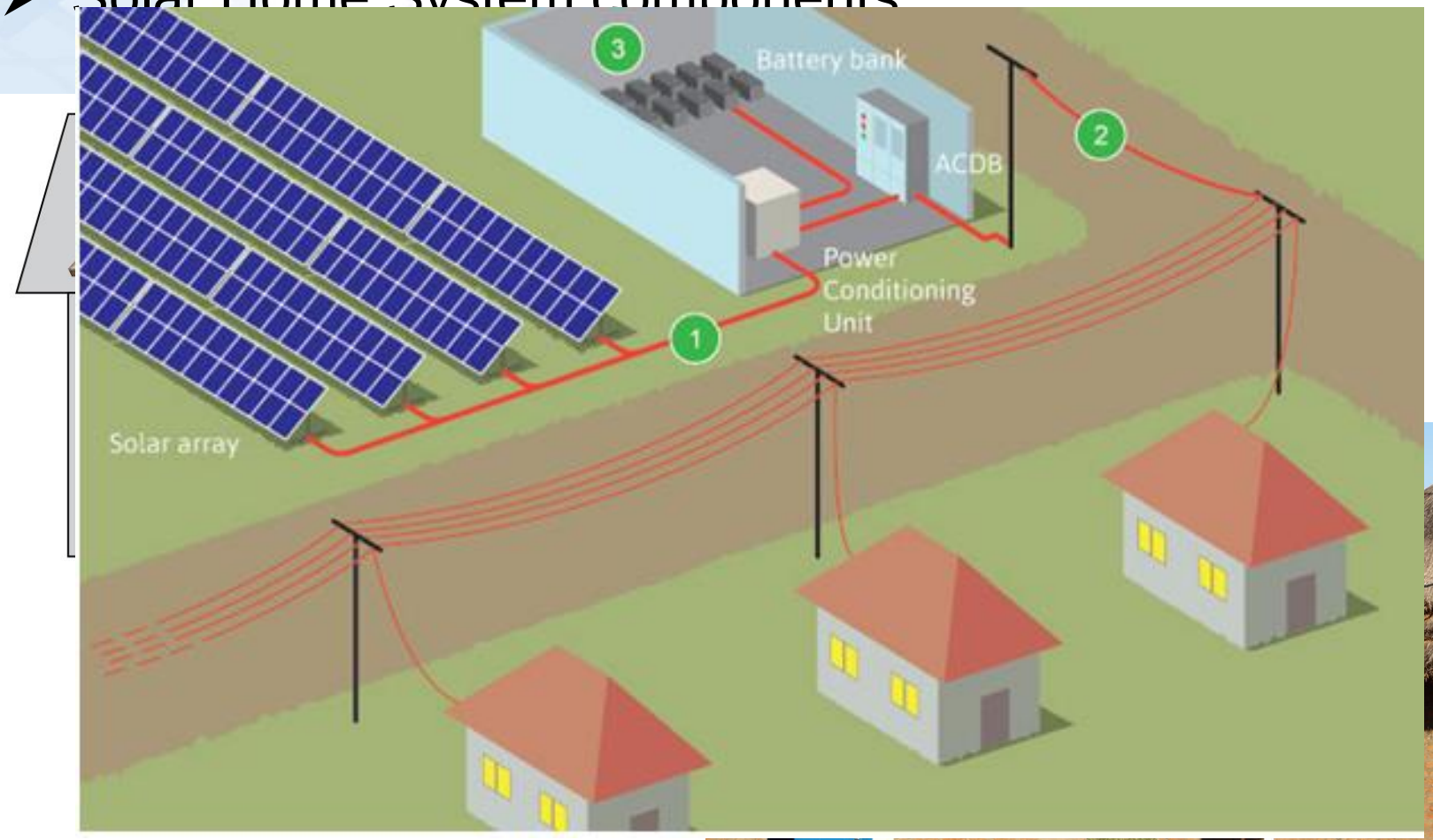
➢ **What do "competitive" costs look like in Africa?**

➢ **What are the barriers to achieve these levels in new markets in Africa?**

➢ **How do we get there? What facilitating policies are needed?**

Solar home systems and mini-grids

- Mini-grid components
- Solar Home System components



Merits of SHS ?

- Simple system / typically DC use
- It became inexpensive
- Can provide 24 hour power without backup generator

- only supply limited quantities

- Battery management is the challenge

- Temptation to over-discharge

Merits of Mini-grid ?

- 24hour AC power- often better than the central grid
- Batteries for off-peak loads
- Solar to minimize diesel usage
- Basically a mini-utility

- metering, tariff collection, admin. Challenges

Mini-grid productive use in Africa

- Flower farms
- Coffee/ Tea farms
- Hotels and lodges

Technical categorization

Grid connected PV applications	Utility scale (>1MW)	
	Commercial scale	
	Grid connected residential system	
Off grid PV applications	Utility scale (>1MW)	
	Mini grid/ hybrid system	With batteries
		Without batteries
	SHS	Excluding Pico systems (1-10W) and up to 1kW
		Above 1kW below 5kW

Technical categorization

	Stand-alone			Grids		
	DC		AC	AC/DC		AC
System	**Solar lighting kits or rechargeable lanterns**	**DC Solar home systems**	**AC Solar home systems; single-facility AC systems**	**Nano-grid Pico-grid**	**Micro-grid, Mini-grid**	**Full-grid**
	Off-grid					
Application	lighting	lighting and appliances	lighting and appliances	Lighting, appliances, emergency power	all uses (incl. Industrial)	all uses (incl. Industrial)
key component	Generation, storage, lighting, cell charger	Generation, storage, DC special appliances	Generation, storage, lighting, regular AC appliances. Building wiring incl. but no distribution system	Generation + single-phase distribution	Generation + three-phase distribution + controller	Generation + three-phase distribution + transmission

Data source

Multipronged approach: The contact sources

1. Government authority
2. Energy related economic community
3. List of companies registered on regulatory organization's websites
4. Alliances, Business associations / Private companies
5. International development organizations
6. Development banks

Total data collected :

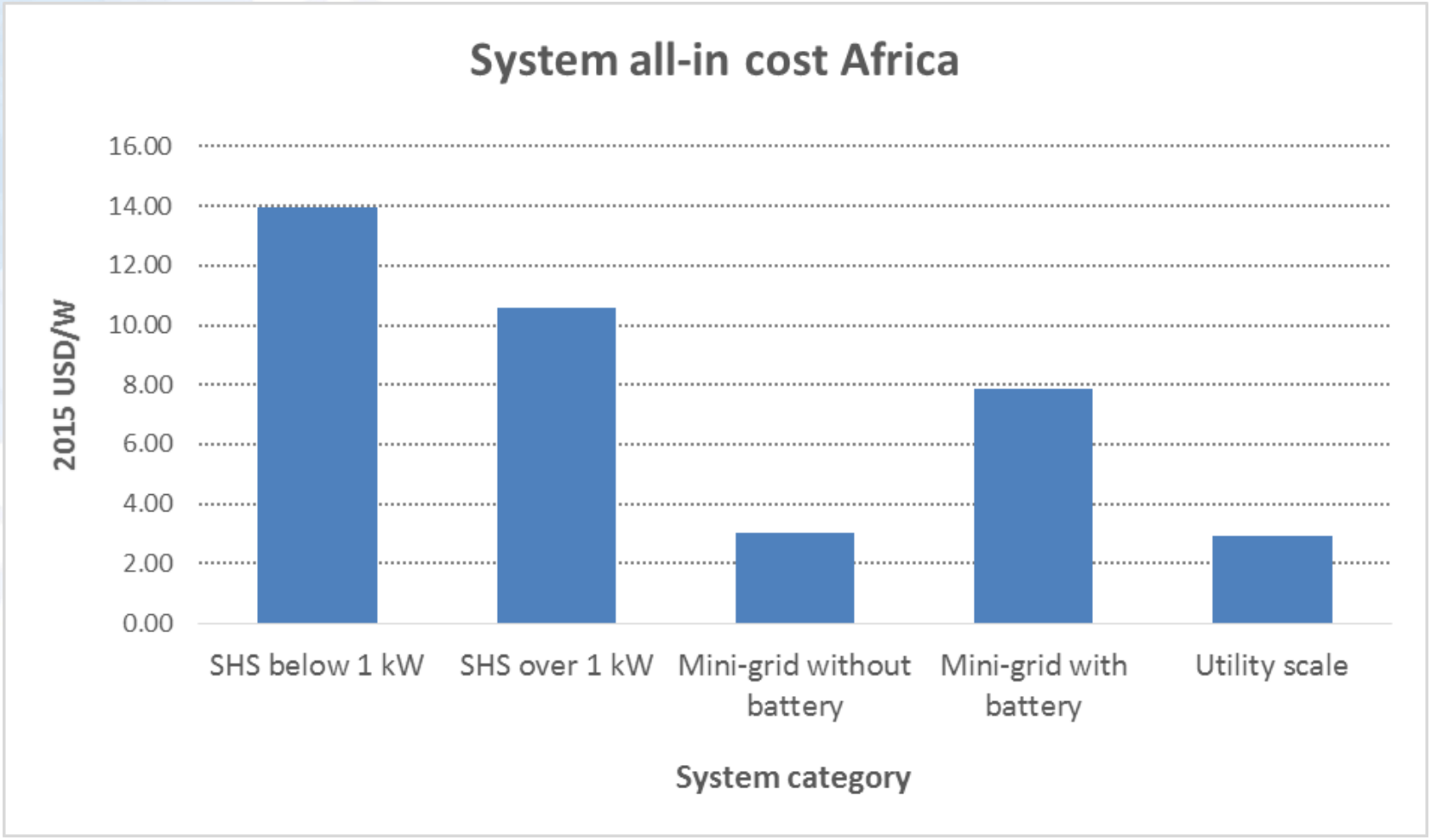
Over 360 data sets from 17 countries in Africa

