Leveraging Technology, Market Creation and the Private Sector to Improve Global Access to Power

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International Symposium | Tokyo March 7, 2018

IFC | International Finance Corporation
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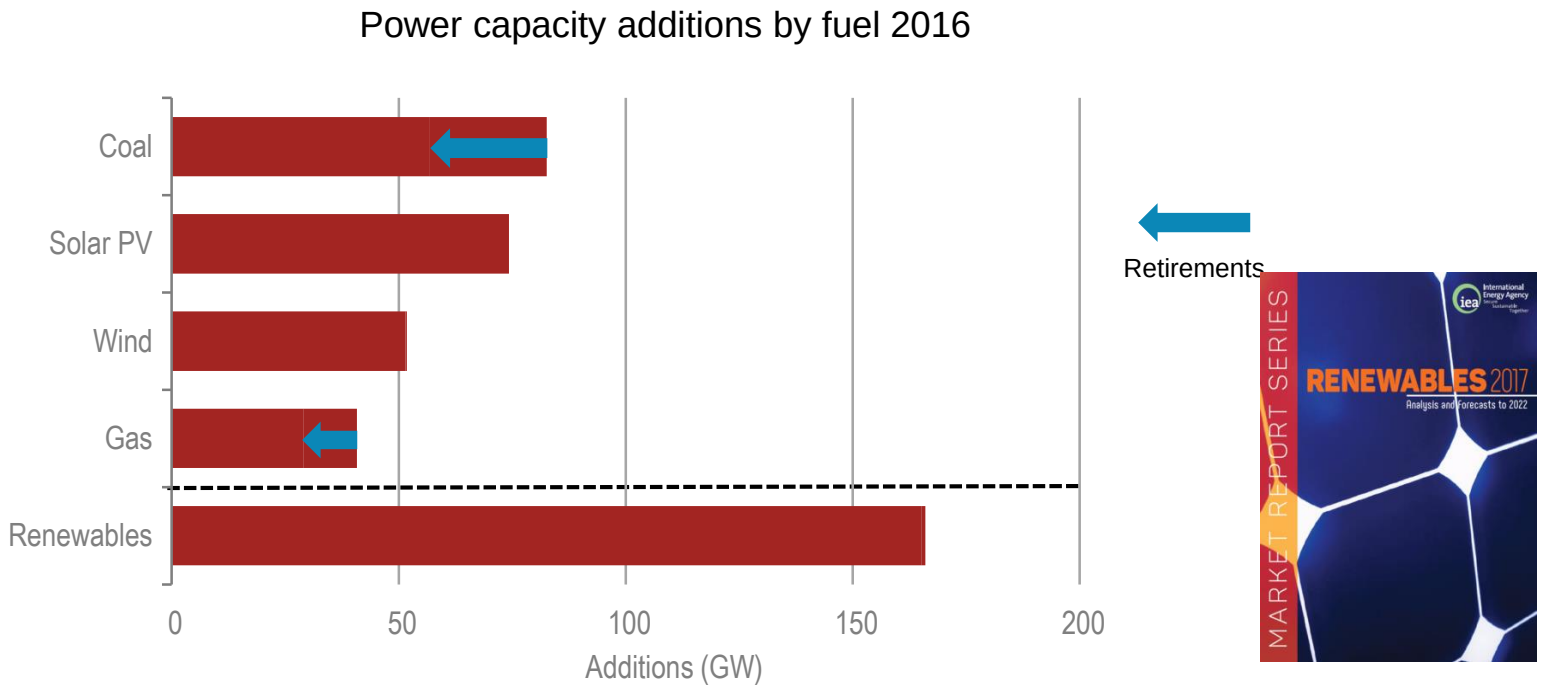
Creating Markets, Creating Opportunities

"Climate Change is a Defining Issue of Our Time"
UN Secretary General Ban Ki Moon

Rapid Expansion of Renewable Energy is part of the solution….

- Global Overview of Key Market Trends
- Changing Context of Energy Sector and Development Context in Developing World
- Role of World Bank Group and IFC Financing

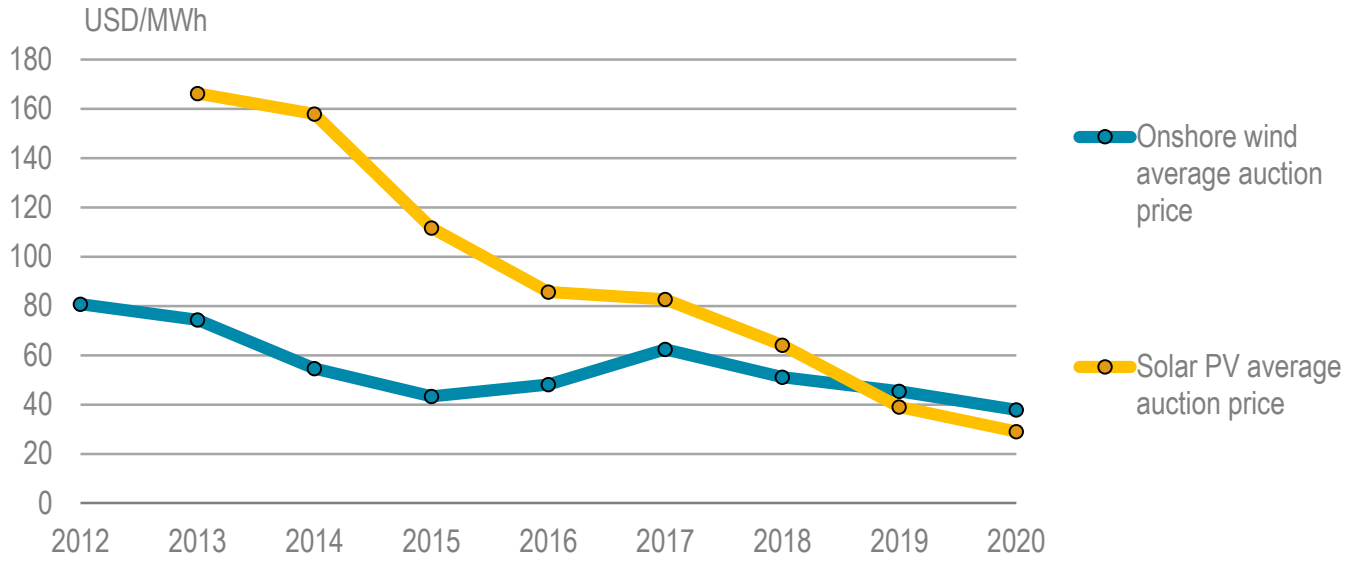
Renewables are hitting new records driven by solar PV



Renewables breaking an all-time record accounting for two thirds of global net capacity additions; For the first time solar PV becoming the global leader in net capacity growth

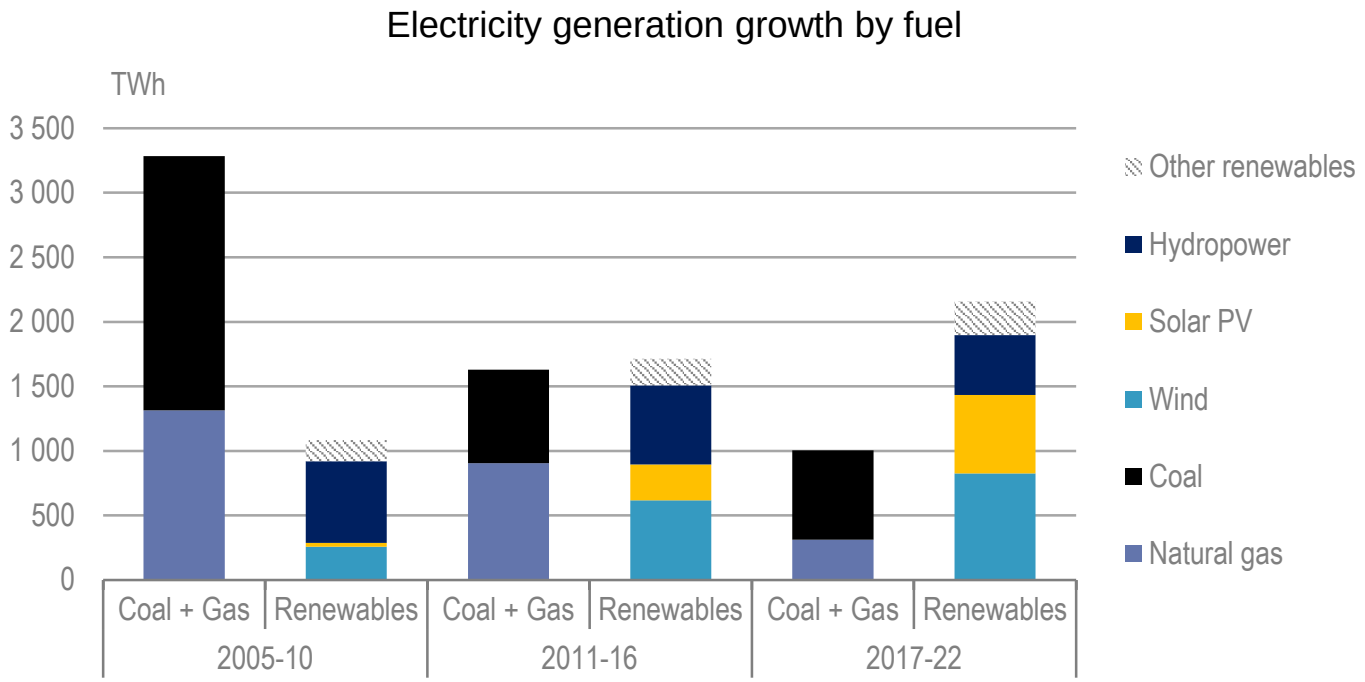
Competition from auctions are driving costs down

Announced wind and solar PV average auction prices by commissioning date



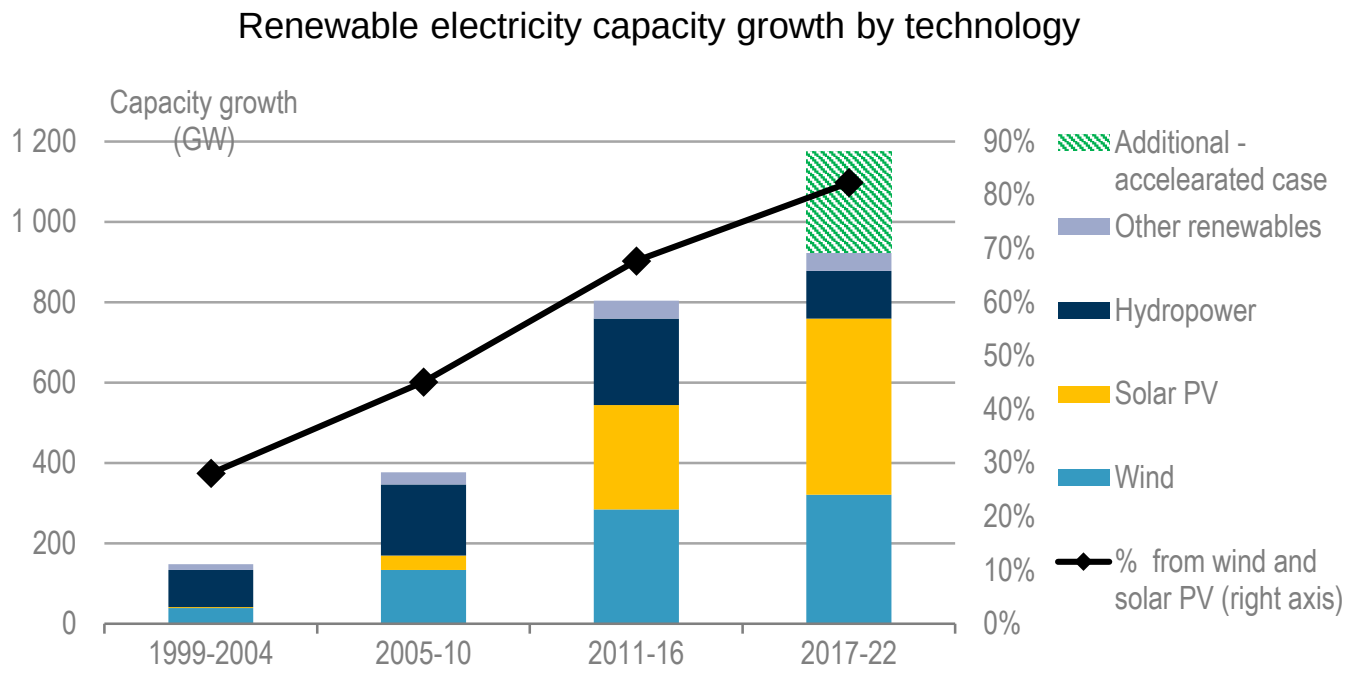
Price discovery through competitive auctions effectively reduces costs along the entire value chain; Auctions with long-term contracts will drive almost half of new capacity growth over 2017-22

