
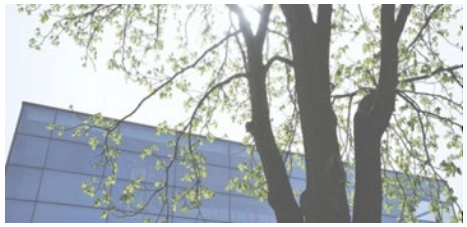

Institute for Advanced Sustainability Studies
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The water intensity of different power generation technologies and the global status of wind and solar PV

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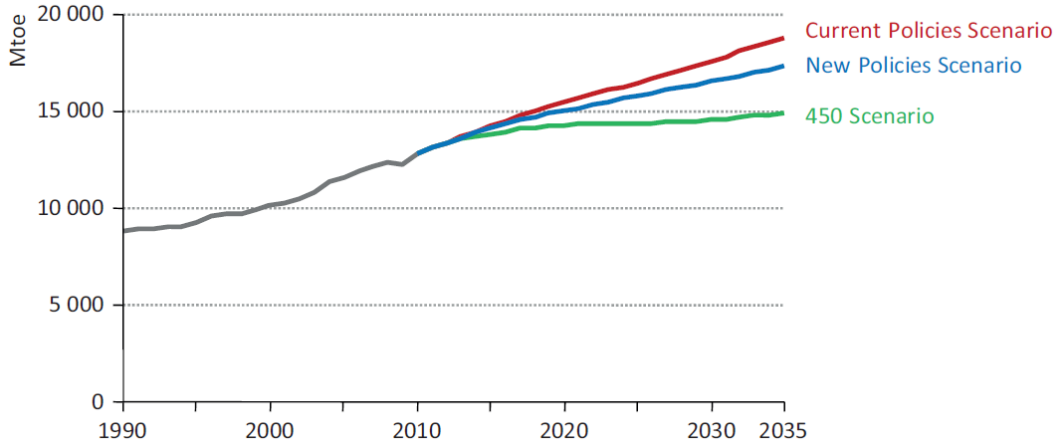
Transdisciplinary Panel on Energy Change

Outline

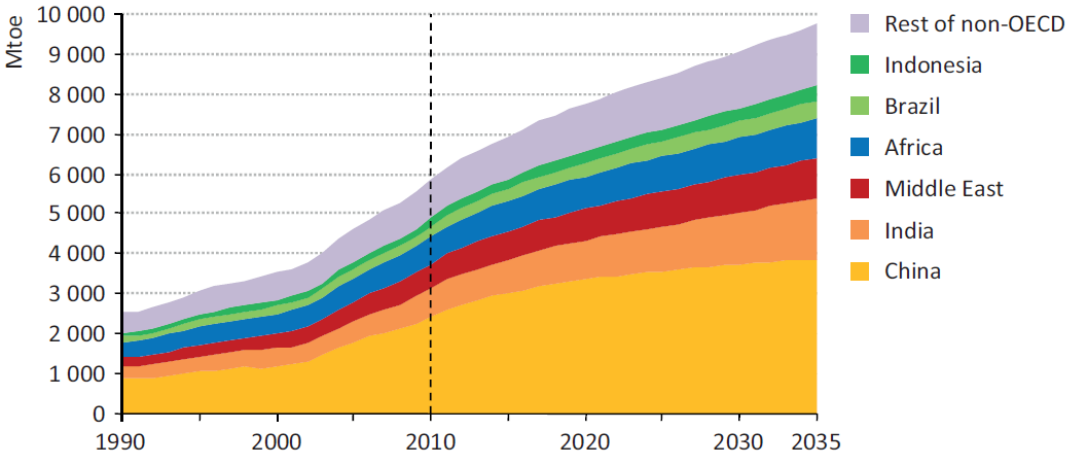
- Why we talk about power generation in the context Water-Energy-Nexus
- The water intensity of different power generation technologies
- Potentials of wind and solar PV
- The global status of wind and solar PV

Motivation
Water Demand for Energy Supply

- Energy supply: **15 %** of total **global** water **withdrawals** in 2010 (IEA, WEO, 2012)
- **11 %** of withdrawn water was **consumed** (IEA, WEO, 2012)



- A **strong increase** in global energy demand is very likely
- Growth rates are highest in **developing and emerging countries**