➡ **Analysis on 'PV costs in Africa'**
publication in June 2015

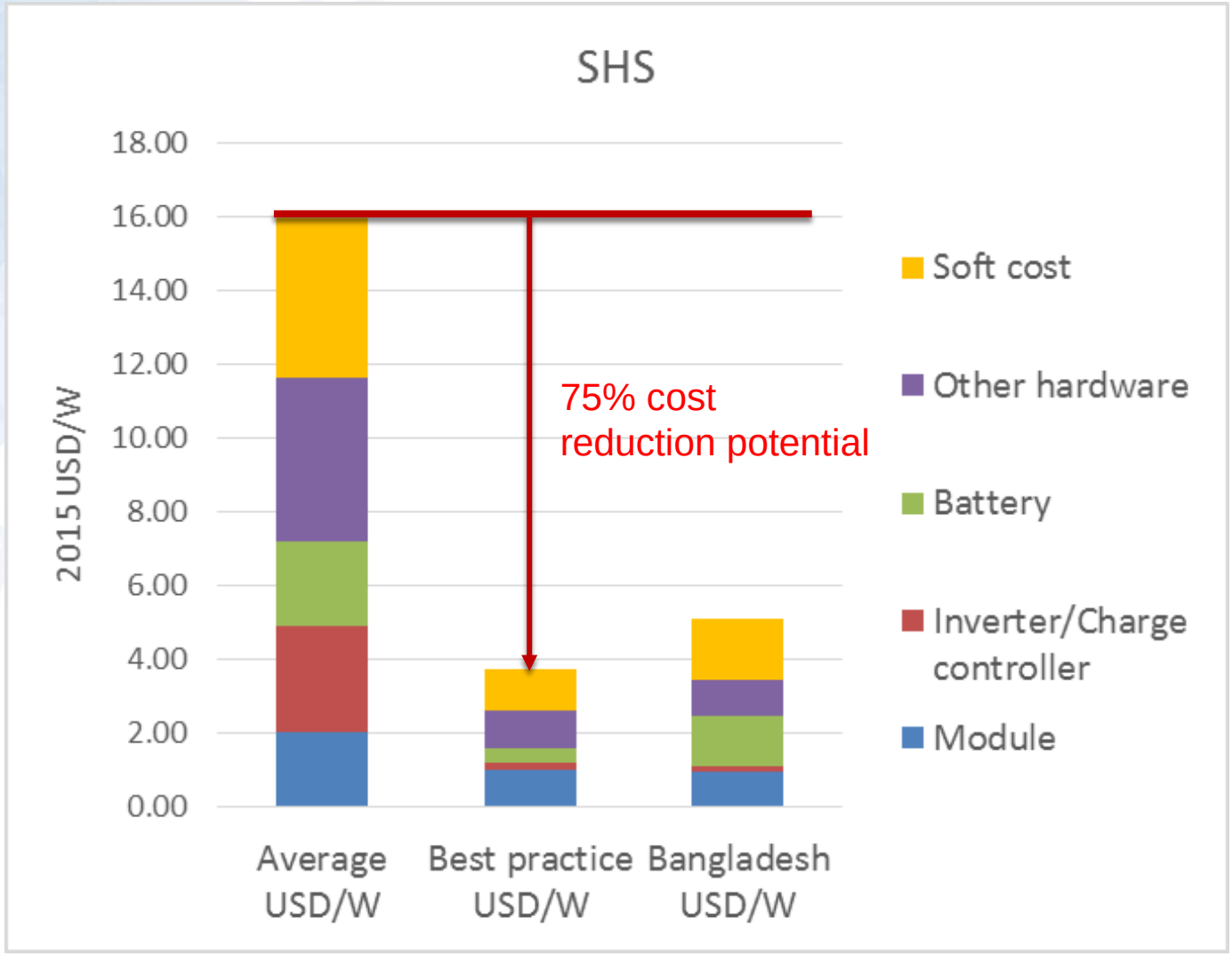
Cost breakdown for the analysis

- **Module costs**
- **BoS Hardware costs** (Inverter, wiring and cables, rack, monitoring system and battery etc.)
- **BoS Soft costs** (customer acquisition, system design, financing and installation costs etc.)
- **Total system price**