Renewables expected to dominate power generation growth



Renewable generation to expand by over a third with its share increasing from 24% in 2016 to 30% in 2022, rapidly closing the gap with coal

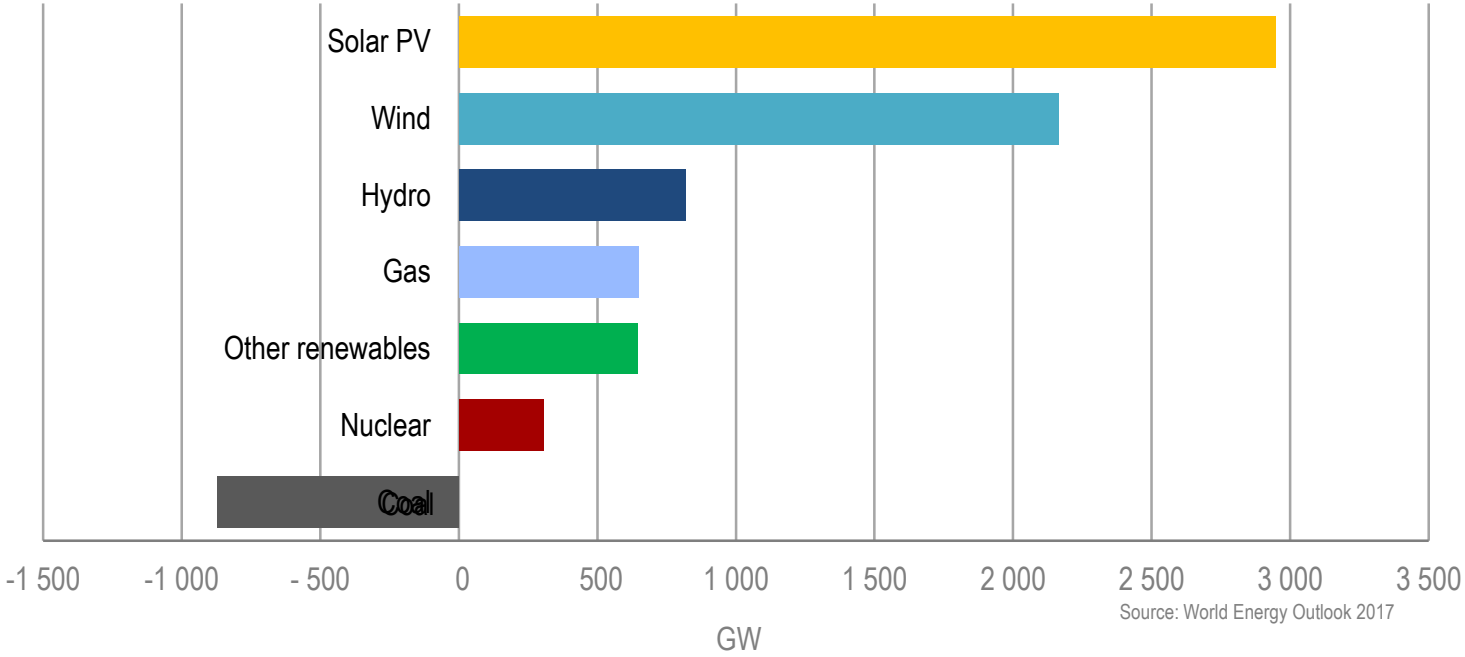
Renewables growth is more dependent on wind and solar PV



Solar PV enters a new era, becoming the undisputed leader in net power capacity growth worldwide; In the Accelerated Case solar PV forecast to triple capacity up to 880 GW by 2022

Renewables dominate capacity additions to reach sustainability goals

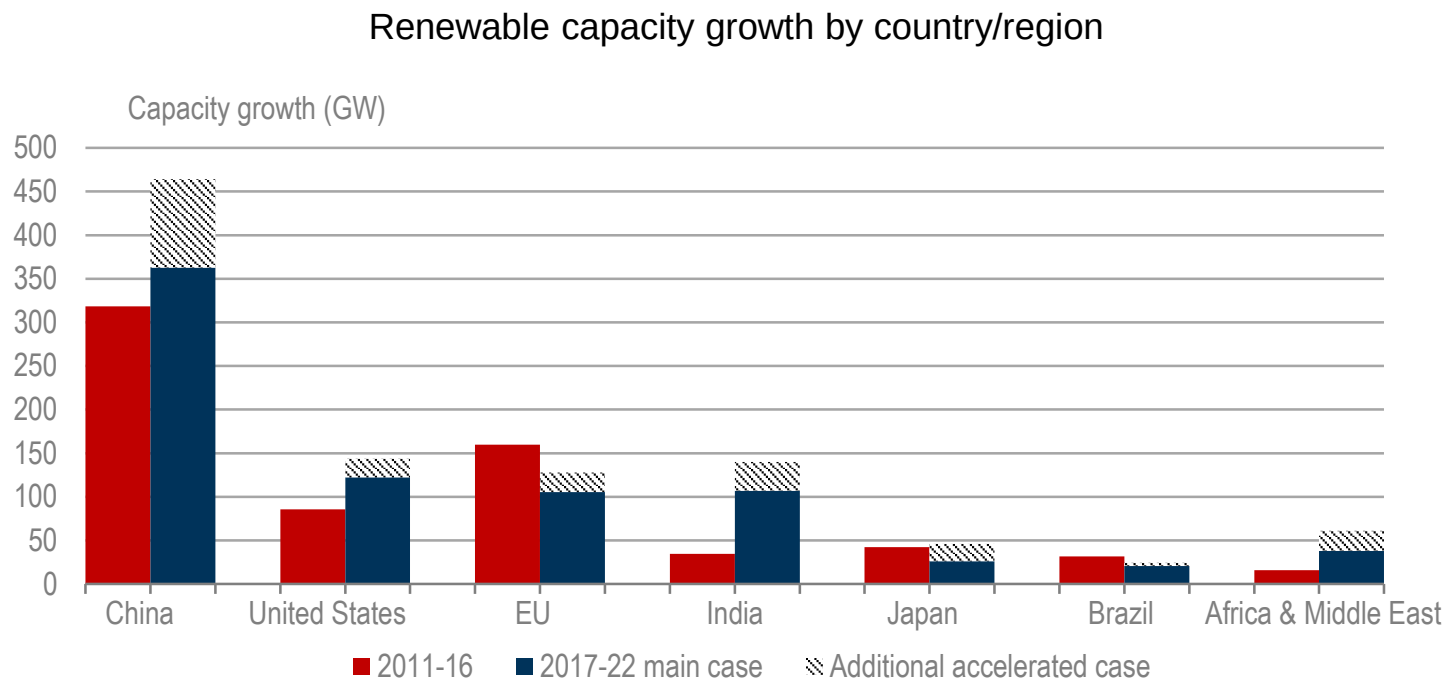
Global net capacity additions 2016 – 2040 in the WEO Sustainable Development Scenario



Source: World Energy Outlook 2017

Renewables account for 63% of total world electricity generation by 2040 in the SDS, with wind and hydro becoming the largest sources of generation. China and India account for over 40% of net renewable additions.

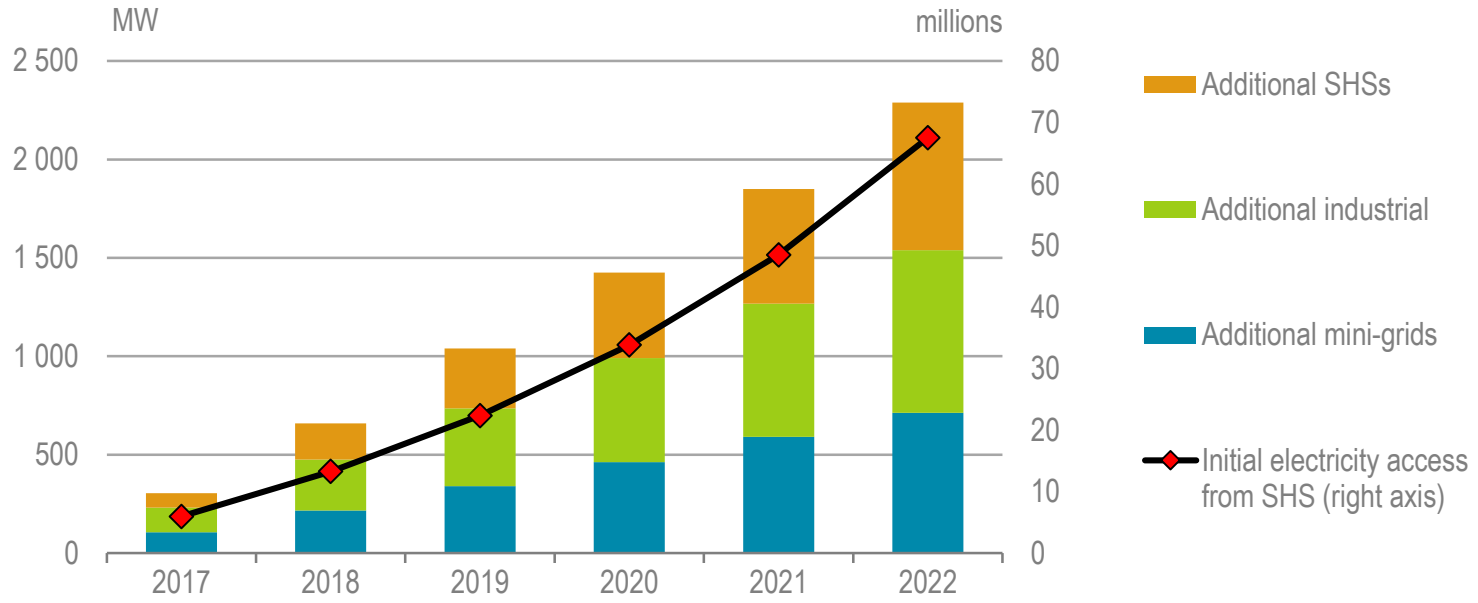
China continues to lead growth while India overtakes the EU



The forecast is 12% more optimistic vs. last year mainly due to solar PV revisions in China and India; Growth could be 27% higher with enhanced policies addressing regulatory uncertainties and grid integration

Solar PV enabling electrification in India, Bangladesh and sub-Saharan Africa

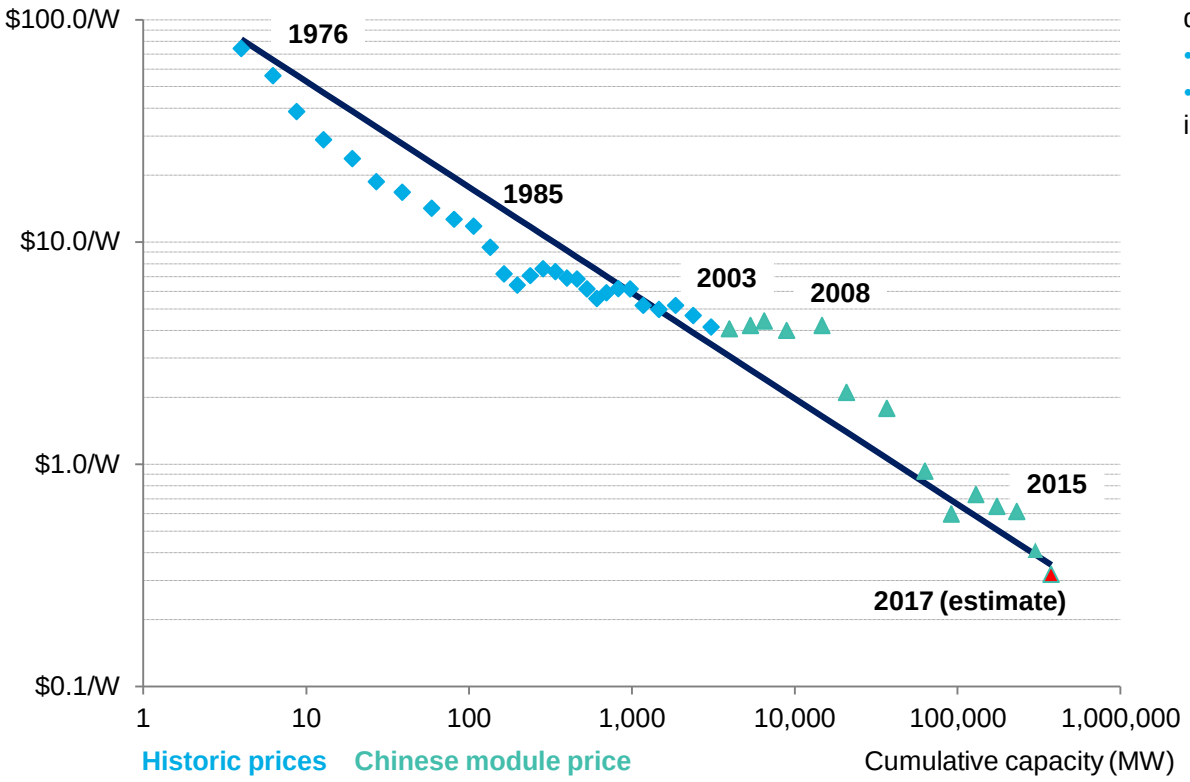
Cumulative growth of off-grid solar PV applications in developing Asia and sub-Saharan Africa