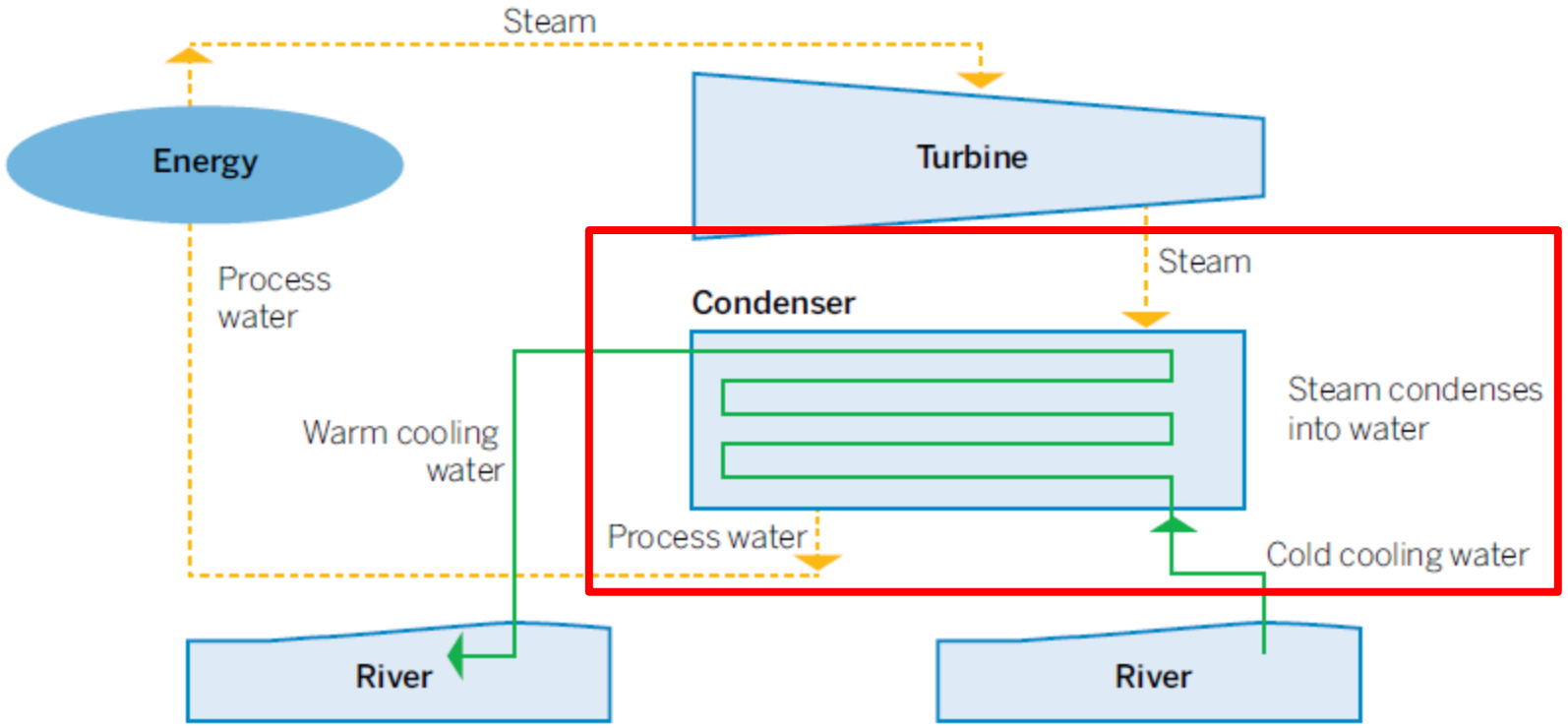


Source: IEA, WEO, 2012.

Motivation
Power Generation and the Nexus

- Power generation is the energy sector's most intensive user of water (IEA, WEO, 2012).
- Power generation is highly water-dependent: thermal power plants and hydro-power dominate globally.
- Electricity's share in total energy consumption will likely increase with global economic development (IEA, WEO, 2012).
- Energy system transformations come along with increased electrification (e.g. electric mobility, electric heating/cooling)

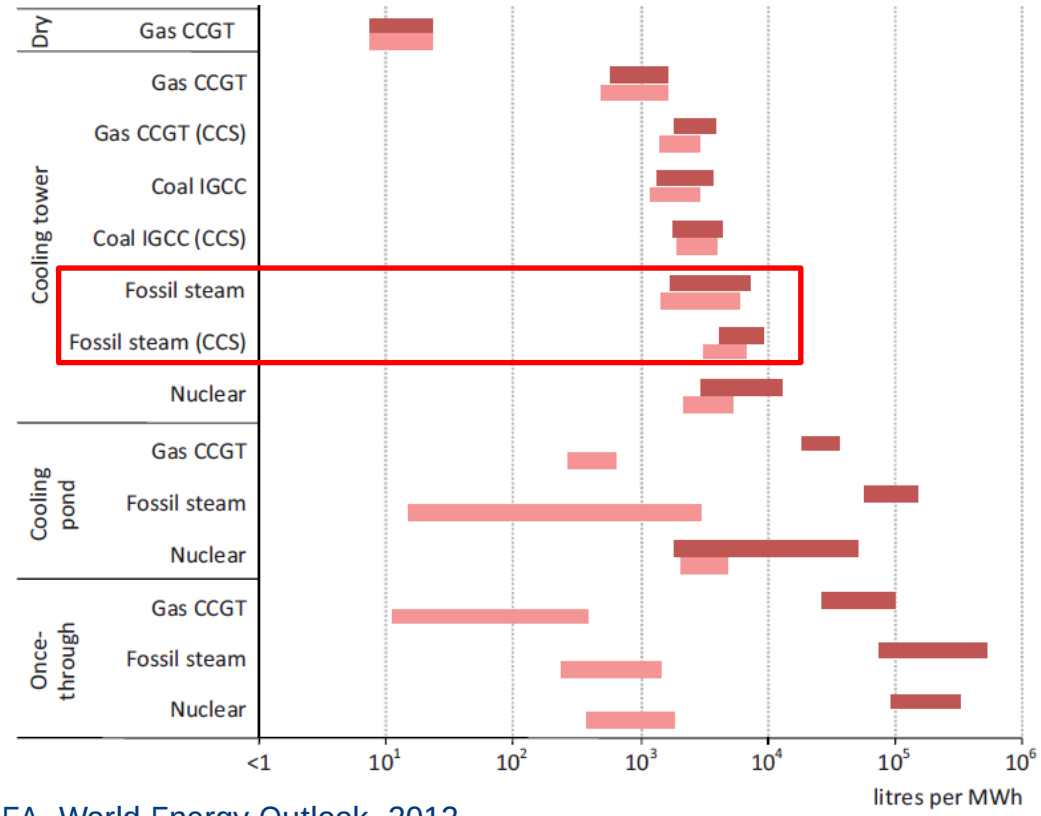
The dominant reason for water demand in power generation