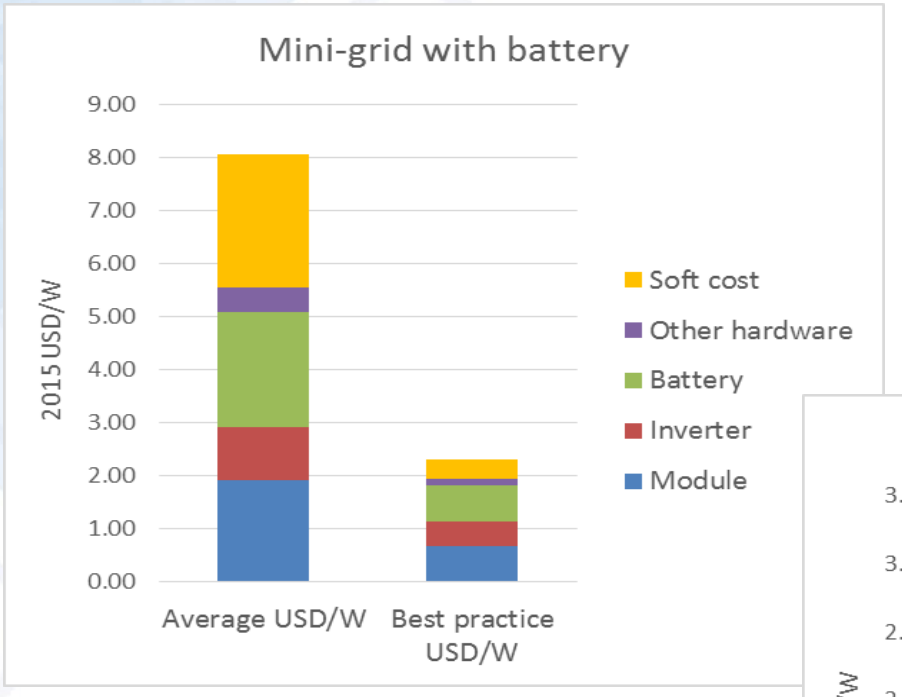
Total system price of PV in Africa



SHS costs in Africa

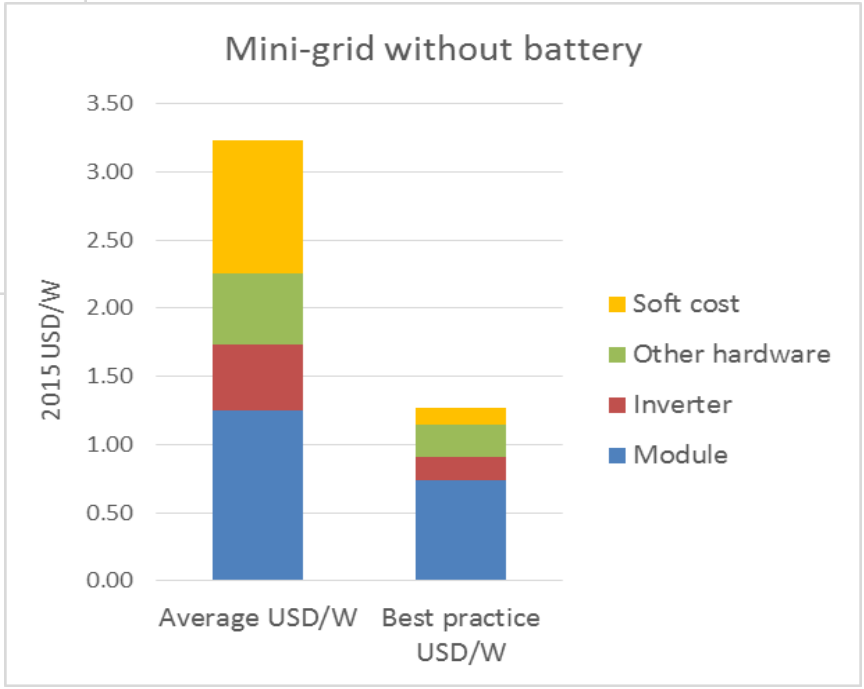


Mini grid costs in Africa

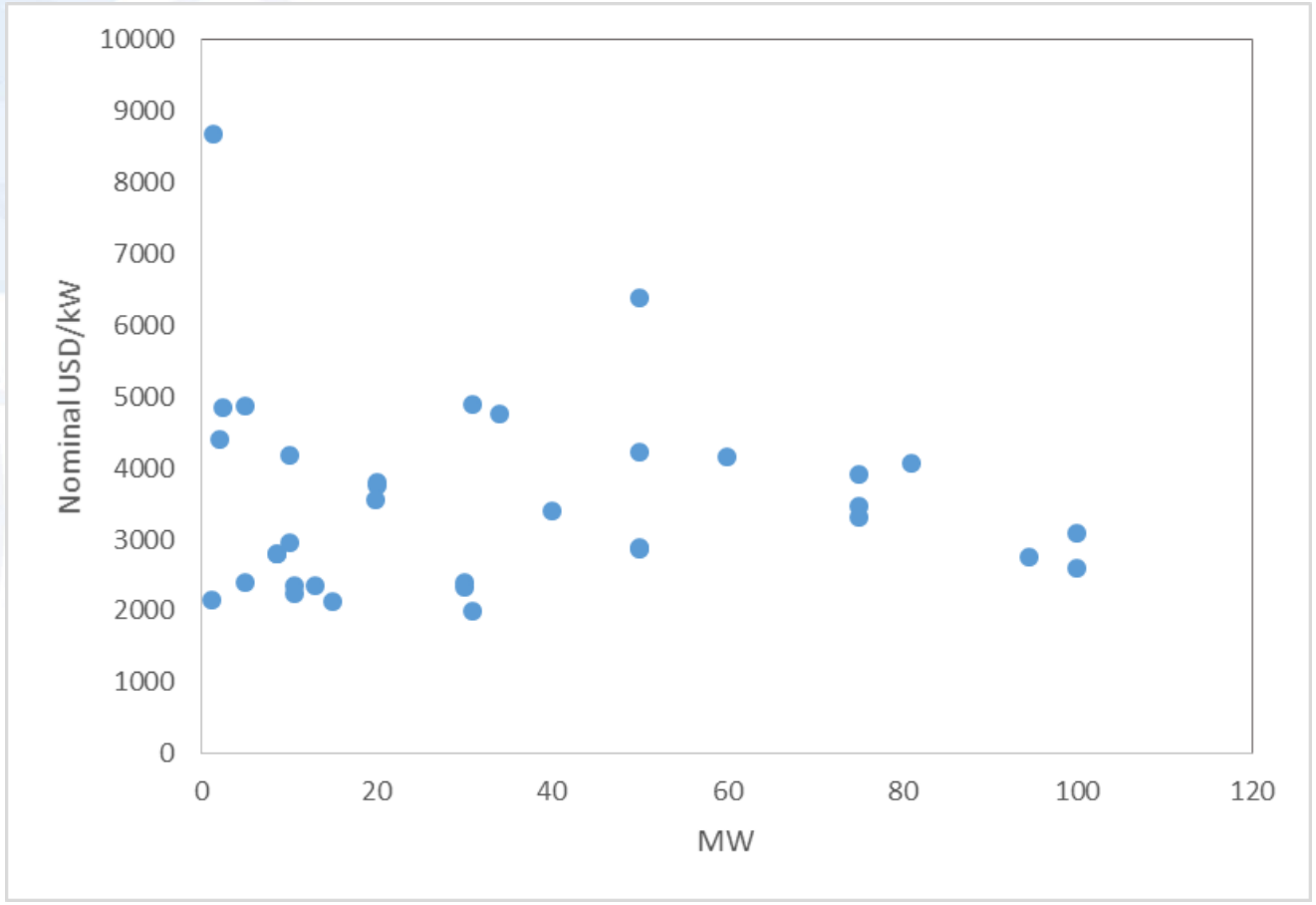


All cost components have large potential to cut the cost down

Especially, **Soft cost**



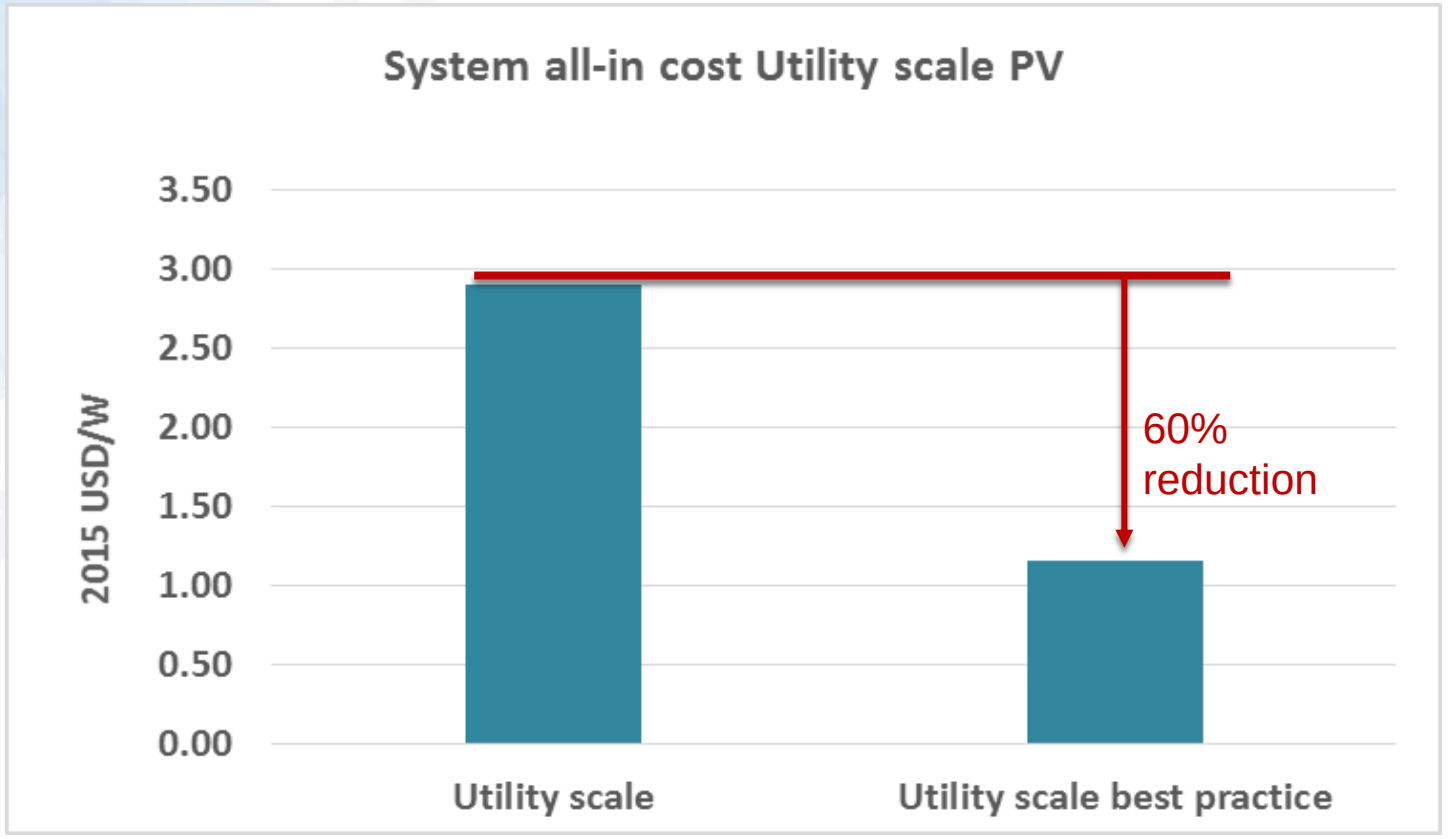
Utility scale solar PV costs in Africa



Operating or under construction in 8 African countries

Source: IRENA Renewable Cost Database and Global Data, 2014

Utility scale PV costs in Africa



Conclusion

- Large potential of cost reduction opportunities in Africa
  - Every cost components
  - Especially in soft cost
- Policy recommendation will be provided to accelerate deployment of PV