With government policies and innovative business models, off-grid PV capacity triples in Africa and developing Asia. Small home systems bring initial electricity access to almost 70 million by 2022

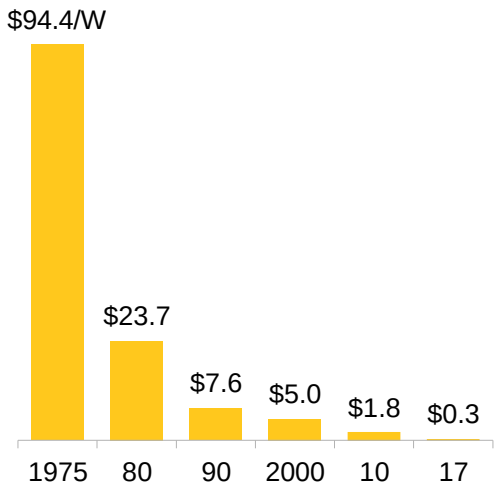
Technology is fundamentally changing the energy landscape

Crystalline silicon solar PV experience curve



Since 1975:

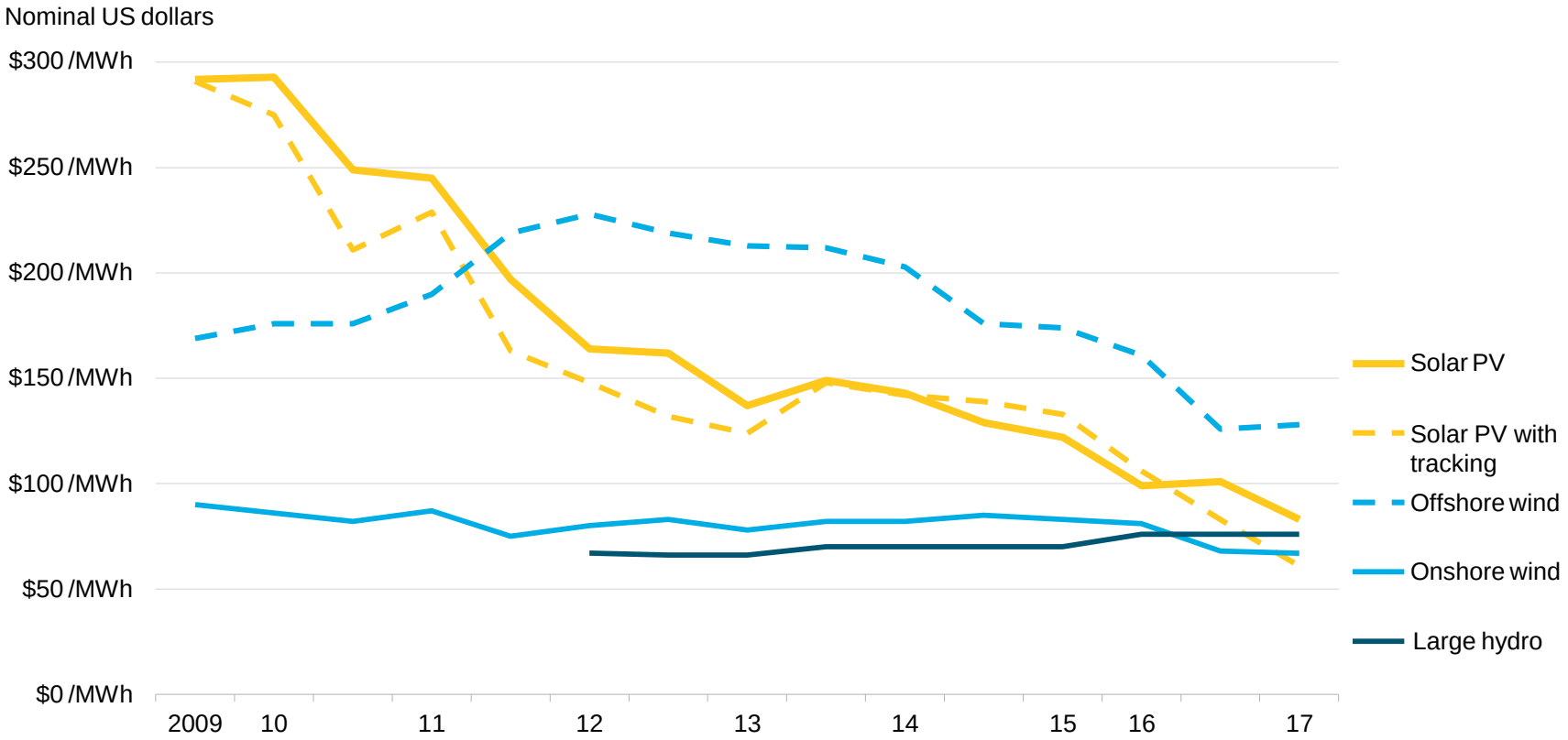
- 28% decrease in price for every doubling of production
- 99% decrease in unit cost
- 160,000x increase in cumulative installations



Source: Bloomberg New Energy Finance, Paul Maycock

The cost of clean electricity has fallen substantially

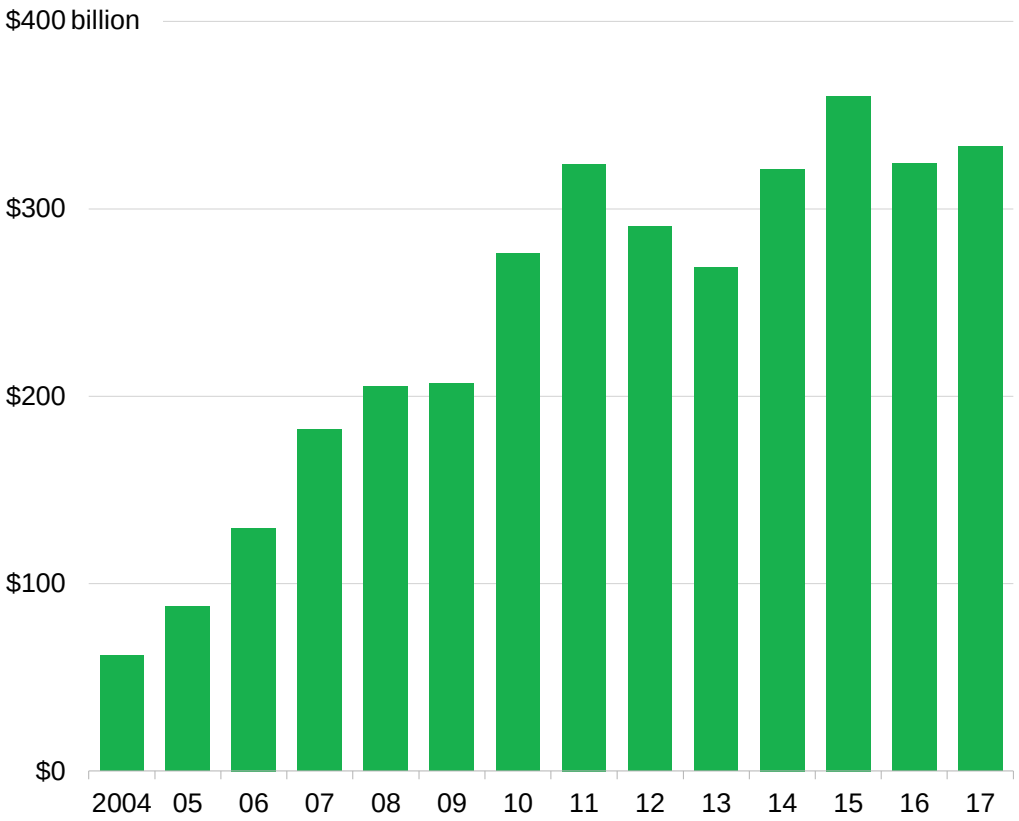
Global benchmarks



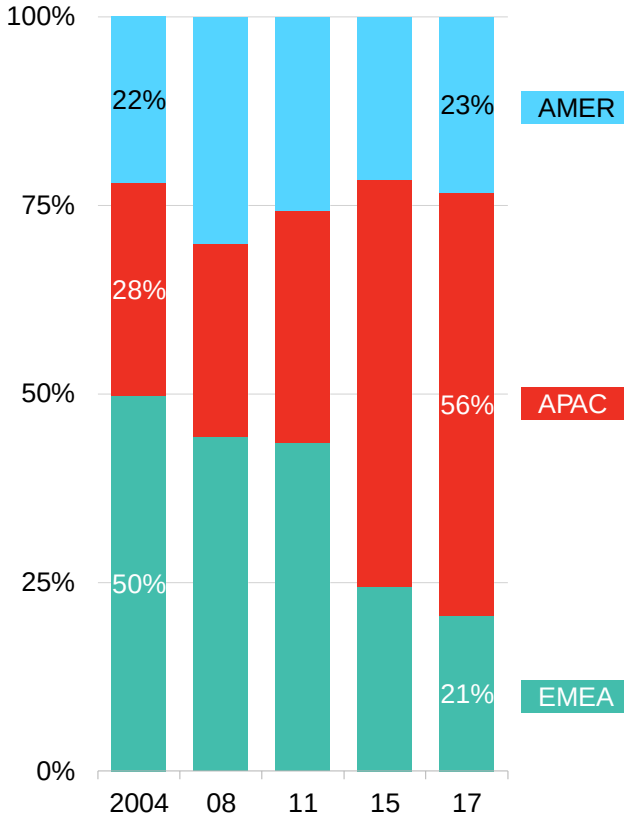
Source: Bloomberg New Energy Finance

Clean energy investment often exceeds $300bn per year

New financial investment in clean energy



By region



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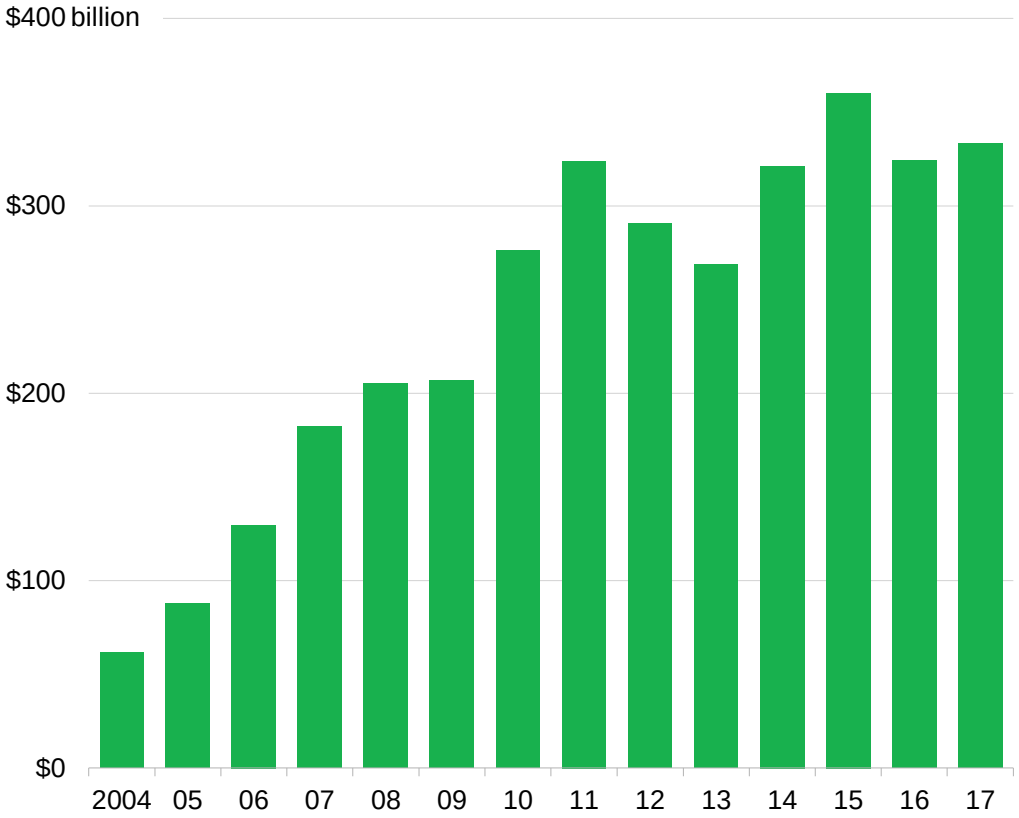
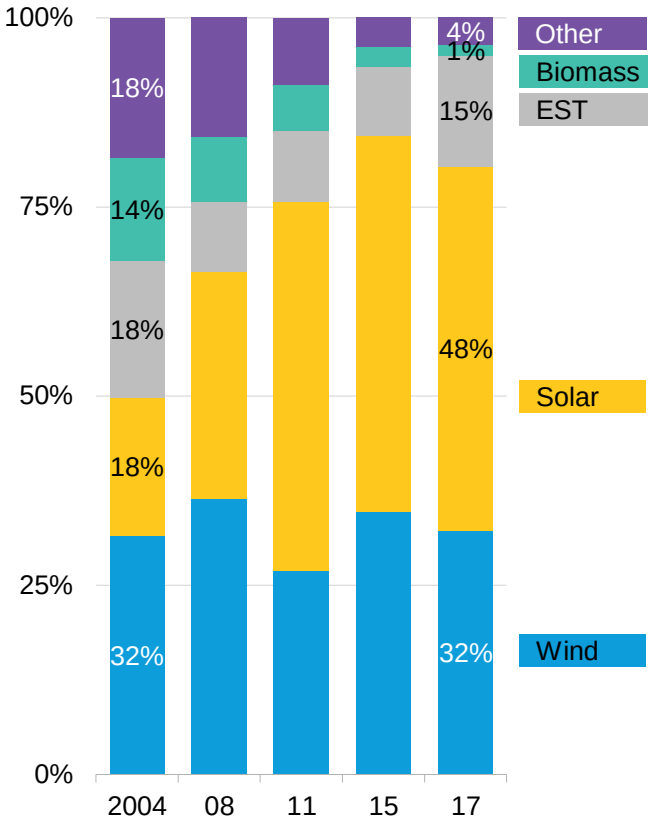