Source: FAO, 2011.

- Water demand for condensation of working medium through cooling

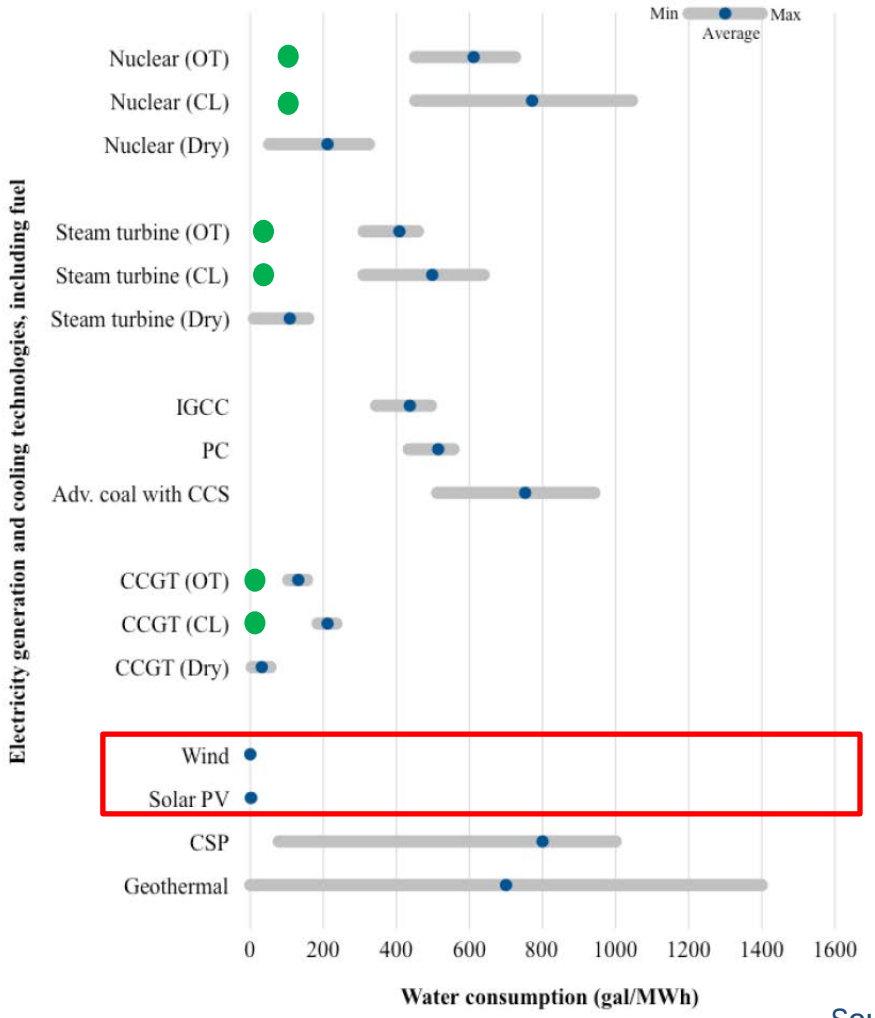
Water demand in thermal power generation for different cooling technologies



IEA, World Energy Outlook, 2012

- Once-through cooling means higher withdrawal but less consumption compared to closed-loop cooling
- Dry cooling and hybrid cooling are technological options to decrease water demand, but result in lower efficiency and higher costs
- Deployment of CCS means higher water demand