Analysis on 'PV costs in Africa'
publication in June 2015

Audience participation time

A) 172

B) 139

C) 140

D) None of the above (is it over yet?)

IRENA'S
PV PARITY INDICATORS

PV Parity Indicators

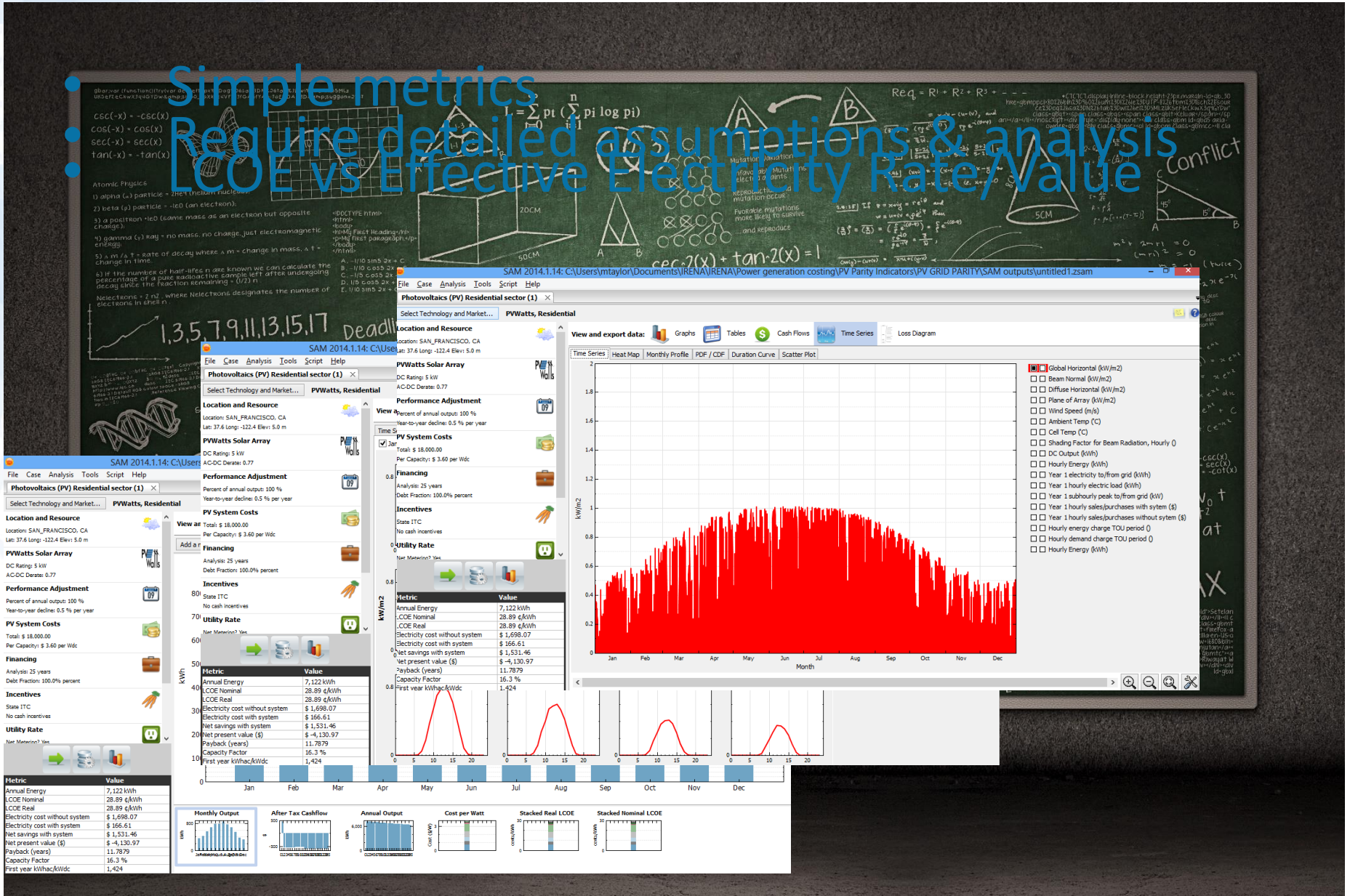
- Tracks quarterly competiveness
- Indicators, not actual costs
- Target audience are policy makers and thought leaders
- Start with North America
- Can lead to more detailed analysis
- Supports other IRENA activities

Installed cost variation by city

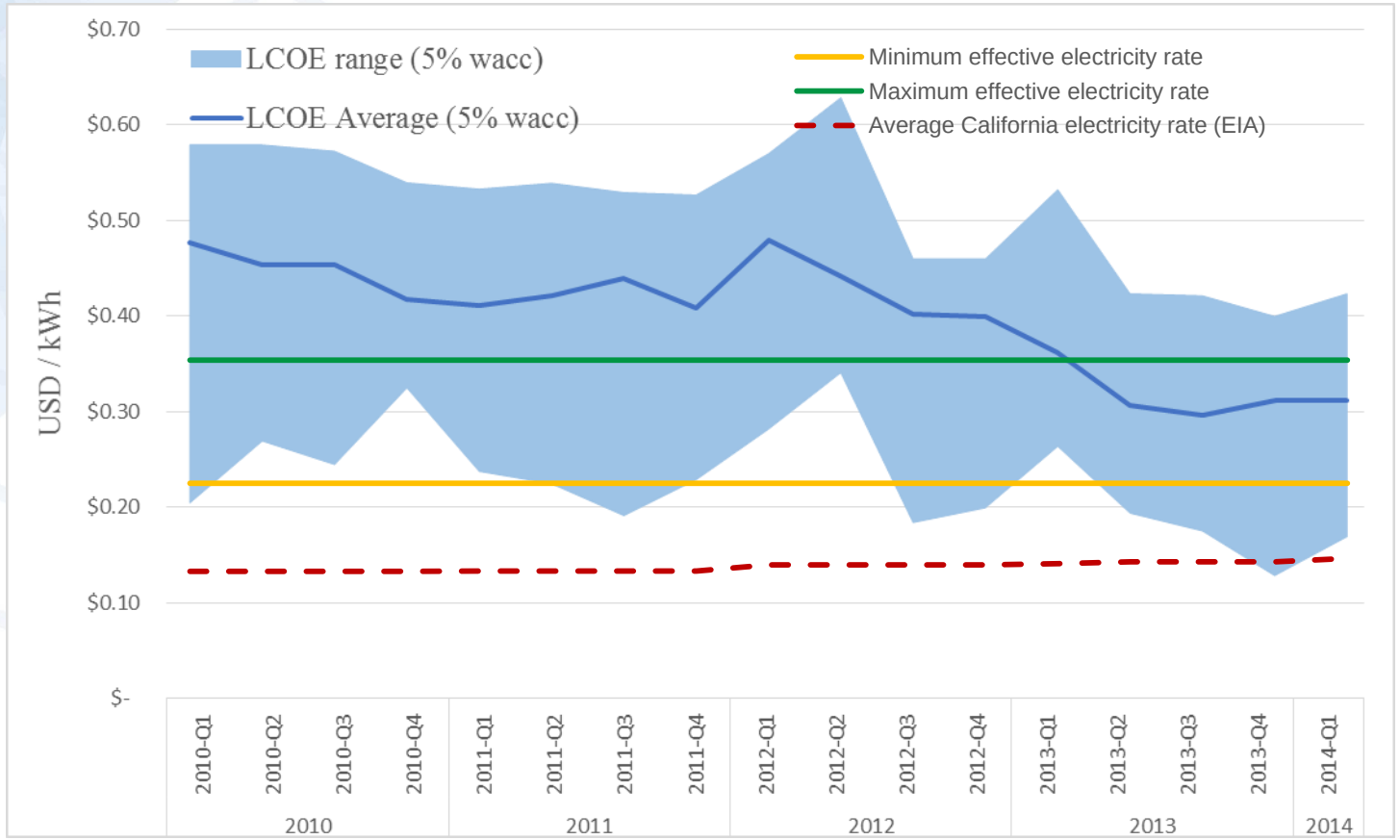
Consistently wide variation in installed costs, why?