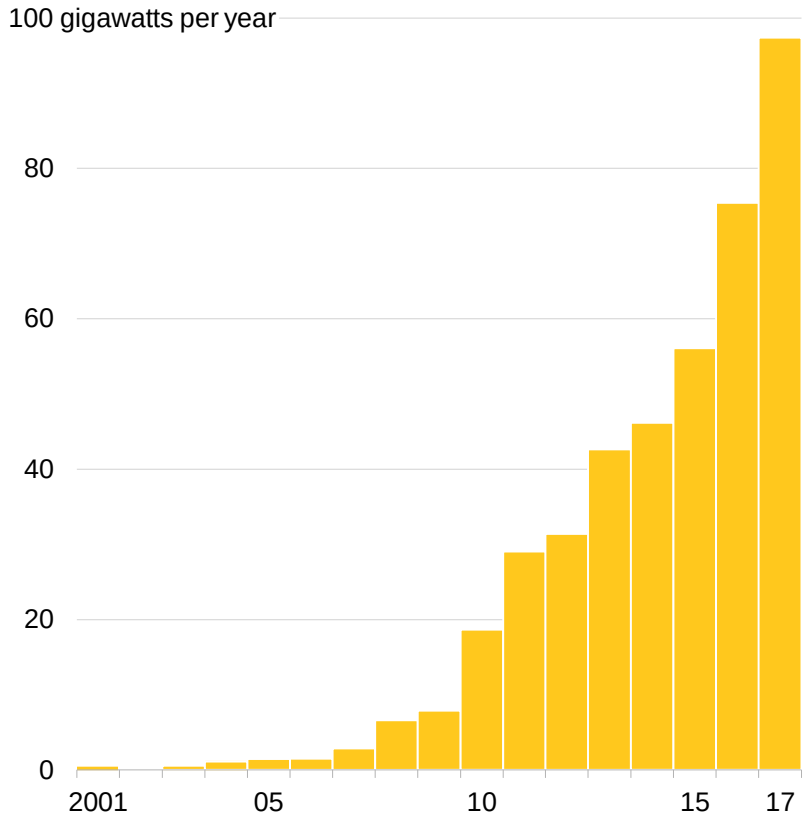
By sector



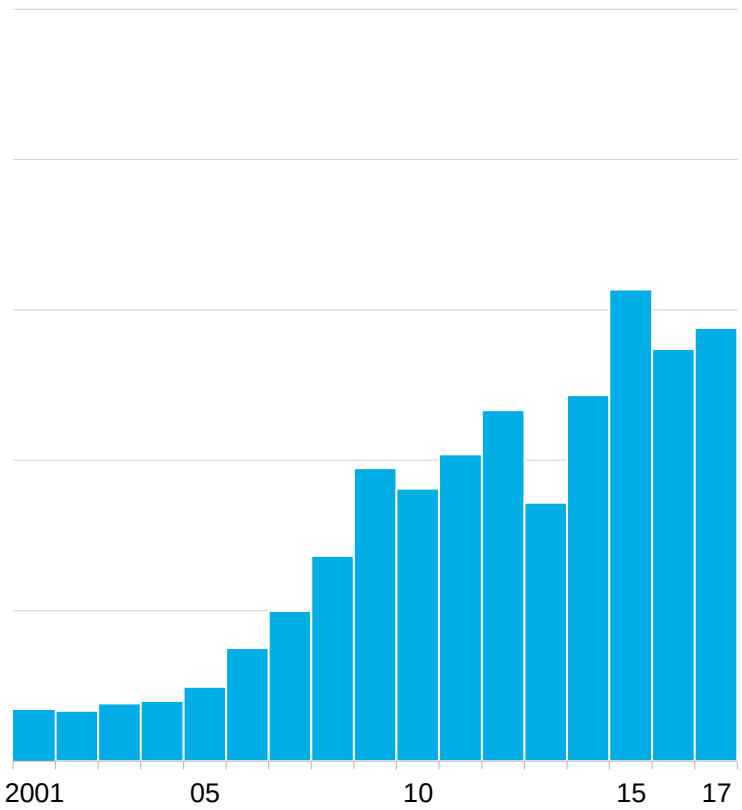
Source: Bloomberg New Energy Finance. Note: “EST” is “Energy Smart Technologies”.

Global wind installations have risen 10-fold since 2000

Annual solar photovoltaic installations



Annual wind installations



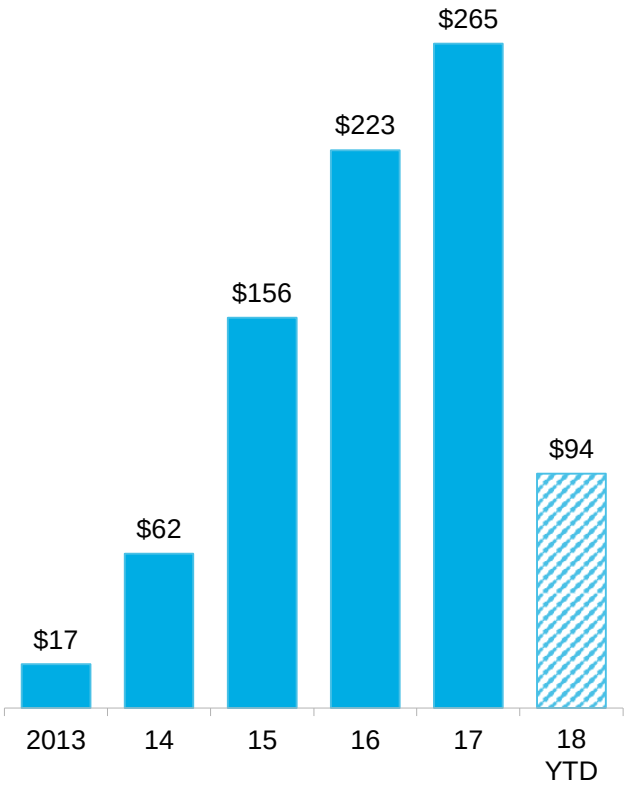
Source: Bloomberg New Energy Finance

Energy Landscape and the BNEF View

Distributed, technology-enabled solar is being deployed rapidly

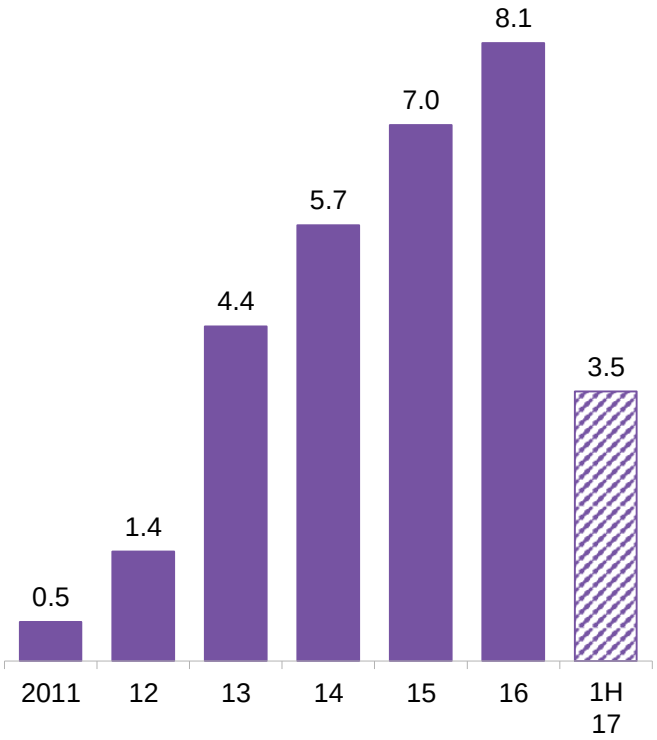
Annual pay-as-you-go solar asset financing

Million $USD



Sales of branded portable solar kits

Million units



Source: Bloomberg New Energy Finance

Energy storage

Ongoing cost reductions are improving economics

- Lithium-ion battery prices fell 73% from 2010 to 2016, showing a learning curve of 19% for every doubling of capacity (~$273/kWh in 2016 expected to fall to $73/kWh by 2030)
- Capital cost of energy storage systems to decline by more than 40% by 2025 mainly driven by decline in cost of batteries

Huge growth potential in battery market

- >USD250bn global storage market by 2030
- EVs represent the bulk of future demand, followed by electric busses, energy storage systems, and consumer electronics
- Uplift in M&A activity with global leaders seen entering the storage segment (Engie, Total, AES, Daimler, etc.)

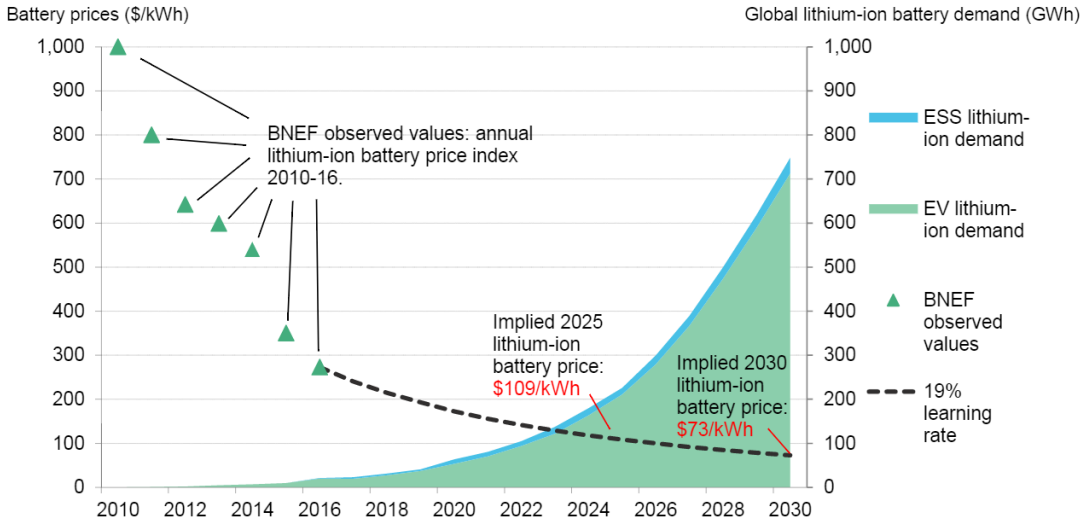
Storage is supporting grid integration of renewables

- Increased renewable penetration requires more balancing/frequency control that storage can provide

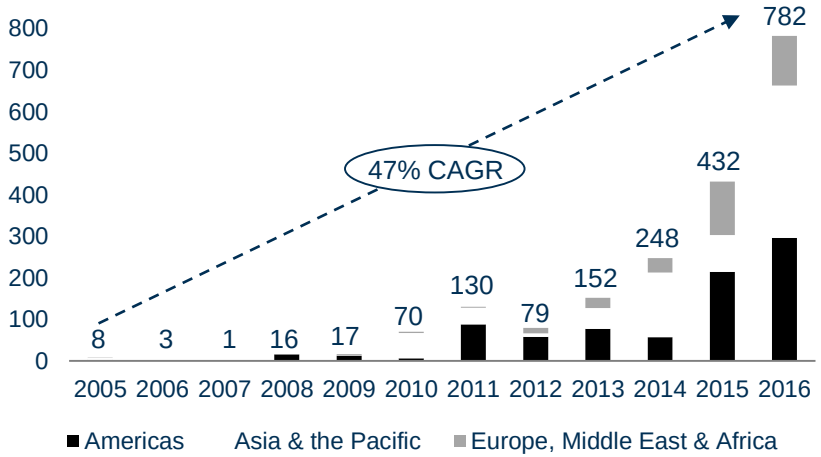
Lithium-ion is the dominant technology today

- Preferred due to high energy density (though low discharge capability)
- But other chemistries, like Aluminum Zinc, Vanadium Flow, Solid State, have promising battery characteristics
- In addition, solar thermal storage is also showing increasing promise

Lithium-ion price and demand, history and forecast



Annually commissioned energy storage by region, 2009-16 (MW)



US, China and India are driving much of the growth

Source: IEA, New Energy Outlook; BNEF Energy Storage Project Database.