Water consumption including fuel production

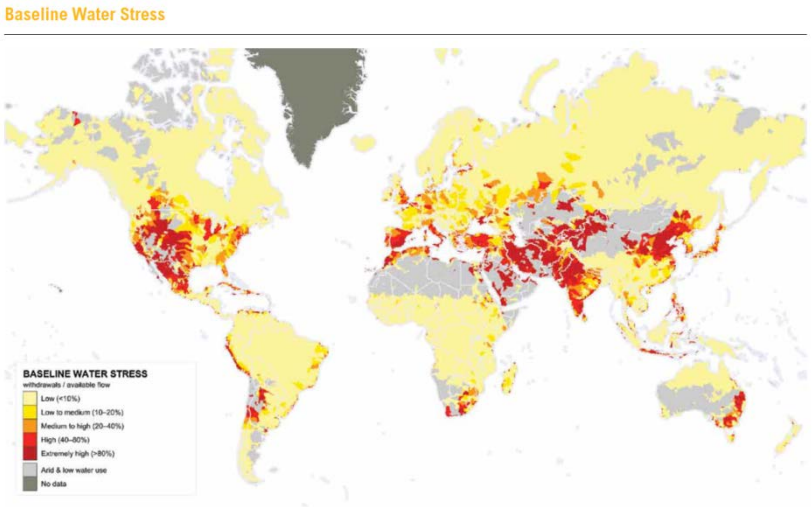


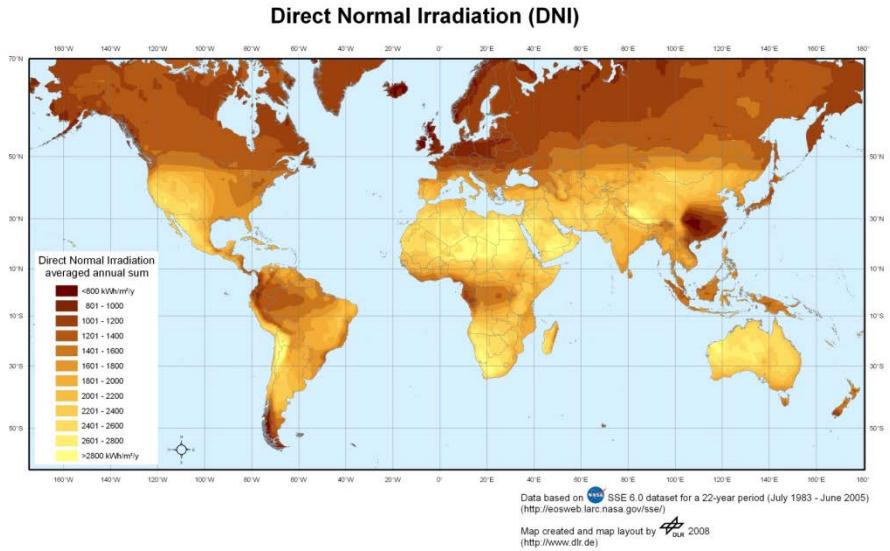
- Water consumption of nuclear power plants is highest, than coal, than natural gas
- Operational consumption by far exceeds consumption in fuel production
- Wind and solar PV consume close to no water

● Fuel production

Source: Mielke et al., 2010

Solar energy resource potential





- Many regions with high baseline water stress have considerable solar energy resource potentials