Methodology

- Simple metrics
- Require detailed assumptions & analysis
- LCOE vs Effective Electricity Rate/Value



Residential PV Parity: San Francisco



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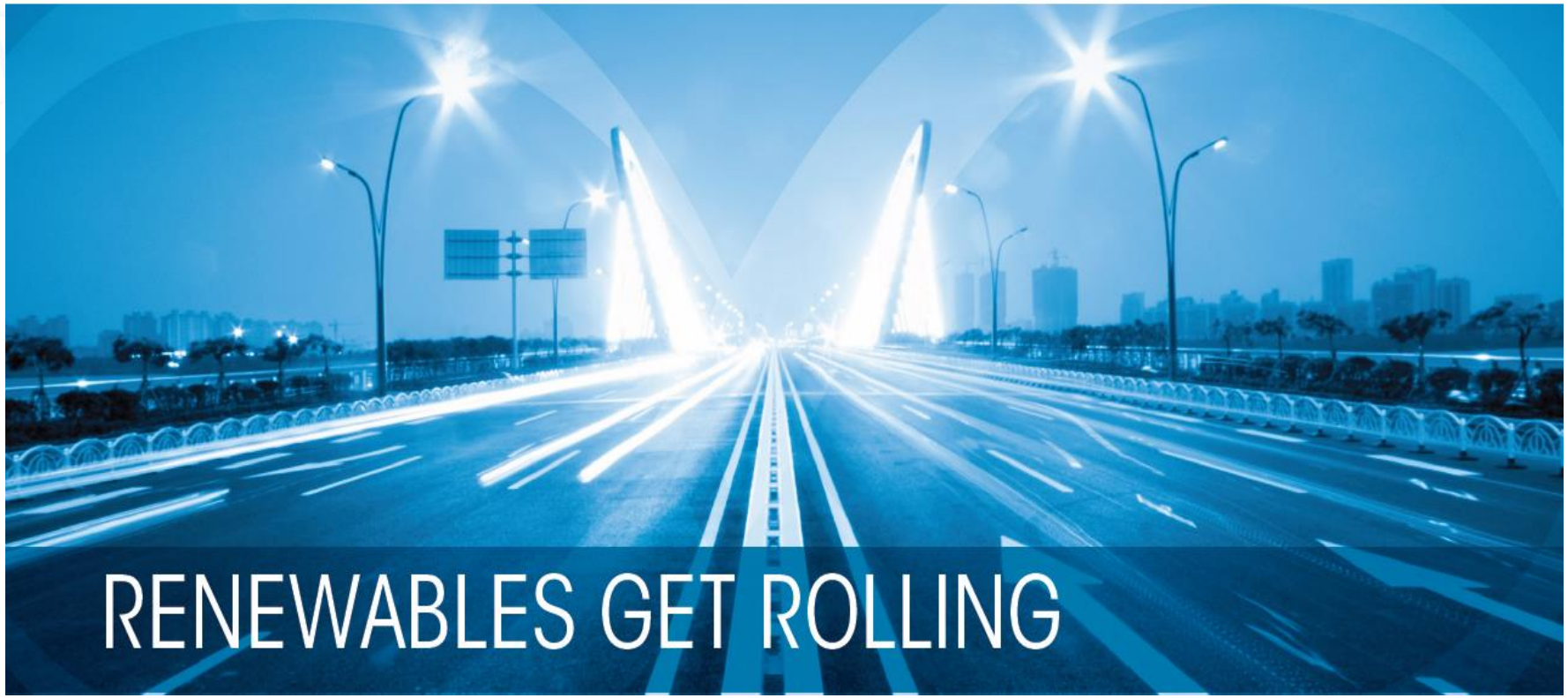
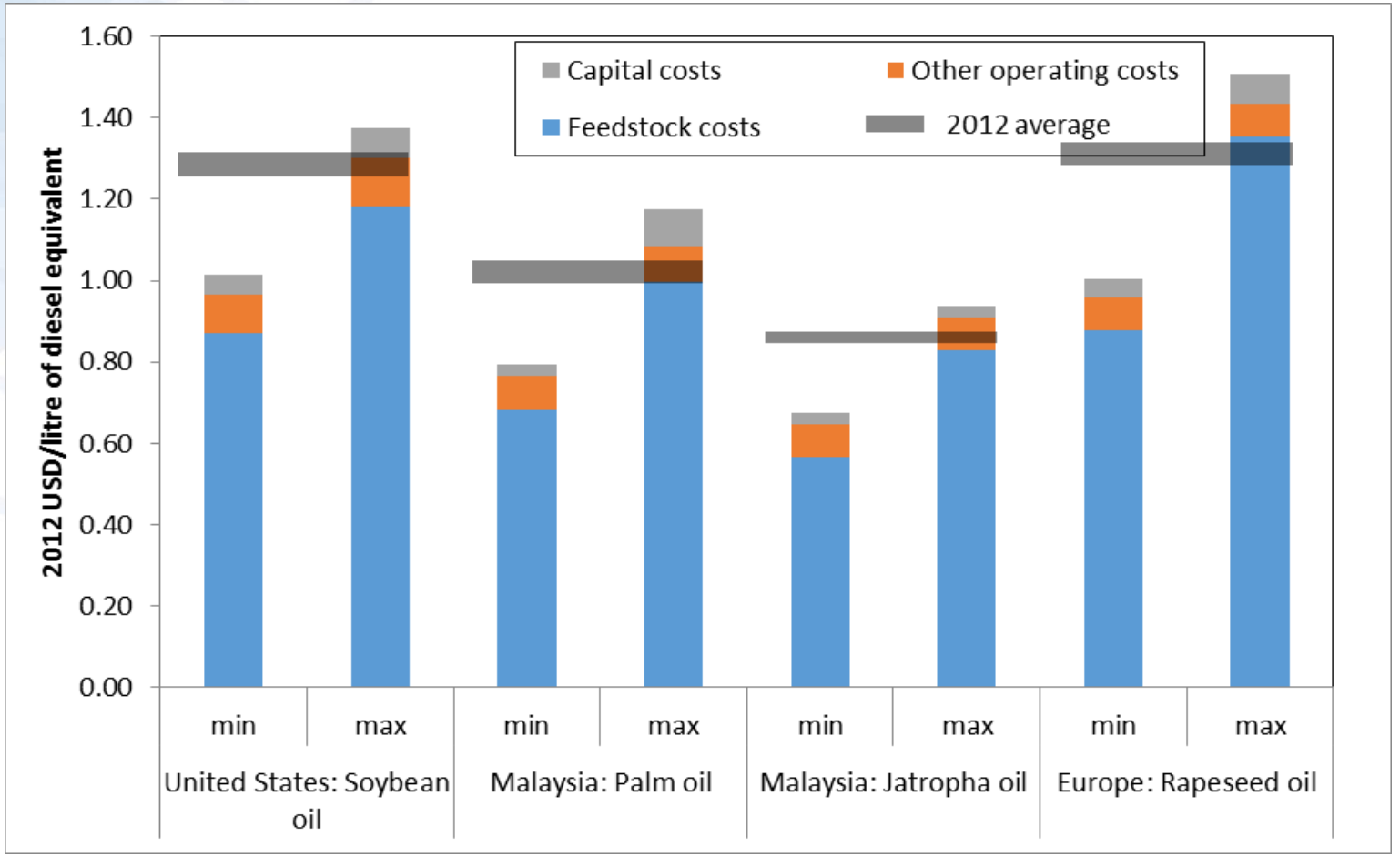