Energy storage

The value of storage depends on the application and market, with economic value of various storage applications generally expected to increase in the coming years

Utility and market applications

Energy and ancillary services market
- Frequency regulation
- Renewable energy tech firming
- Wholesale energy arbitrage
- Load following
- Black start
- Voltage regulation

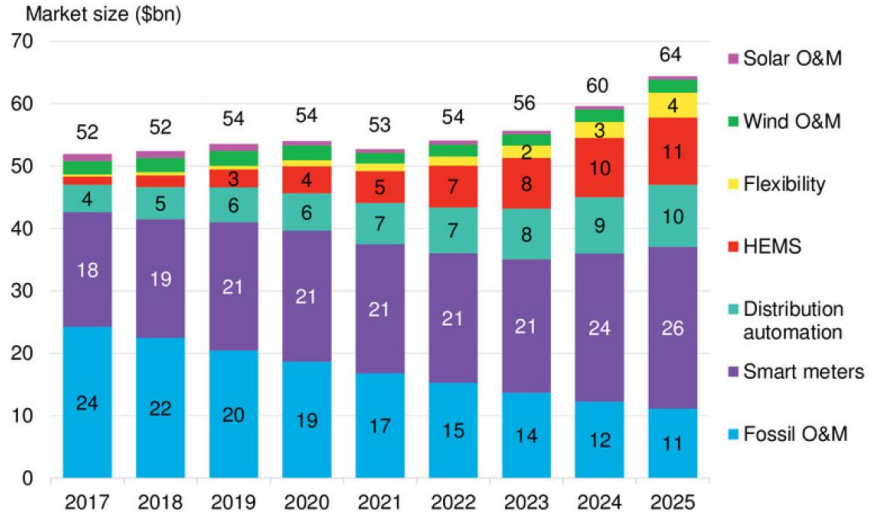
Capacity payments
- Local capacity
- Transmission and distribution investment deferral
- Reserve capacity

Behind the meter and customer applications

Customer rate arbitrage
- C&I consumer arbitrage
- Behind-the-meter solar plus storage

Customer reliability benefits
- Power reliability
- Power quality

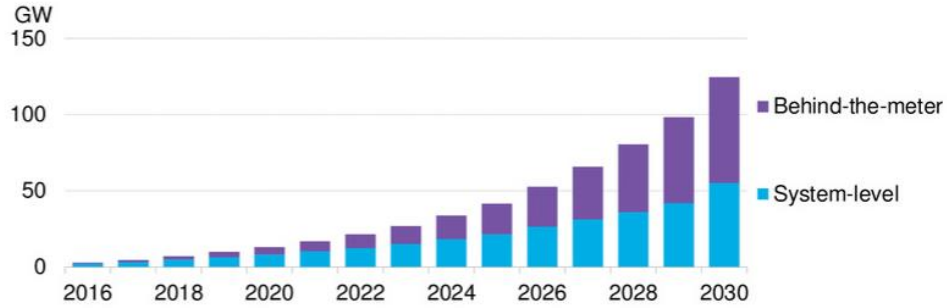
Market size for digital technologies in energy is expected to reach $64bn by 2025



Source: Bloomberg New Energy Finance Note: HEMS is home energy management systems.

Behind-the-meter storage will make up 56% of total by 2030

Market Cumulative storage deployment, GW



Falling Prices for CSP Plants with Molten Salt

The prices for electricity from concentrated solar power (CSP) plants with molten salt energy storage have dropped by more than half since SolarReserve started developing its Crescent Dunes plant in 2009. Some recent bids to build new plants show the price trajectory.

CSP MOLTEN SALT TOWER PROJECTS

PROJECT/LOCATION	DEVELOPER(S)	CAPACITY/ STATUS	POWER PRICE	DATE PRICED
Crescent Dunes *Tonopah, Nevada*	SolarReserve	110 MW *(operating)*	**13.5¢/ kWh**	2009
Noor III *Ouarzazate, Morocco*	ACWA Power, Sener	150 MW *(under construction)*	**15¢/ kWh**	2014
Redstone *Postmasburg, South Africa*	SolarReserve, ACWA Power	100 MW *(preferred bidder)*	**12.4¢/ kWh**	2015
MBR Solar Park Phase 4 *Dubai, UAE*	ACWA Power, Shanghai Electric	100 MW* *(construction to begin 2018)*	**7.3¢/ kWh**	2017
Aurora *Port Augusta, South Australia*	SolarReserve	150 MW *(construction to begin 2018)*	**6¢/ kWh**	2017
Copiapo *Copiapo, Chile*	SolarReserve	260 MW *(pending bid)*	**<5¢/ kWh**	2017

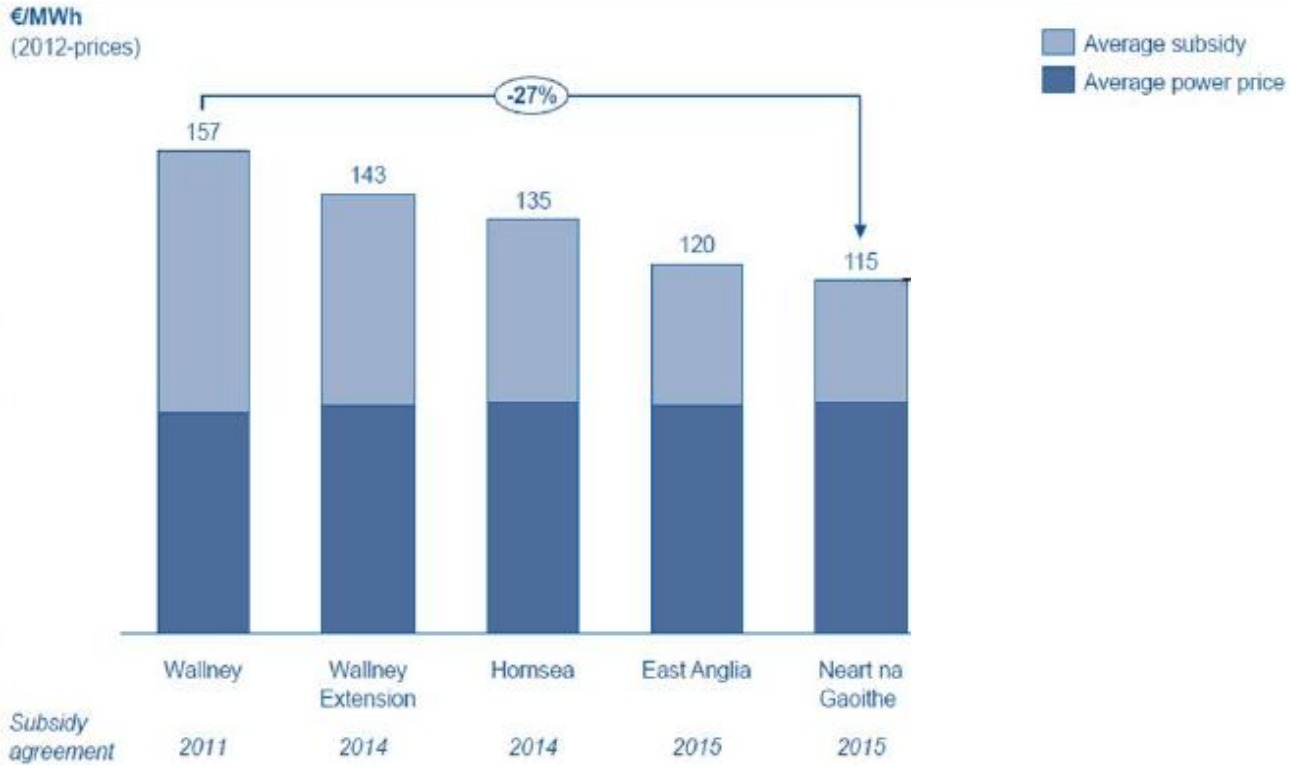
Power price is based on the power purchase agreement (PPA) signed by the developer for power from the project; it may not reflect other sources of project income such as the sale of environmental credits or excess power.
**PPA for this project covers a mix of trough and CSP tower facilities.*

SOURCES: SolarReserve; National Renewable Energy Laboratory

PAUL HORN / InsideClimate News

Drivers of Growth in Offshore Wind

EU Auctions have dramatically reduced prices …



Current prices = $70 - $90 per MWh; future prices < $50 per MWh

By 2022 in UK, offshore wind will be cheapest form of new generation

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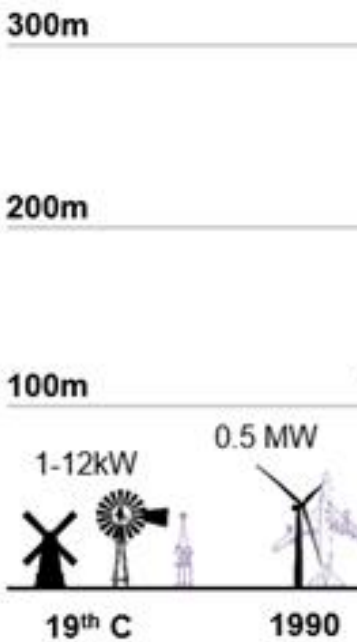
Drivers of Growth in Offshore Wind

Turbines are getting bigger …



Sources: Various; Bloomberg New Energy Finance

For a 8.0 MW Vestas V164 offshore turbine:

- **Total height = 220 meters**
- **Each blade is 80 meters long and weighs 35 tonnes**
- **Nacelle has footprint of 150 m^2 and height of 8 meters**

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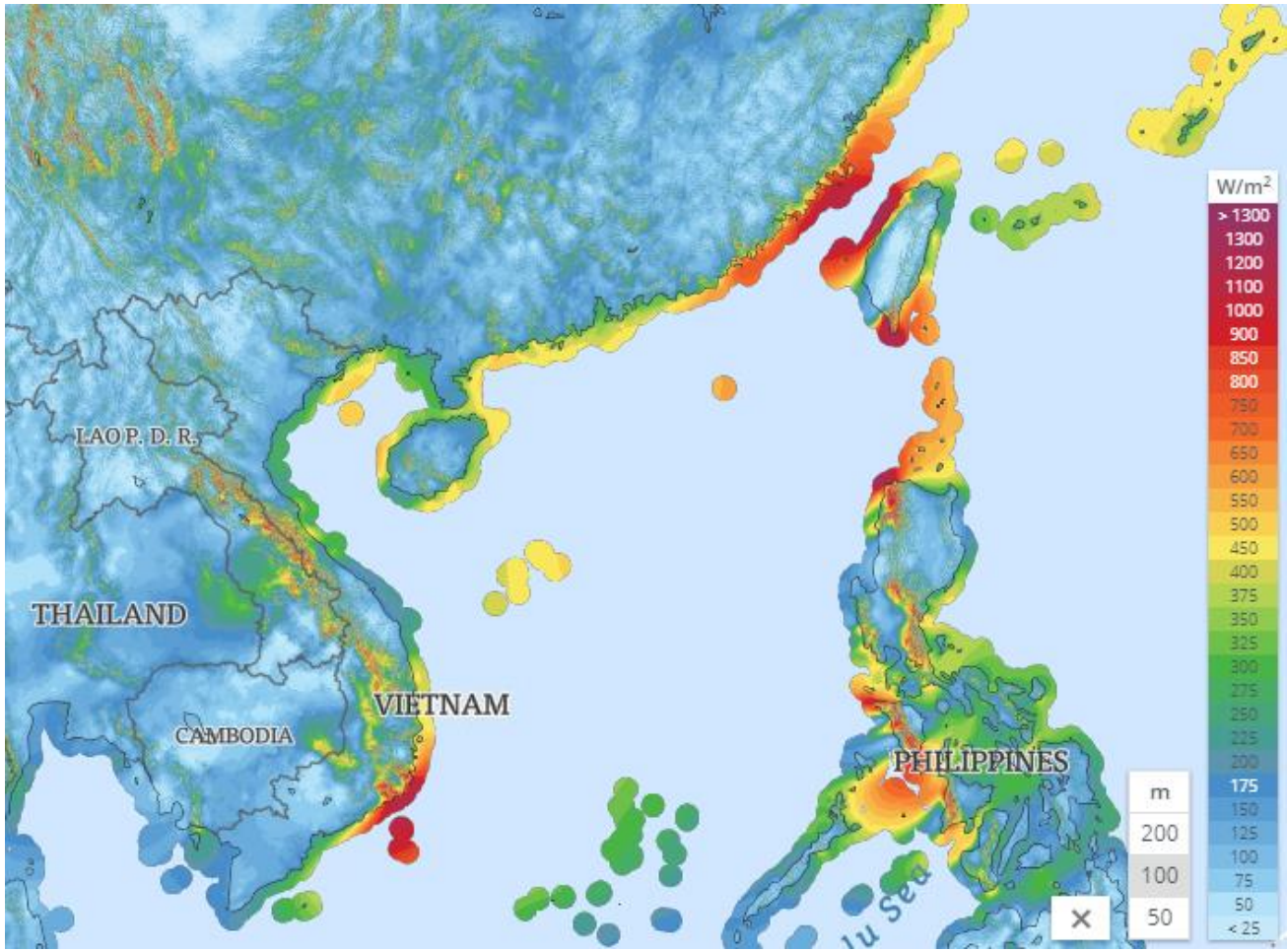
Drivers of Growth in Offshore Wind