Economic potential
Rapid cost reduction of solar PV modules

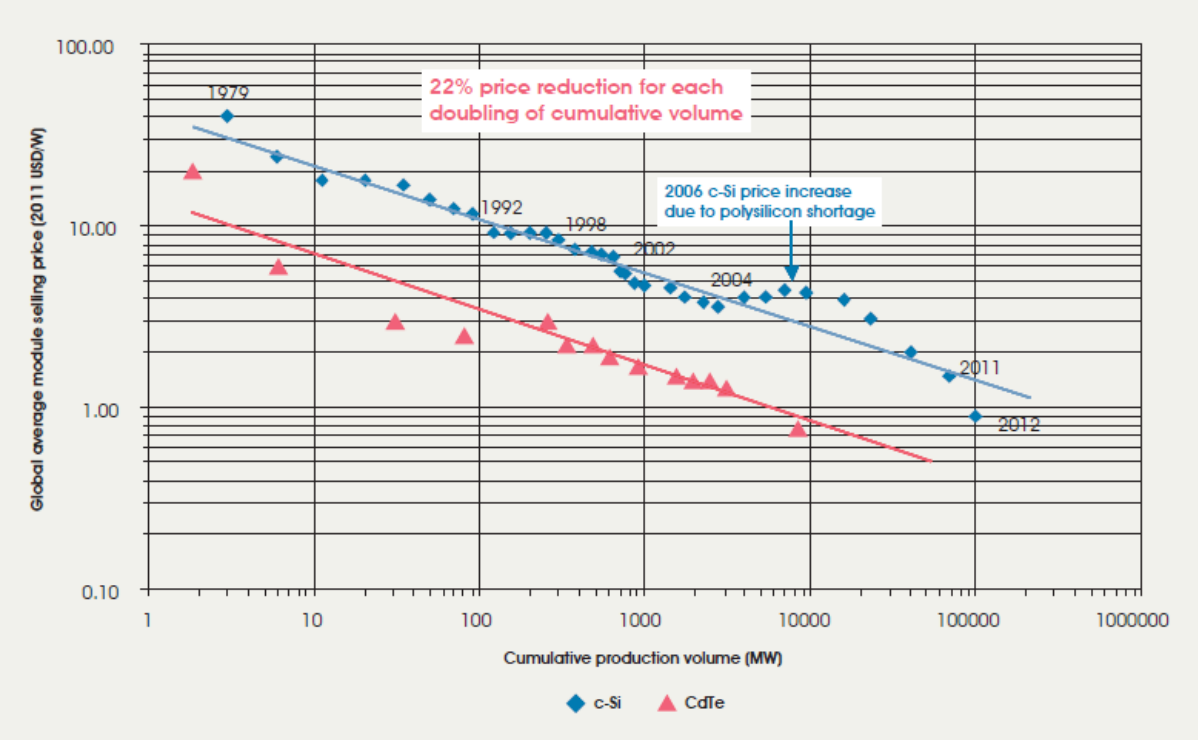


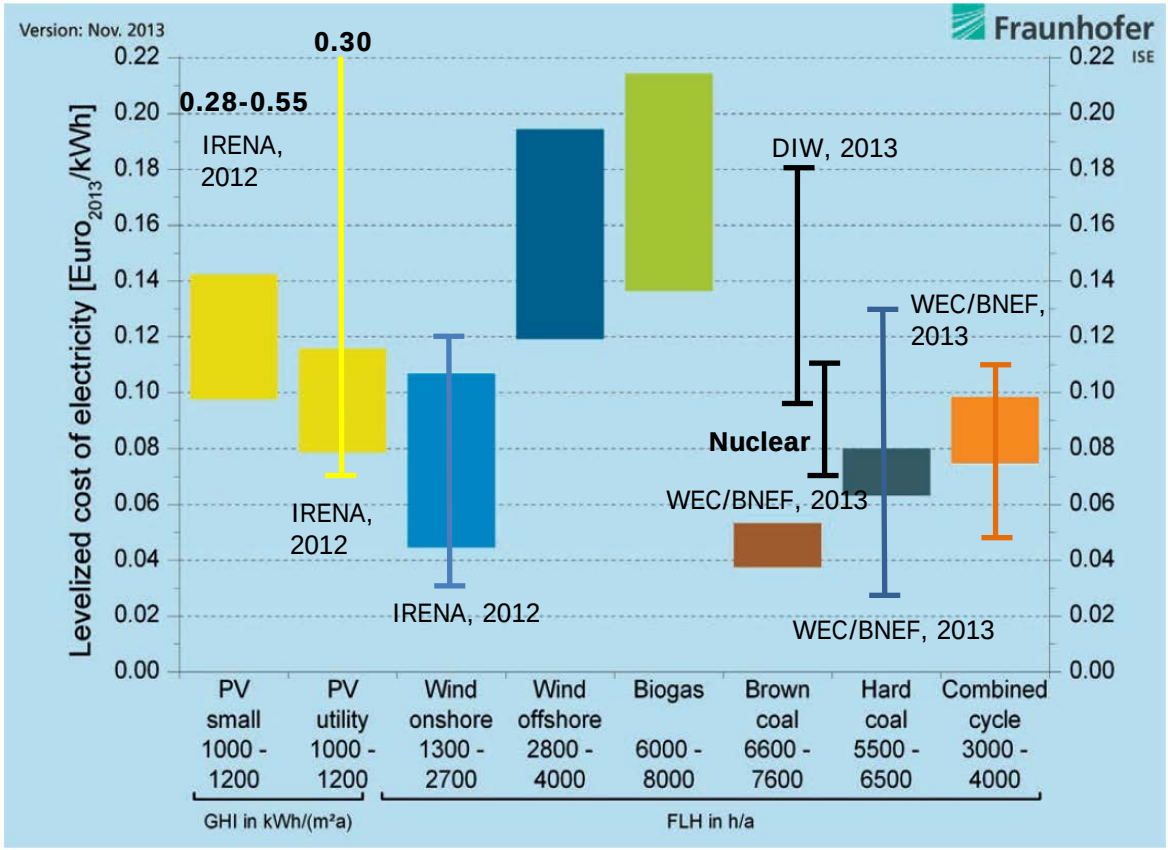
FIGURE 6.2: SOLAR PV MODULE COST LEARNING CURVE FOR CRYSTALLINE SILICON AND THIN-FILM

SOURCE: BASED ON DATA FROM EPIA AND PHOTOVOLTAIC TECHNOLOGY PLATFORM, 2011; LIEBREICH, 2011; SOLOGICO, 2012 AND IRENA ANALYSIS.

Source:
IRENA, 2013.