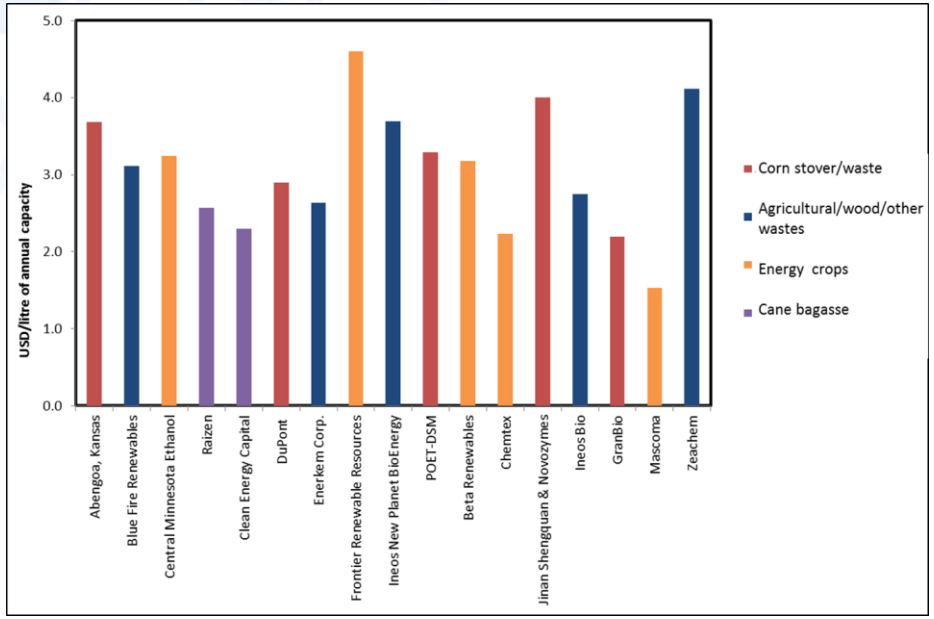
Conventional biofuels: Biodiesel

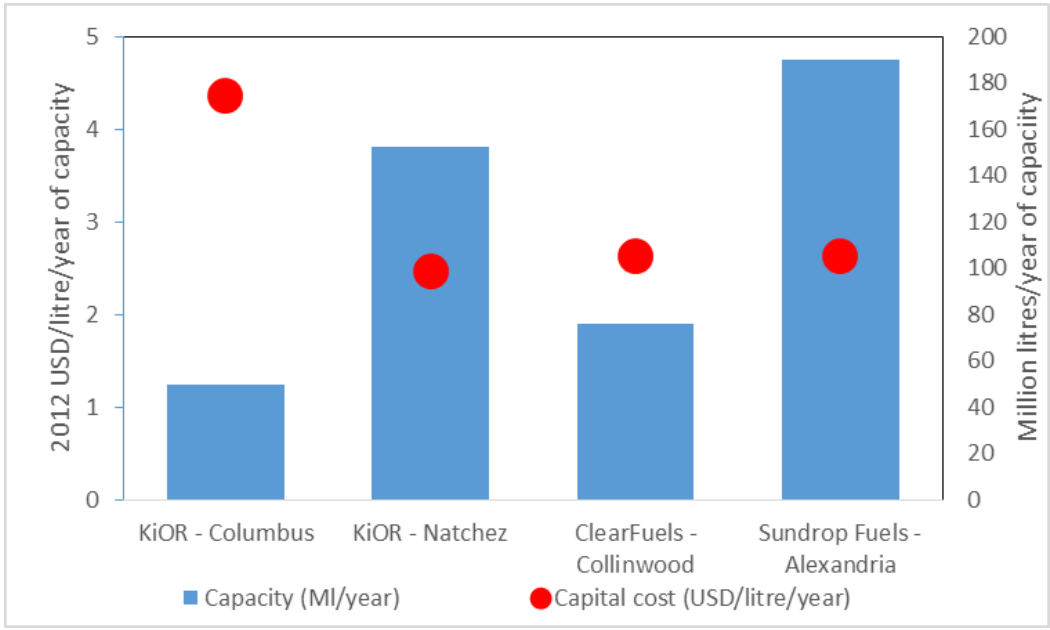
Biodiesel production costs (2009 to 2010)