Abundant offshore wind resource

- **High winds close to major demand centers**



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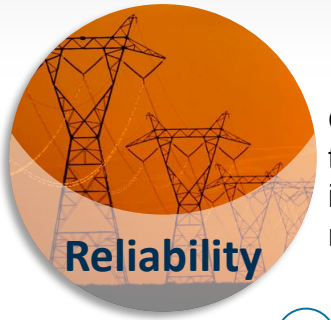
1 Power Critical for Development: Access to power is essential to achieve the Twin Goals of poverty alleviation and shared prosperity

There is a significant need to scale up investment in emerging market power…

1.2 billion individuals currently lack access to electricity



Outages are more than **6x more likely** in emerging markets

Total GHG emissions in LICs and MICs are **2.2x larger** than HICs

…as the power sector is one of the most important drivers of development

Recent gas-fired project in Bangladesh increased employment by **~1 million and increased GDP by 1.7% annually**[1]

Female employment rates increased by 9% after rural households in South Africa gained access to electricity[2]

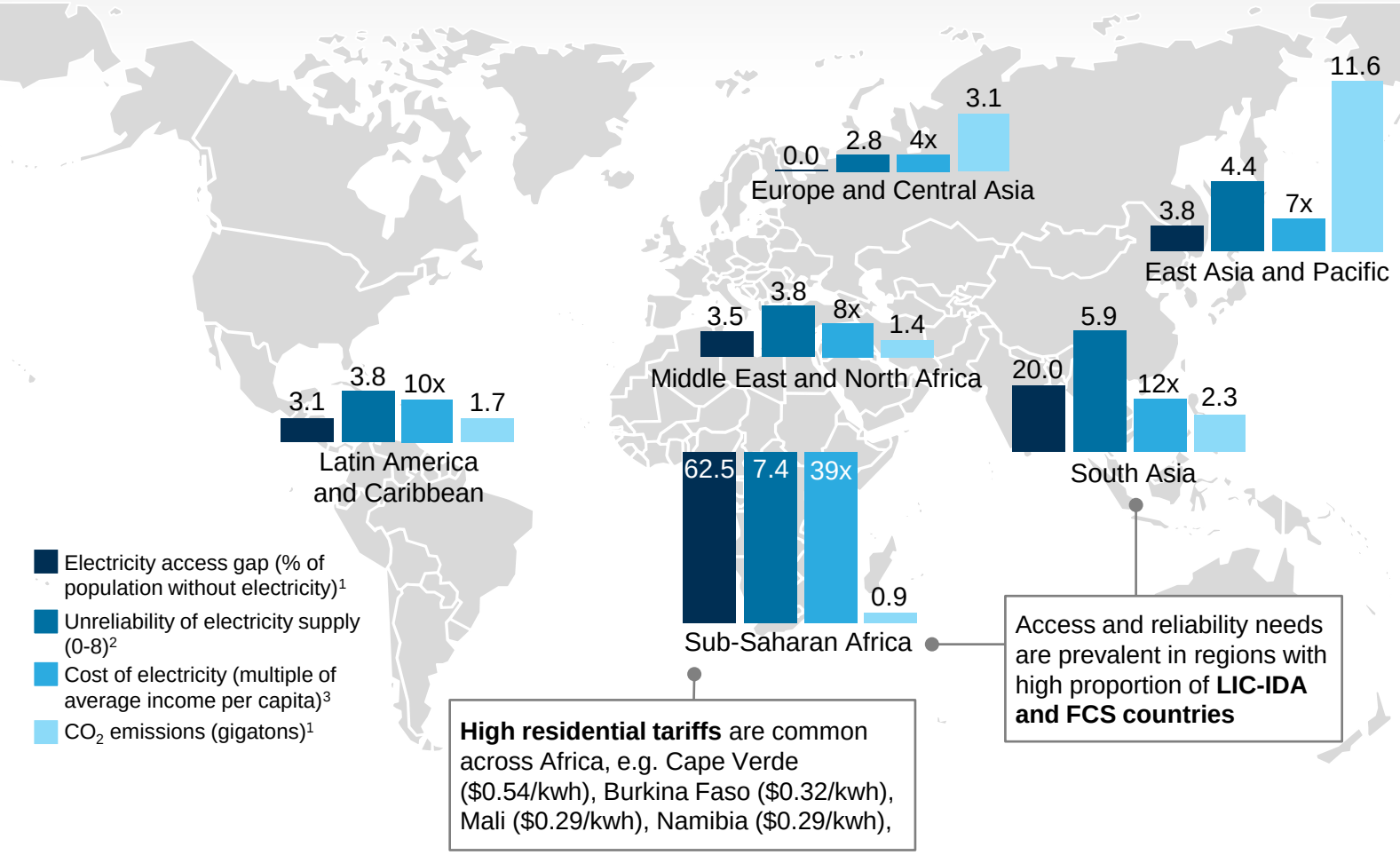
In the Indian state of Assam, complete rural electrification could **raise the literacy rate from 63% to 74%**[3]

Household electrification in El Salvador **reduced the incidence of acute respiratory infections** among children by 34%[3]

1 IFC internal estimates using SAM input/output models 2 Makoto Kanagawa and Toshihiko Nakata, "Assessment of access to electricity and the socioeconomic impacts in rural areas of developing countries," Energy Policy, volume 36, issue 6, June 2008 2 World development report 2012: Gender equality and development, World Bank, September 2011. 3 Manuel Barron and Maximo Torero, "Household electrification and Indoor Air Pollution," OCF Berkeley

1 Power Critical for Development: Power investments are needed to address energy access, reliability and climate change across regions

Development potential in power sector by region



- Of the **1bn+ people** in LICs and MICs **without access to electricity**, ~90% are found in Sub-Saharan Africa (~600mn) and South Asia (~340mn)
- **Electricity supply** is unreliable across developing regions, but **the problem is acute in Sub-Saharan Africa (7.4) and South Asia (5.9)**
- **CO_2 emissions** are most concentrated in regions with relatively better electricity access, such as **Europe & Central Asia**, and **East Asia**

1 World Bank WDI Database – Electricity access rates 2014, CO_2 emissions 2013
2 Doing Business – Getting Electricity Database 2016, Reliability and Transparency of Tariff Index, inverse (0=most reliable, 8= least reliable)
3 Doing Business – Getting Electricity Database 2016, measured as cost of obtaining permanent electricity connection for a newly constructed warehouse as a percentage of average income per capita

1 Power for Development: The power sector is experiencing profound changes, driven by shifts in technology and business models

Shift in generation away from fossil fuels to renewables		▪ Power generation is shifting away from fossil fuels to renewables, as **solar PV and wind have reached price parity with new fossil fuel capacity in more than 30 countries**[1] – Renewables made up more than half of cumulative planned capacity additions by end of 2016
Increasing importance of grid flexibility and resiliency		▪ Grids must be made more flexible and resilient via new investments and technologies to accommodate new renewables and increase efficiency – **Global smart grid market is expected to surpass $60bn in 2020;** although majority is expected to be in OECD, investments in emerging markets are expected to follow
Rapid growth of distributed generation		▪ In regions where the grid is unavailable, unreliable or the cost of connection and power is high, there will be continued growth in distributed generation – **Distributed generation accounted for $46bn of investment in 2015**
Increase in new business model innovations		▪ **Innovative businesses that deliver power as a service directly to consumers are growing** (e.g., Mobisol which provides solar home systems via a PAYGO model) and are increasing their market share of consumer spend on power at the expense of traditional utilities.
Shift in capital flows to key sub-sectors and emerging markets		▪ **Capital flows are shifting to renewables, distributed generation and to select emerging markets, creating more competitive capital markets** – Lower cost capital for power sector investments is increasingly being provided by local and international commercial banks, regional development banks, export credit agencies, and bilateral financing agencies – often via auctions

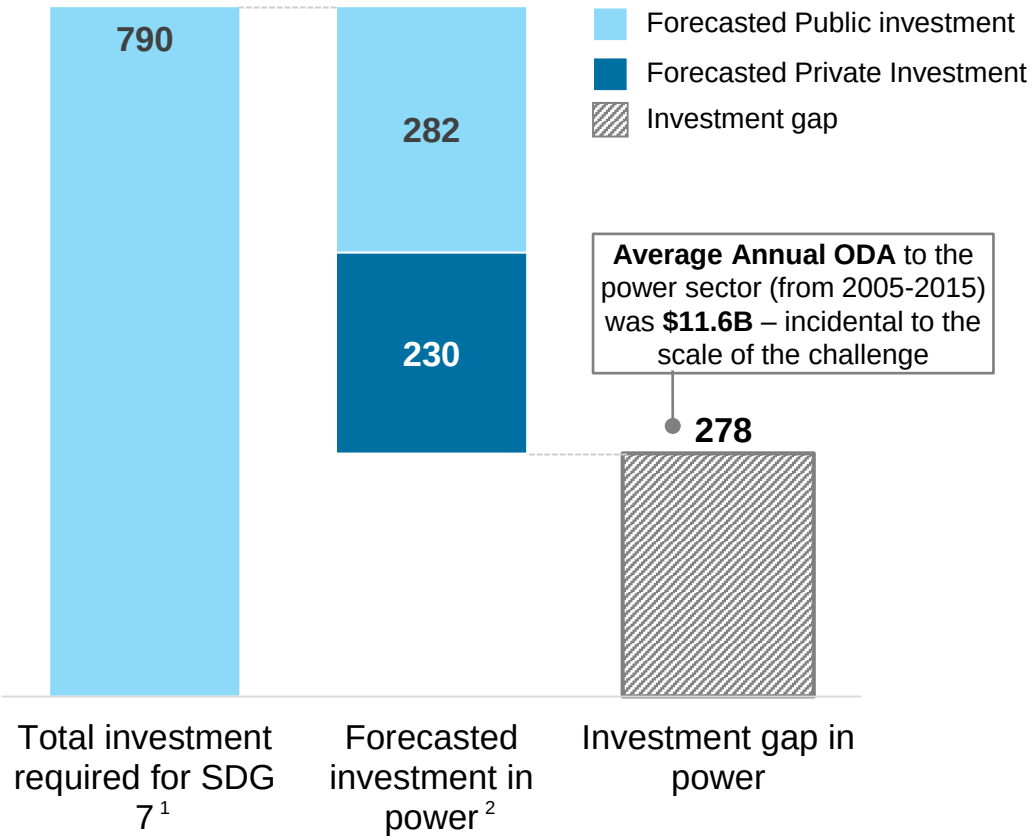
1 As reported by the World Economic Forum in Dec 2016

SOURCE: EIA, GTM research, WEF, World Energy Investment, UNEP's 10th Global Trends in Renewable Energy Investment, Bloomberg New Energy Finance

2 Scaling-Up Power Investment: Rising aspirations are creating even larger investment gaps – these cannot be met by public sources alone

Annual investment required to achieve SDG 7, forecasted investments, and investment gap (2016-30F)

US$ billion p.a.



Constraints to Public Sector Investment

Fiscal

- Limited fiscal space and elevated borrowings constrain scope of public sector investment in major infrastructure projects

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Political

- Scarce public funds compete against other governmental priorities – health, education
- Public subsidies and tariffs to consumers distort energy market

+

Innovative

- The power sector is in a period of transformative technological change
- State-owned utilities are less able to adapt to these changes and are at risk of falling further behind

=

Enhanced Role for Private Sector

1 Total investment required for SDG7 ranges from $630bn/year (low estimate) to $950bn/year (high estimate). Midpoint was taken for this analysis ($790bn).
2 Estimated annual investment in this sector was estimated to be $512bn total for the power sector based on WEO. Based on UNCTAD, 45% of investment in developing countries is expected to come from private sector.