- More than 20% price reduction for each doubling of cumulative volume
- From 2002 to 2012: 100-fold increase of cumulative production volume

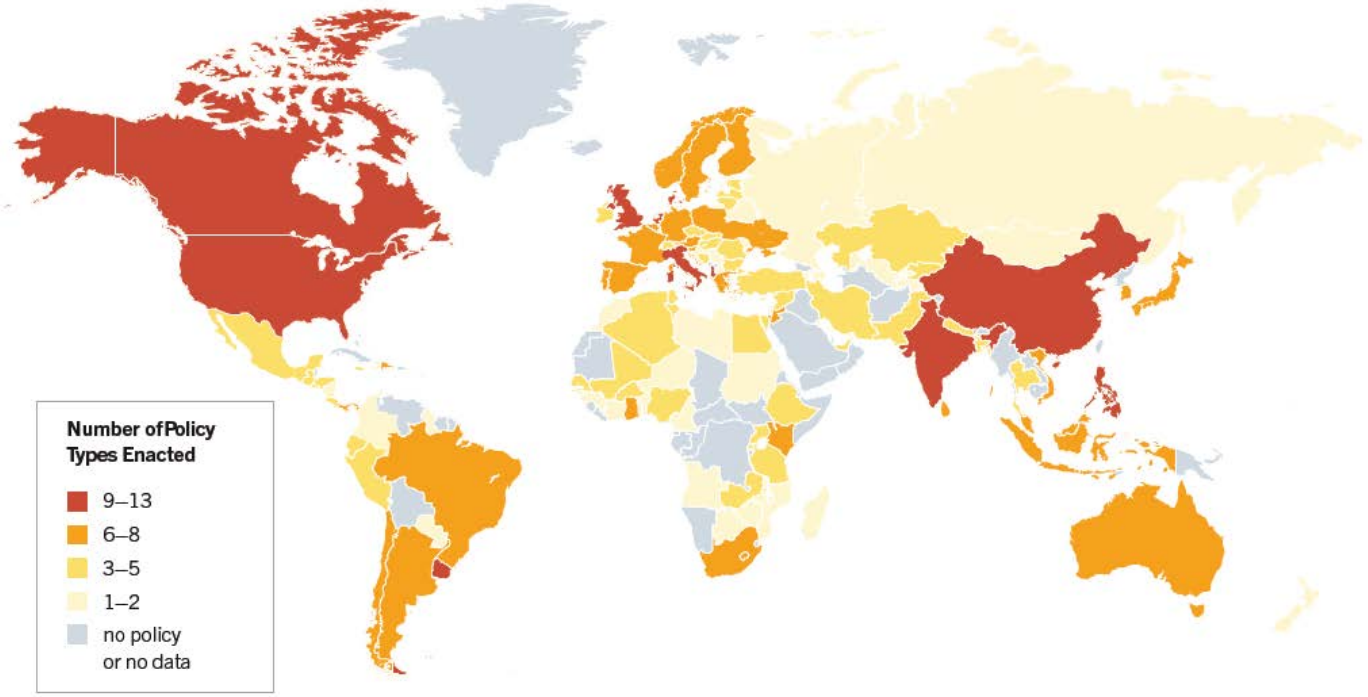
Economic potential
Levelized cost of electricity



- LCOE comprises:
  - Capital costs
  - Fuel costs
  - CO2-costs
  - Fixed operation costs
  - Variable operation costs
  - Capacity factor
- Competitiveness strongly depends on region
- Wind and utility scale solar PV are cost competitive with new conventional power plants on a LCOE basis

Source:
Fraunhofer ISE, 2013; IRENA, 2012; WEC/BNEF, 2013; DIW, 2013.

Market potential
Renewable Energy Policies

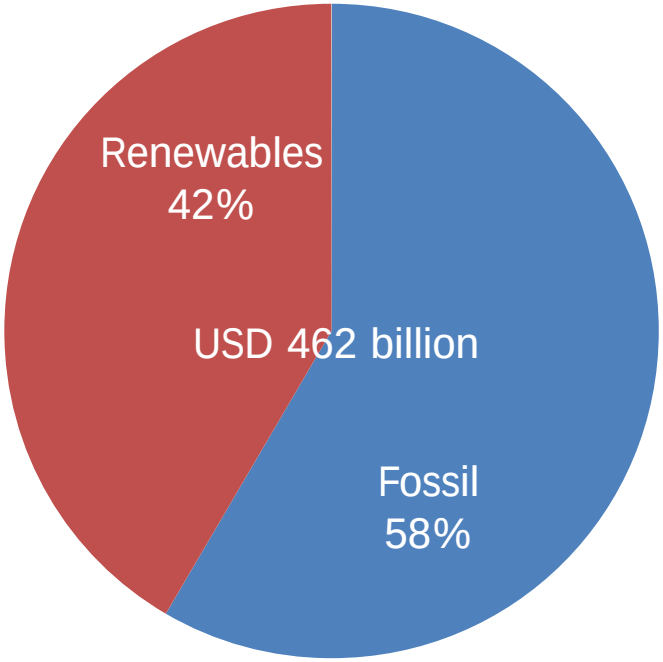


Source: REN21, 2014

- Renewable Energy Policies have diffused over the globe
- Renewable energy targets (defined by 144 countries) create long-term perspective for renewables