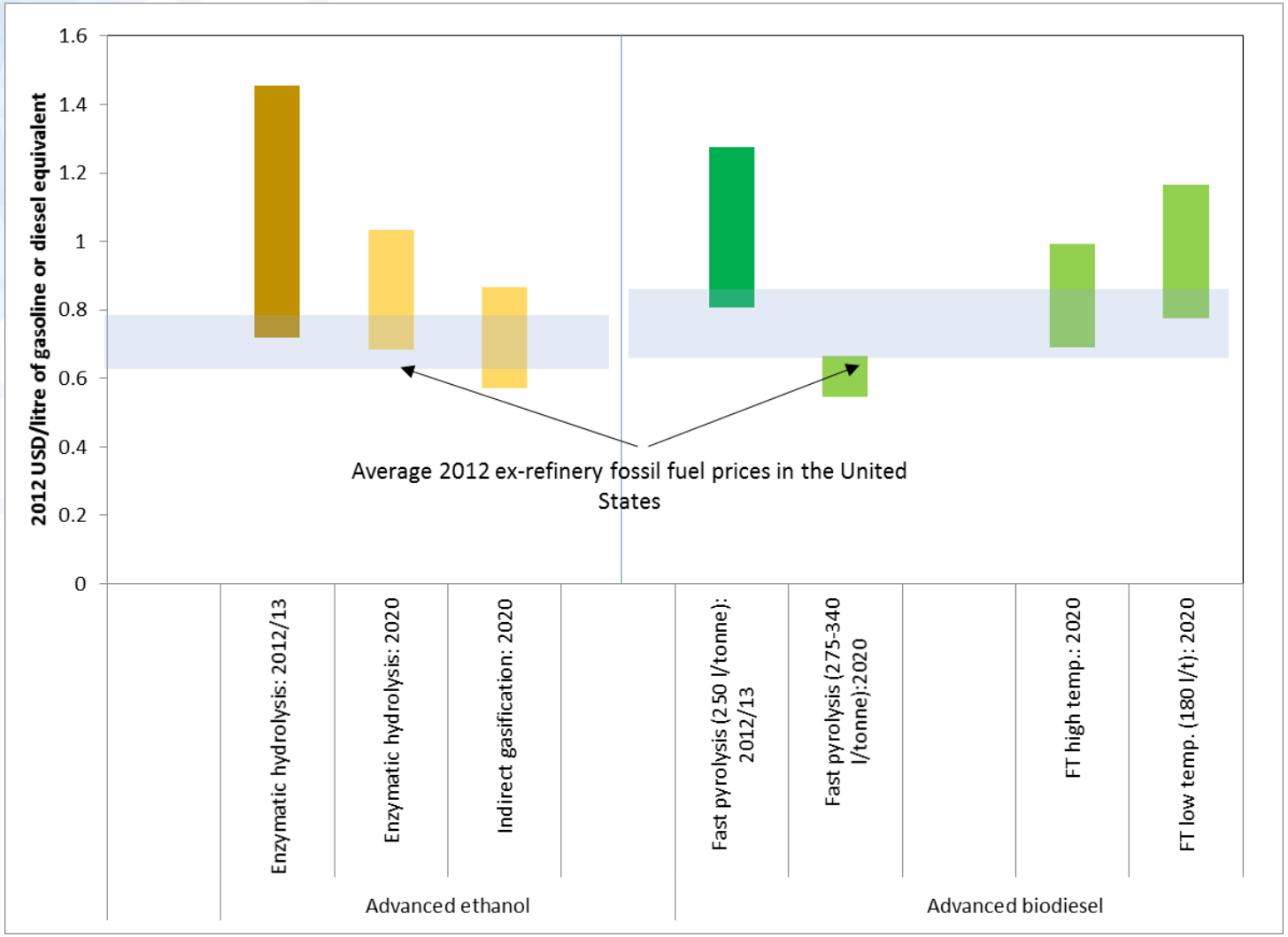
Advanced biofuels

Numerous advantages

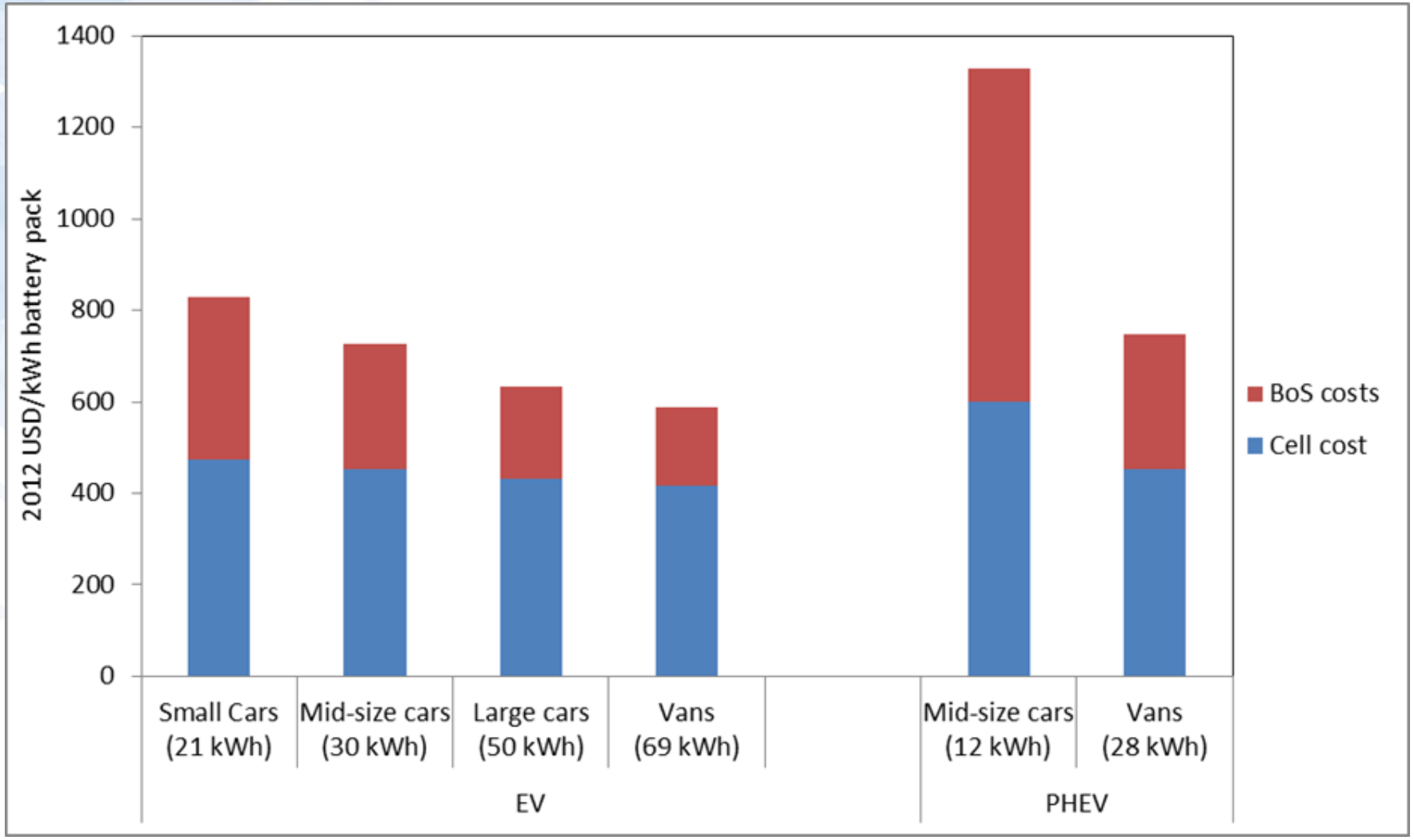




Advanced biofuels

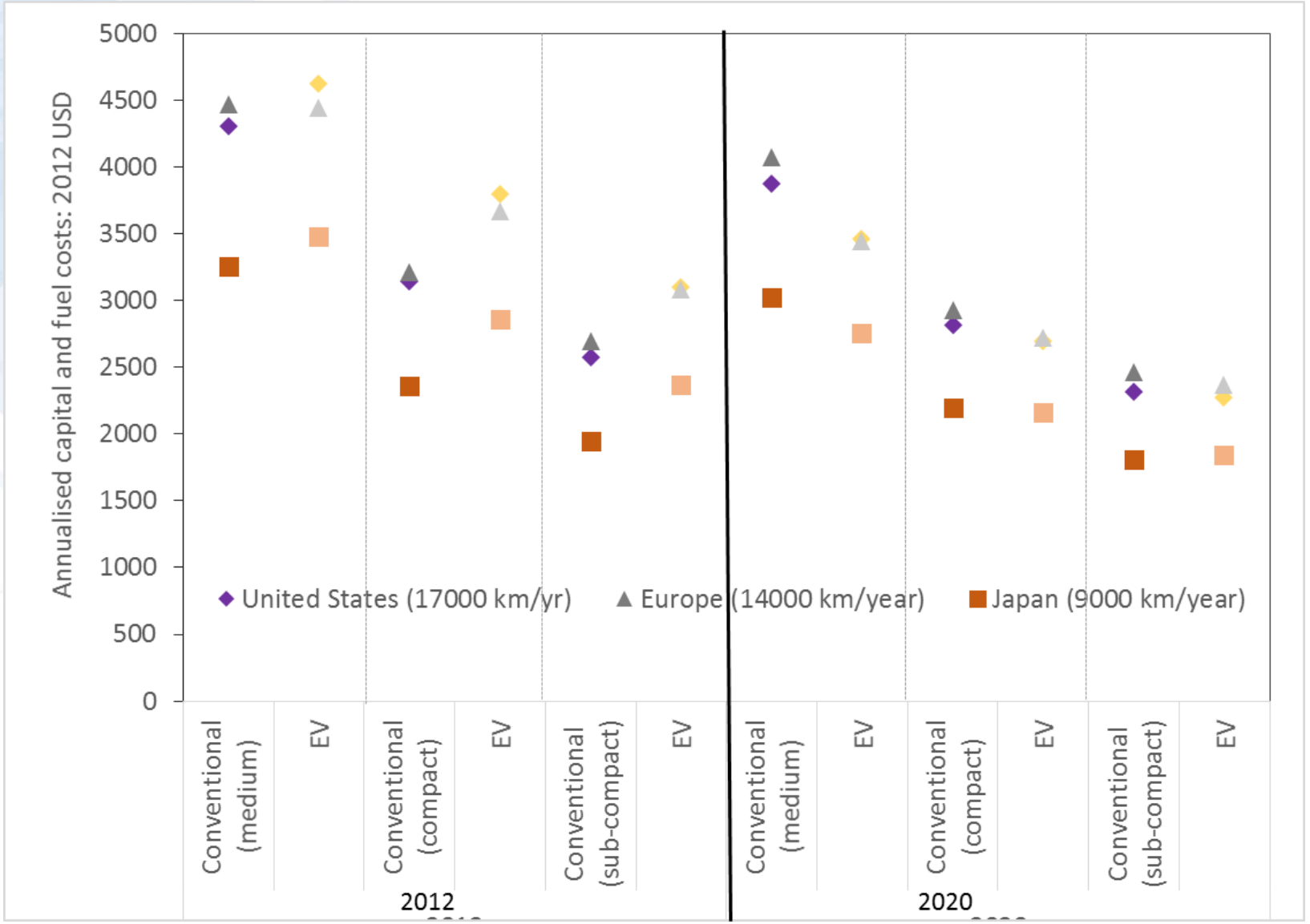


Electrification



Battery pack costs are high, EV's could be a more interesting solution than PHEV's

Pure electric vehicles




Outlook to 2020 and beyond is promising
Advanced biofuels and electrification to be competitive
Don’t forget biomethane
Success
Just Ahead