SOURCE: World Energy Outlook, UNCTAD, World Investment Report 2014: Investing in the SDGs: An Action Plan

2 Scaling-Up Power Investment: Private sector also faces challenges in scaling-up investment

Challenges in attracting private investment

Generation

- Lack of **adequate procurement regimes** in emerging markets inhibits direct investment in generation projects
- **Strong public sector** presence for political economy reasons, limiting competition and crowding out private investment
- **Subsidies and below market tariffs** inhibit cost recovery and necessary upkeep
- Financially **weak utilities** and lack of alternate buyers

Transmission & Distribution

- **Poor performance of T&D sub-sector** undermines the soundness of the entire power sector
- Sub-sector **traditionally operated by SOEs** across emerging markets
  - SOEs with **weak governance and corporate structures** as well as low operational efficiency dissuade private investment
- **Rural and remote customers** in areas with high-need complicate T&D economics and limit scale and scope of progress

Disruptive Technology

- Governments are unable to keep up with the **rapid pace of technology-driven change** within the power sector and hence are behind in creating business enabling environment to capitalize on new technology

3 World Bank Group can optimize public sector policies and investments and catalyze private sector solutions

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Power sector planning, investment and reform	Procurement advisory	De-risking via long-term insurance
Electrification plan	Project preparation and financing	Credit enhancement
Institutional development	Investment and mobilization of private capital	Damage prevention
Tariff and subsidy reform	Corporatization of public utilities	

4 IFC is at the forefront of market creation in the power sector

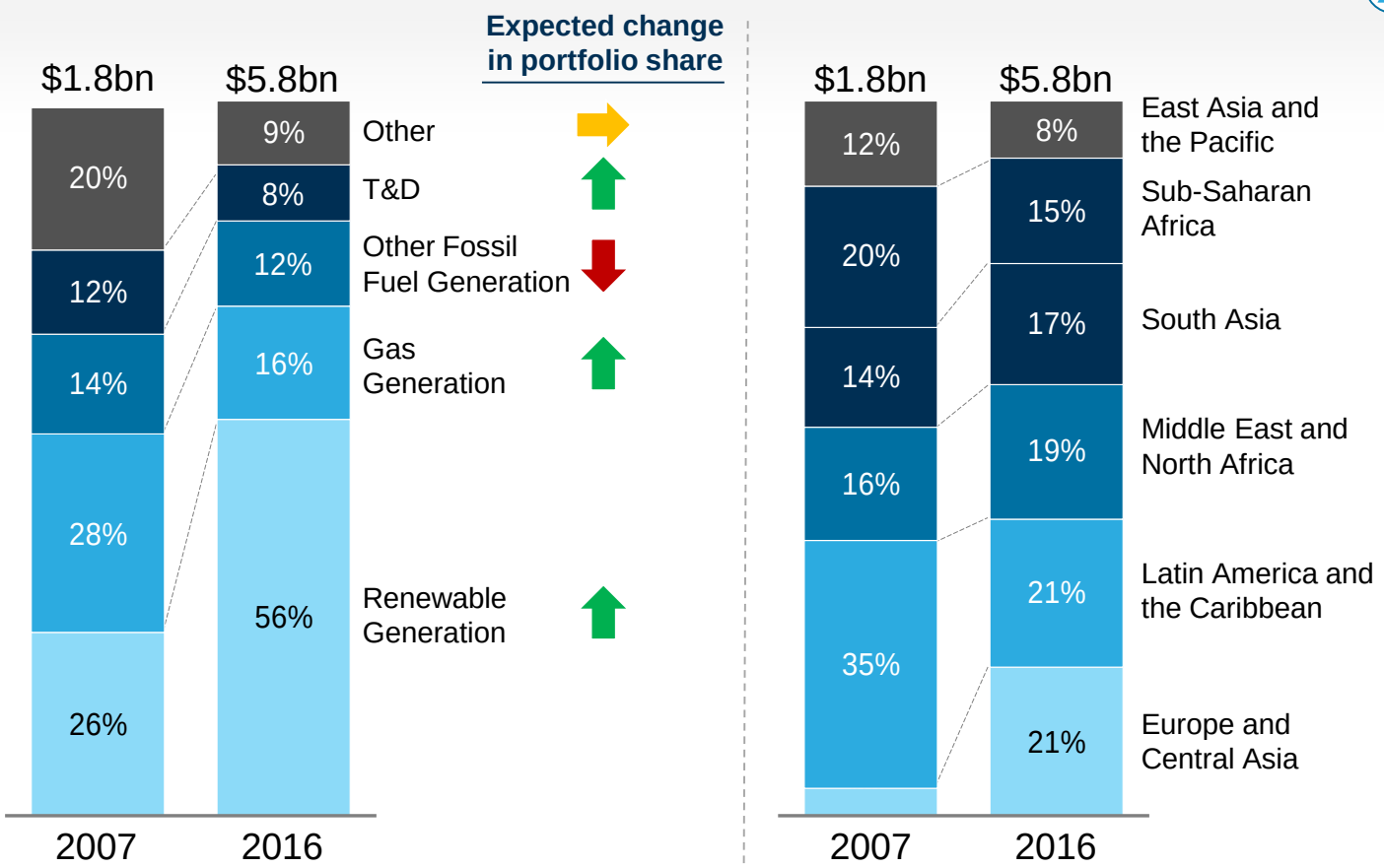
Procurement advisory	▪ **Scaling Solar in Zambia** aligns a "one-stop-shop" aimed at creating bankable utility-scale solar power projects ▪ **Established a bankable PPA** regime and energy auction process in Argentina
Solar PV aggregation	▪ **Jordan's Seven Sisters** project aggregates 7 small solar power projects into a single, standardized financing structure
Energy storage	▪ **Building up capabilities** in new market segment through venture capital investments
InfraVentures	▪ **Provides project development support** and financing to 24 projects, mainly wind and hydro
Transmission & Distribution	▪ Multiple investments in private distribution; supported **distribution privatization;** project financed **private transmission** ▪ **Enables renewables penetration and access**

Key enablers

- Continued **close coordination with World Bank, government and other actors** is necessary in upstream interventions
- **Market creation requires sustained efforts** over extended periods of time with uncertain outcomes

4 IFC has reoriented its strategy towards renewables

IFC Power sector portfolio shares by subsector and region (FY07 to FY16), % portfolio share



Power is the largest real sector component of IFC's portfolio, averaging $2.2bn in Commitments + Mobilization from FY12-FY16

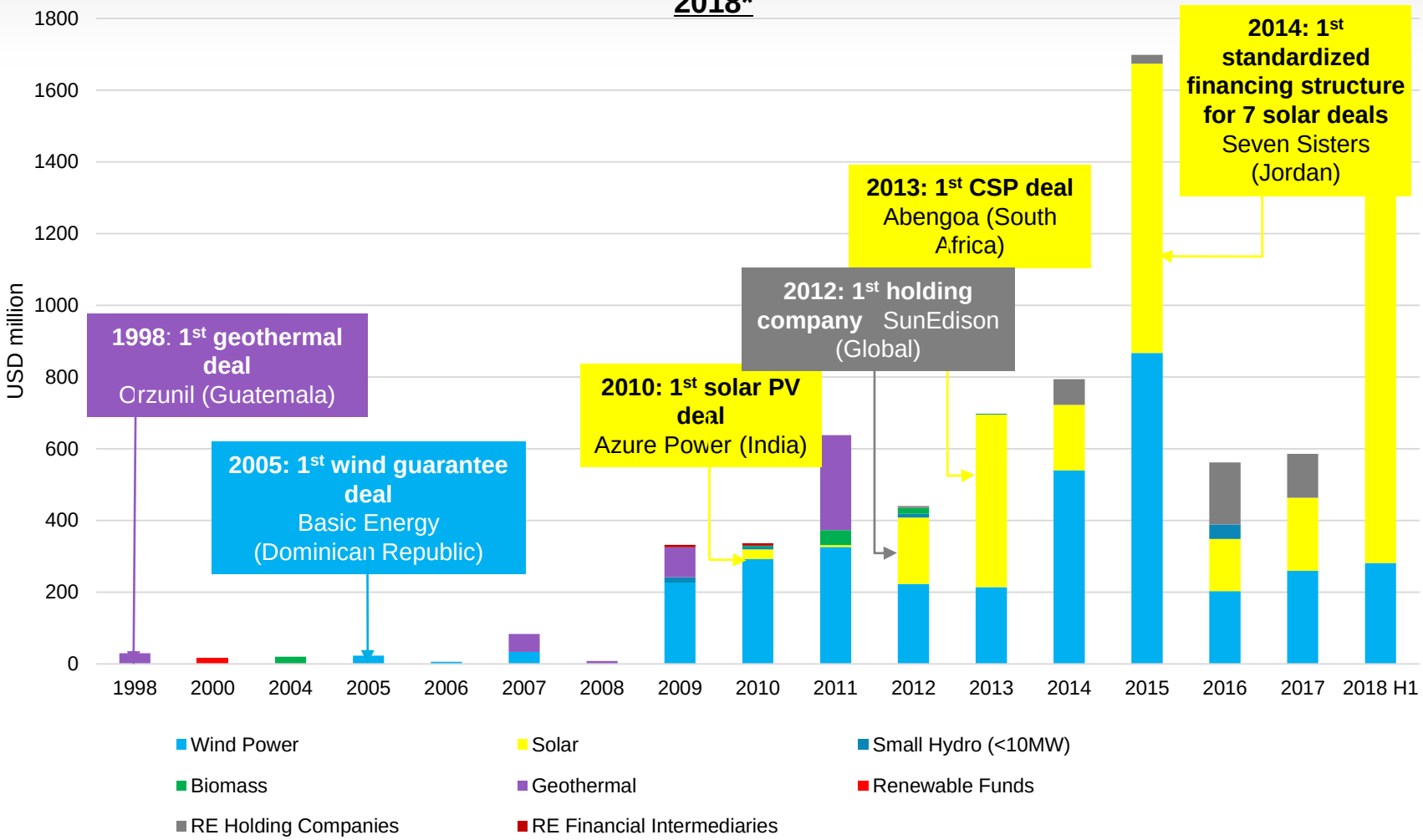
Lessons learned

- Integration of renewables into energy systems carries a number of technical risks, notably oversupply, curtailment and interconnection delay
- Resource risk is significant in geothermal and biomass projects
- Technical risks in hydropower remain very material
- Changing economics in the power sector can pose significant stress on sponsors
- Policy support underpinning renewables investments may not always be stable
- Policy risk remains high in a number of IDA countries, notably with respect to tariff adjustments
- E&S issues are emerging in wind projects

3 IFC's experience in Renewables

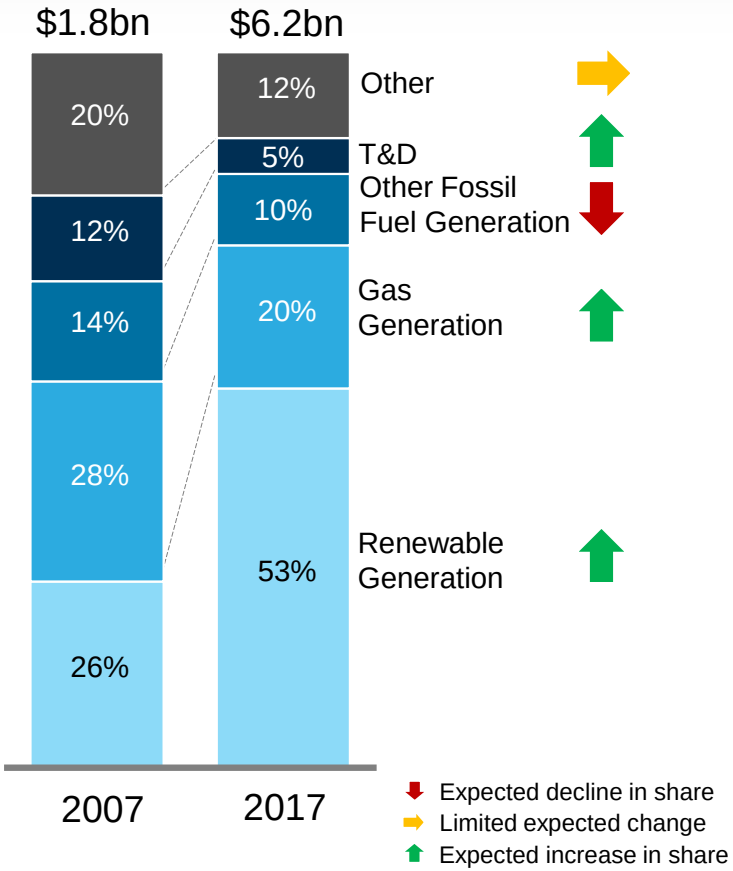
Excluding large hydro, IFC has invested $ 7.7bn (original commitments, 49% IFC own account + 51% mobilization) in renewable energy since IFC's first non-hydro renewables deal in 1998.