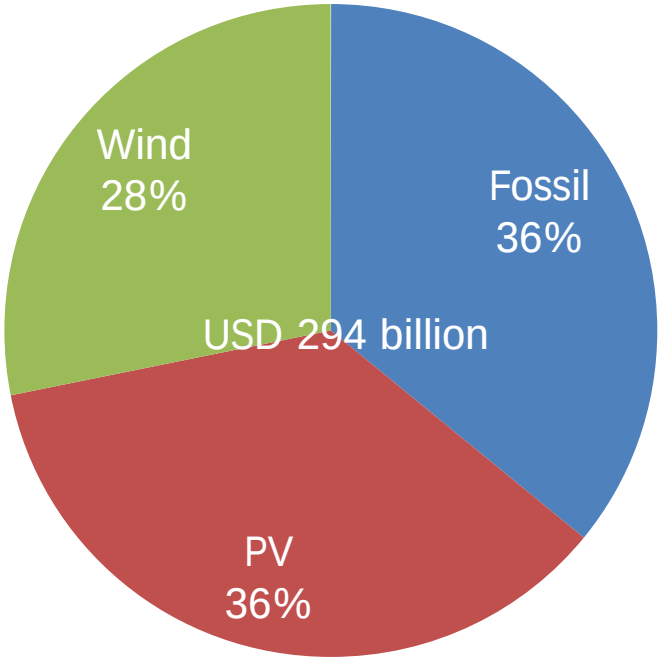
Market potential
Investment in power generation 2013

Gross investment



Renewables not including Hydro > 50MW

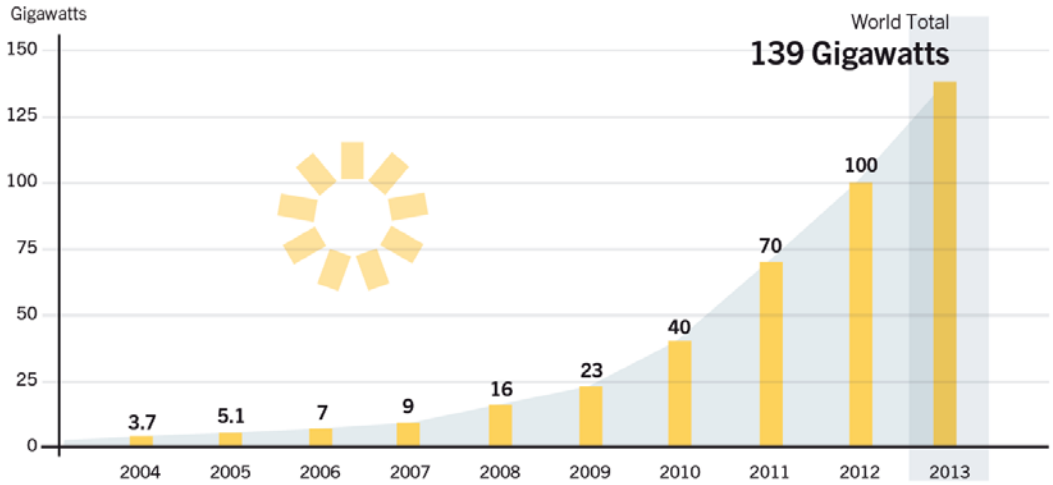
Net investment (Capacity addition)



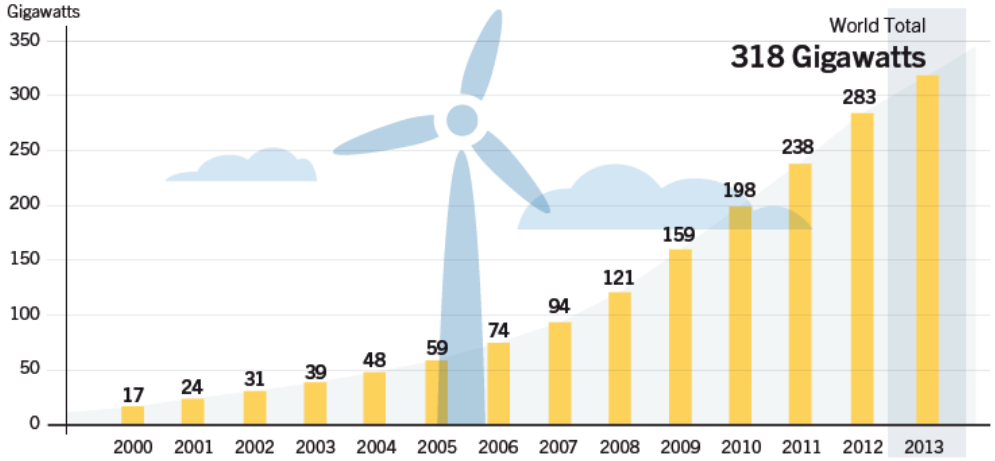
Source: REN21, 2014

- Average annual investment in nuclear power (2000-2013): USD 8 billion (IEA, 2014)
- Cost reductions, support mechanisms and renewable targets have created favorable environment for investments in wind and solar PV