Upcoming work of IRENA costing

PV parity indicators

Global wind learning curve

Stationary applications

RE power cost reduction potentials

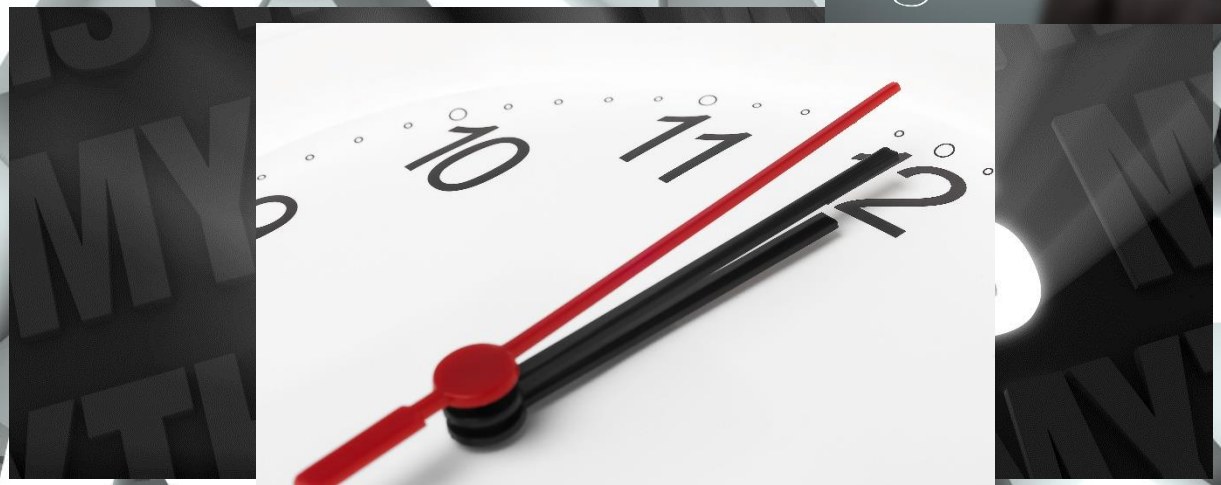
RE and energy security

IRENA's PV cost analysis

Transparent data

Simple methodology

Timely and policy re



IRENA's Cost Analysis

Bringing Our Future Forward

Thank you!

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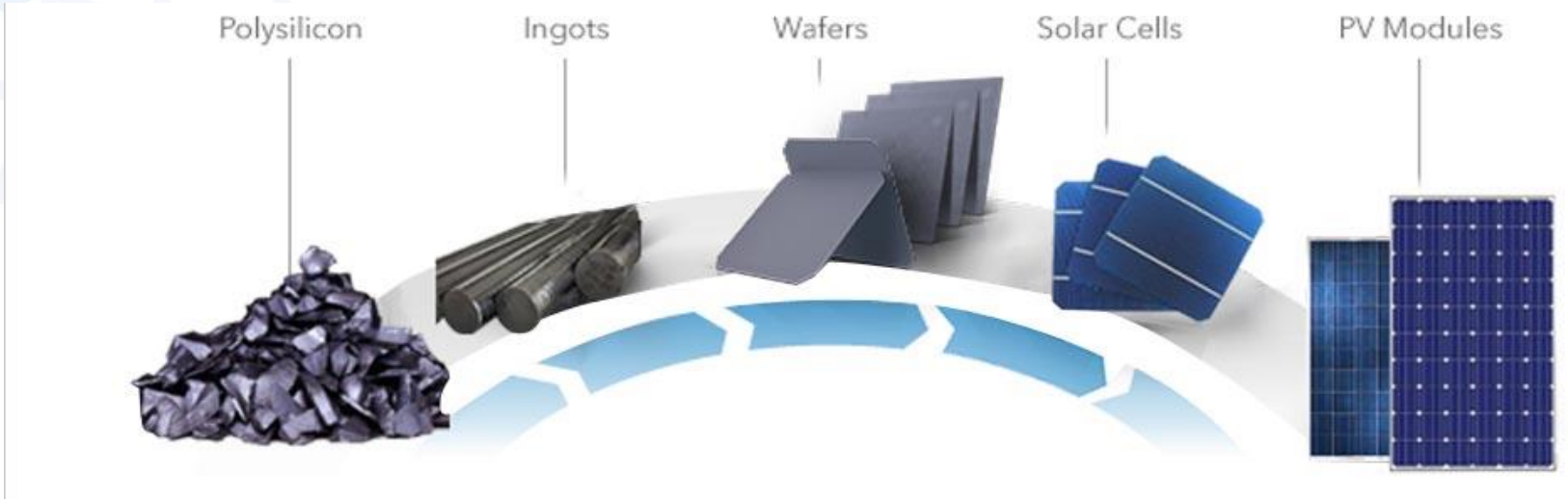
Additional slides

What is solar PV?

Photovoltaics

= Photo (Light) + Volt (electro-motive force)



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IRENA Renewable COSTING ALLIANCE

http://costing.irena.org/irena-renewable-costing-alliance.aspx

Costing alliance encourages

The sharing of real world RE project data

Supports higher quality analysis

Allows IRENA to deepen the analysis

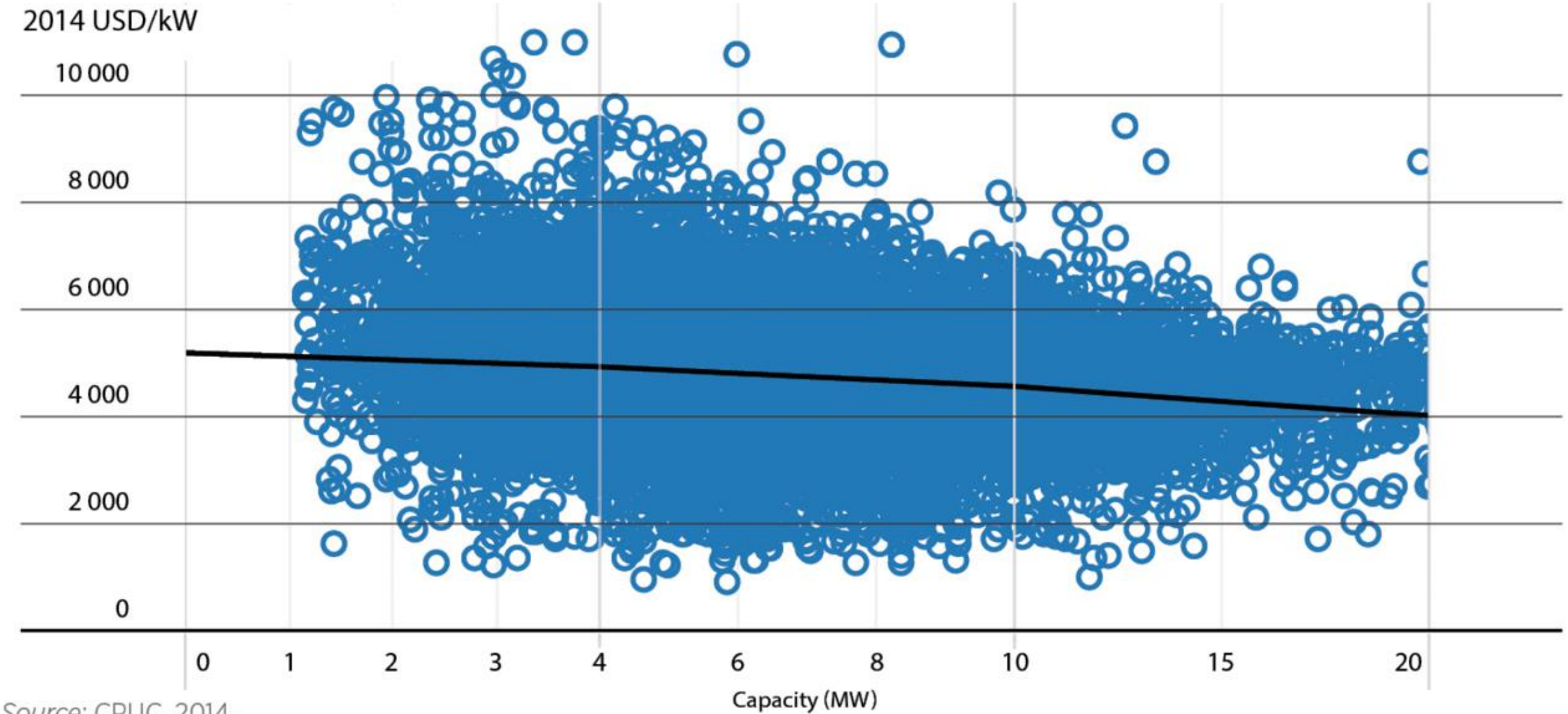
Evidence based decision making

Successful deployment of RE technology

Alliance structure

- Member countries
- Private sector members
- Observers

FIGURE 5.12: TOTAL INSTALLED PV SYSTEM COSTS FOR RESIDENTIAL SYSTEMS IN CALIFORNIA BY SYSTEM SIZE, 2014



Source: CPUC, 2014.