IFC's original commitments (OA + Mob.) in Renewable Energy (excluding Large Hydro), FY 1998-2018*



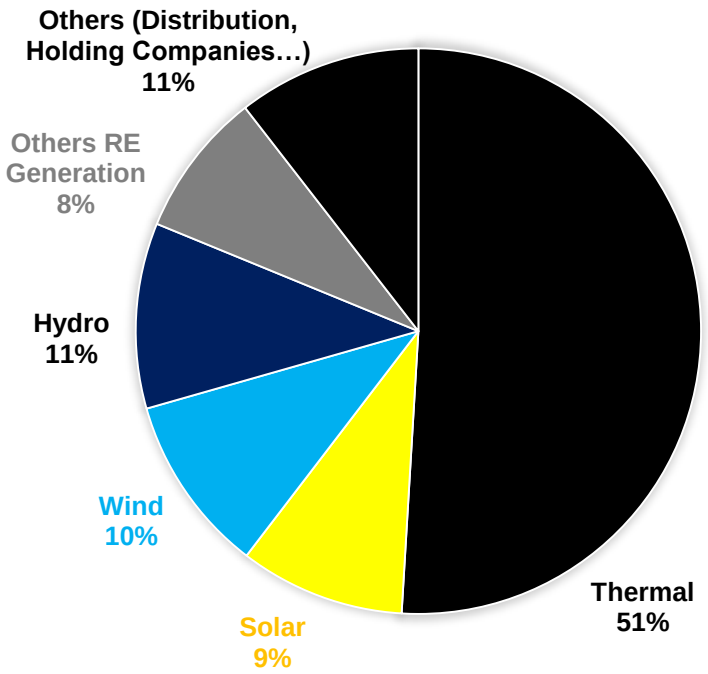
3 IFC's experience in Renewables

Power Portfolio by sector



The share of renewables in IFC Power Portfolio has **doubled** between FY07-FY17

FY2017 Power Commitment Activity by Sector (incl. mobilization)



From the **$2.5bn commitments** for FY17, **Renewables represent 38%**

3 IFC has a strong record as a pioneer in creating and supporting renewable energy investment opportunities

Europe & MENA

- First **competitively tendered solar** (2016) and **innovative structuring** to process seven solar projects (2015) in Jordan
- First **private distribution** (2013), **international wind IPP** (2012), and **private hydro** (2009) in Pakistan

Asia

- First **grid tied solar PV** investment (2009), and first **merchant hydro** in India (2005)
- First **international commercial bank project financing** for wind generation (2010) in China

Latin America and Caribbean

- First **utility-scale solar** and **wind farm** project financing in Mexico
- First **merchant/quasi-merchant hydros** (2005, 2007, 2007) in Chile
- **Largest wind farm** in Panama (2015)

Sub-Saharan Africa

- First **utility-scale solar** CSP projects in the region, South Africa (2013)
- First **large private hydro in Africa**, Uganda (2007)

IFC has financed ~40 GW of generation capacity, including >2 GW of solar PV, >4 GW of wind and 8 GW of hydropower

4 Selected Recent IFC Investment Experience in DG

C&I DG Solar

Solar IPP w/ DG
India
$28.5M (VC/Power)
2010

PV Hybrid Solutions for Telecom Towers
India
$22M (VC)
2010

C&I Solar DG Developer
The Pacific
$2M (Power)
2014

New Solar Hybrid Capex Upgrade for Helio Towers
DRC
$56.5M (TMT)
2017

C&I Solar Aggregator Platform
India
$15M (Power/VC)
2018

Minigrids / Offgrid Solar

PAYGO Solar
E. Africa
$7M (VC)
2013

Energy Access Debt Fund
E. Africa
$17M (MAS/FIG)
2013

PAYGO Solar
E. Africa
$5M (VC)
2017

PV-hybrid minigrids/ telecom towers
Myanmar
$6m (InfraV)
2017

Lithium-Titanate Batteries
China
$37.5M (VC)
2011

Zinc-Air Batteries
US
$7.5M (VC)
2014

+ Storage
New Global Power Initiative
2018

Smart Grid Tech
India
$1.35M (VC)
2012

Energy Optimization IOT
India
$1M (VC)
2013

IoT Middleware
US
$7.5M (VC)
2014

LPWA Network for IoT
France
$5.6M (VC)
2017

LIGHTING GLOBAL
Catalyzing markets for modern off-grid energy

AN INNOVATION OF
WORLD BANK GROUP
THE WORLD BANK IBRD • IDA
IFC International Finance Corporation

GLOBAL OFF-GRID SOLAR MARKET: PROGRAM RESULTS AS OF June 2017

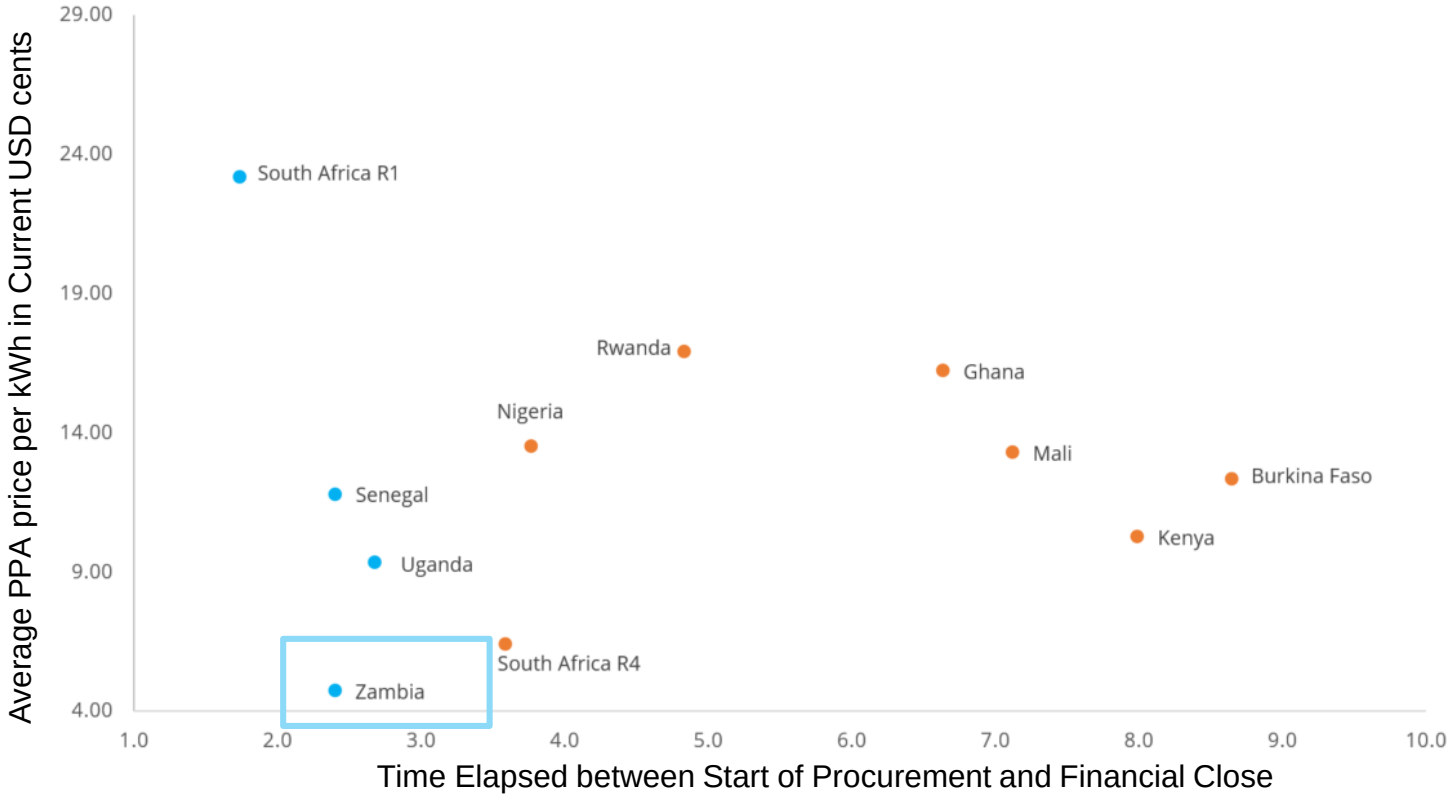
Overall Impact	
>131[1] million	People have benefited from using Lighting Global quality verified solar lighting products
>39.5[2] million	People currently have their basic lighting needs met by Lighting Global quality verified solar lighting products
>8.5[3] million	People in the last 6 months have had their basic lighting needs met by Lighting Global quality verified solar lighting products
>26 million	Lighting Global quality verified solar lighting products have been sold since 2008
>1.75 million	Tons of GHGs avoided annually; CO_2–equivalent of taking 175,000 cars off the road for one year, as a result of replacing kerosene use with Lighting Global quality verified solar lighting products
>75	Countries in Africa, Asia, Latin America, Middle East and North Africa, the Caribbean, and the Pacific are where you can find quality verified products for sale
Quality Standards	
121	Quality verified Pico-PV products and SHS kits currently meet the Lighting Global Quality Standards
57	Manufacturers have products that currently meet the Lighting Global Quality Standards

What is Scaling Solar?

Scaling Solar is a "one stop shop" program for governments to rapidly mobilize privately funded grid connected solar projects at competitive tariffs. The program brings together a suite of World Bank Group services under a single engagement based on a standardized approach to create viable markets for solar power in each client country.

Scaling Solar vs. Regional Benchmarks

Sub-Saharan Solar PV: Comparison of Tariff and Time to Market



● Projects past financial close ● Ongoing projects as of January 1, 2018

Scaling Solar Mandates

Bringing global solar trends to SSA (lower tariffs driven by competition)

"Proof of concept"

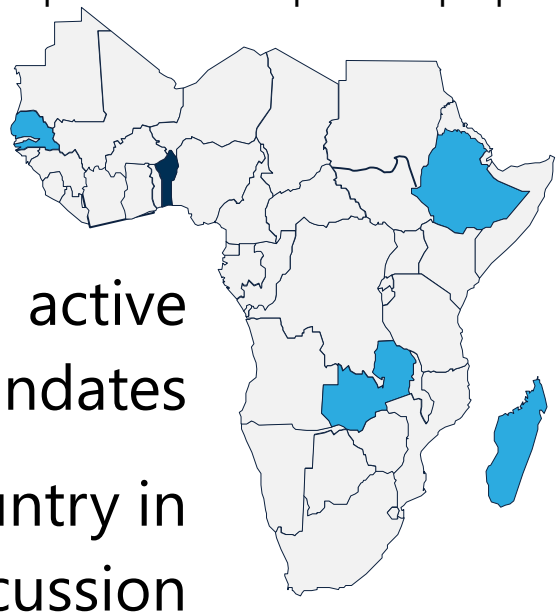
Zambia
Round 1
Project size: 2 projects for a total of 75.7 MWac
Bids: 48 applicants at qualification, 11 prequalified
Tariff: **Record-low tariff of 6ct/kWh** achieved
Status: **First project under construction**

Senegal
Project size: 100 MWac under procurement
Bids: 28 applicants at qualification, 12 prequalified
Status: Request for Proposals ongoing

Ethiopia
Project size: Round 1 of 250MWac under procurement
Status: In Pre-Qualification stage

Madagascar
Project size: 25 MWac under procurement
In Pre-qualification stage

Round 2
Project size: 300 MW under procurement
Bids: 21 applicants at qualification, 12 prequalified
Status: In preparation for request for proposal



5 active mandates

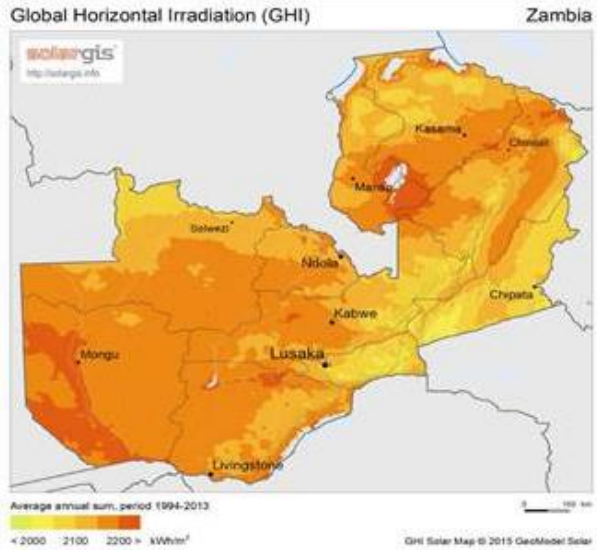
1 country in active discussion

First "Scaling Solar" Program Projects

ZAMBIA

- Projects were developed and tender was prepared and executed to conclusion in 9 months; round 2 for 200MW already announced
- USD 6 cents/kWh non-indexed is equivalent to average in current dollars over contract lifetime of USD 4.7 cents/kWh

	West Lunga Site	Mosi-oa Tunya Site
Neoen/First Solar (47.5 MW)	**USD cents 6.0150/kWh**	
ENEL Green Power (28.2 MW)		**USD cents 7.8390/kWh**



- All bidders who submitted an offer requested the IDA payment guarantee; no IDA loan guarantee was needed
- Both of the winning bidders used IFC as lead financial arranger/senior loan financing; Sponsors also utilized concessional finance loans from IFC-Canada Climate Change Program and IDA partial risk guarantee

Thank You!

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scalingsolar@ifc.org

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