Solar PV and Wind Global Capacity and Additions 2013



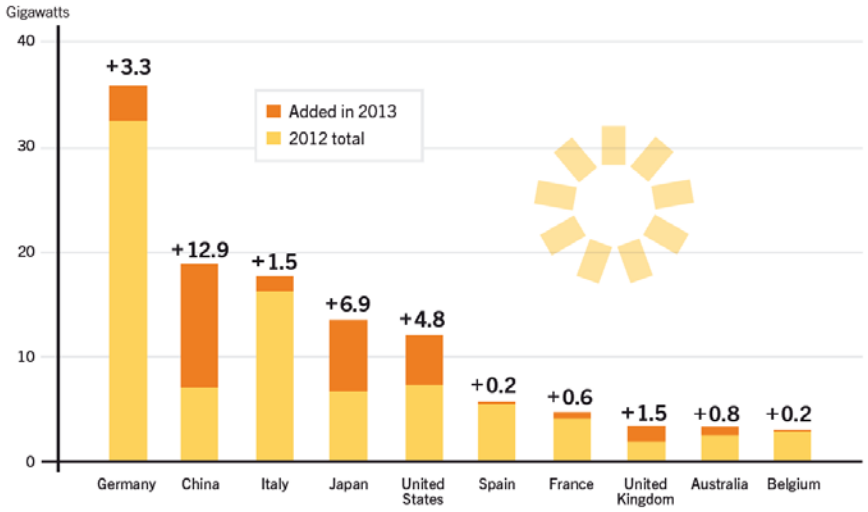
- Power generation equivalent of about 100 nuclear or large coal-fired power plants

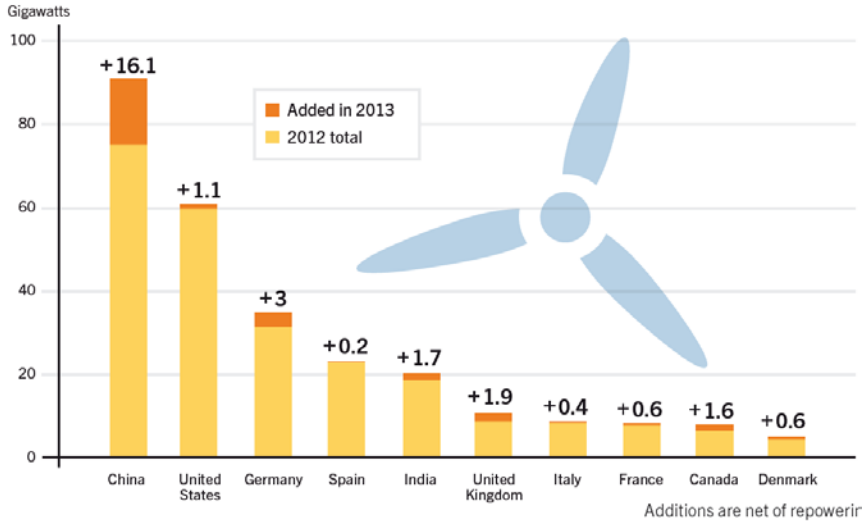


- Growth rate equivalent of about 16 nuclear or large coal-fired power plants per year (2013)

Source: REN21, 2014

Solar PV and Wind Capacity and Additions in Leading Countries





- OECD countries, China and India are dominating
- Several countries with expected future water stress already count on wind and solar PV: China, US, India, Spain, Italy

Source: REN21, 2014

Future Challenges For Wind And Solar PV

- System integration: Flexibility options which supplement wind and solar PV need to be fostered (flexible thermal power plants, demand response, grid development, storage,...)
- Political reliability: retroactive cuts of renewable support due to financial problems in some countries create bad investment environment
- Leveling the playing field: Allocation of external costs (e.g. carbon prizing) and cutting subsidies for fossil fuels and nuclear
- Developing countries need access to financial resources for investment in renewable energy technologies (high share of capital costs)
- Public acceptance needs to be taken seriously in highly impacted regions (wind farms, grids, ...)

Summary

- Wind and solar PV use close to no water for power generation (whole lifecycle)
- Regions with present or expected water stress often have high solar resource potential
- Costs especially for solar PV have decreased strongly and are supposed to decrease further
- Under favorable conditions wind and utility scale solar PV are competitive with new fossil-fueled power plants on a levelized cost of electricity basis
- Support policies for power generation from renewables have shown strong diffusion over the globe
- Power generation from wind and solar PV has been increasing strongly in recent years
- Net investment in power generation from wind and solar PV was about twice the net investment in fossil-fueled generation in 2013

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