Solar energy perspectives

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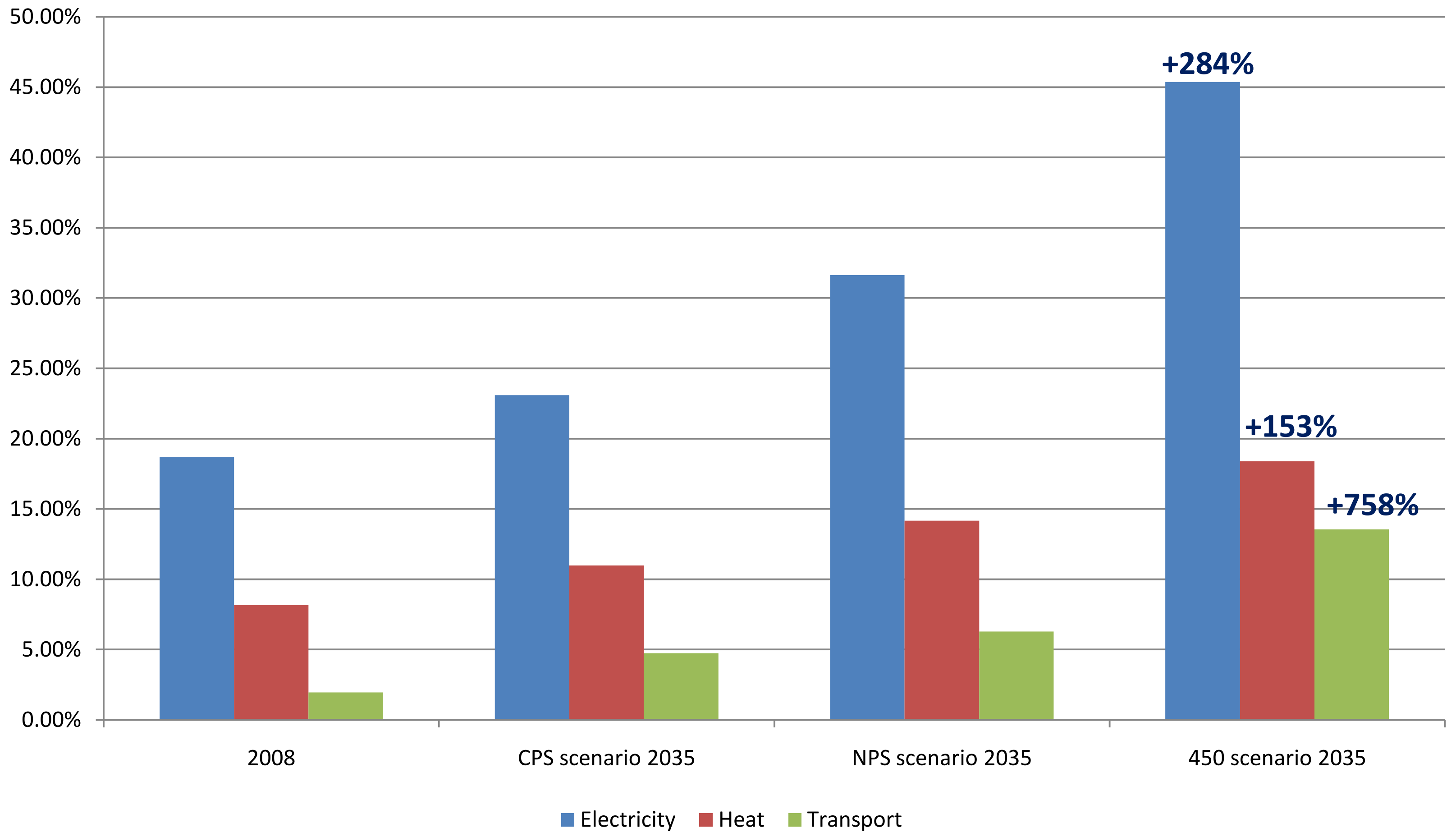
- Renewables as seen by the IEA
- Solar electricity roadmaps
- Grid integration of variable renewables
- The PV boom and related policy issues

Growing shares of renewables in all sectors, for all scenarios

World Energy Outlook 2010

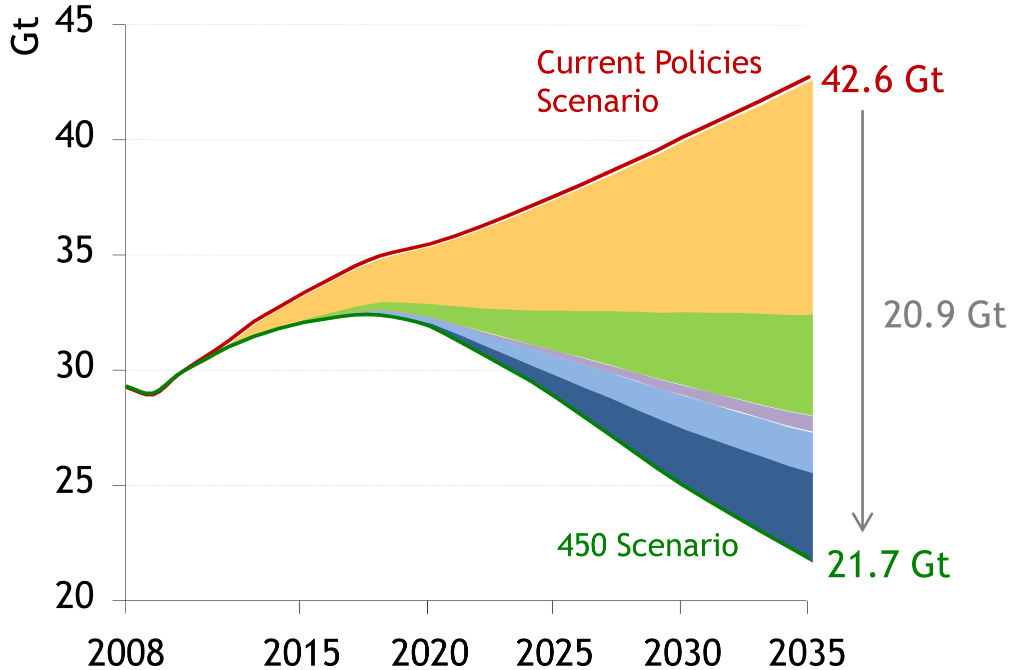


All scenarios point out a large growth of renewables

The 450 Scenario:
How do we get there now?

World Energy Outlook 2010

World energy-related CO_2 emission savings by country in the 450 Scenario relative to the Current Policies Scenario



Share of cumulative abatement between 2010-2035	
Efficiency	53%
Renewables	21%
Biofuels	3%
Nuclear	9%
CCS	15%

Renewables are the second most important contributors to CO_2 emissions reduction

The primary role of renewables in the BLUE scenarios

ENERGY TECHNOLOGY PERSPECTIVES
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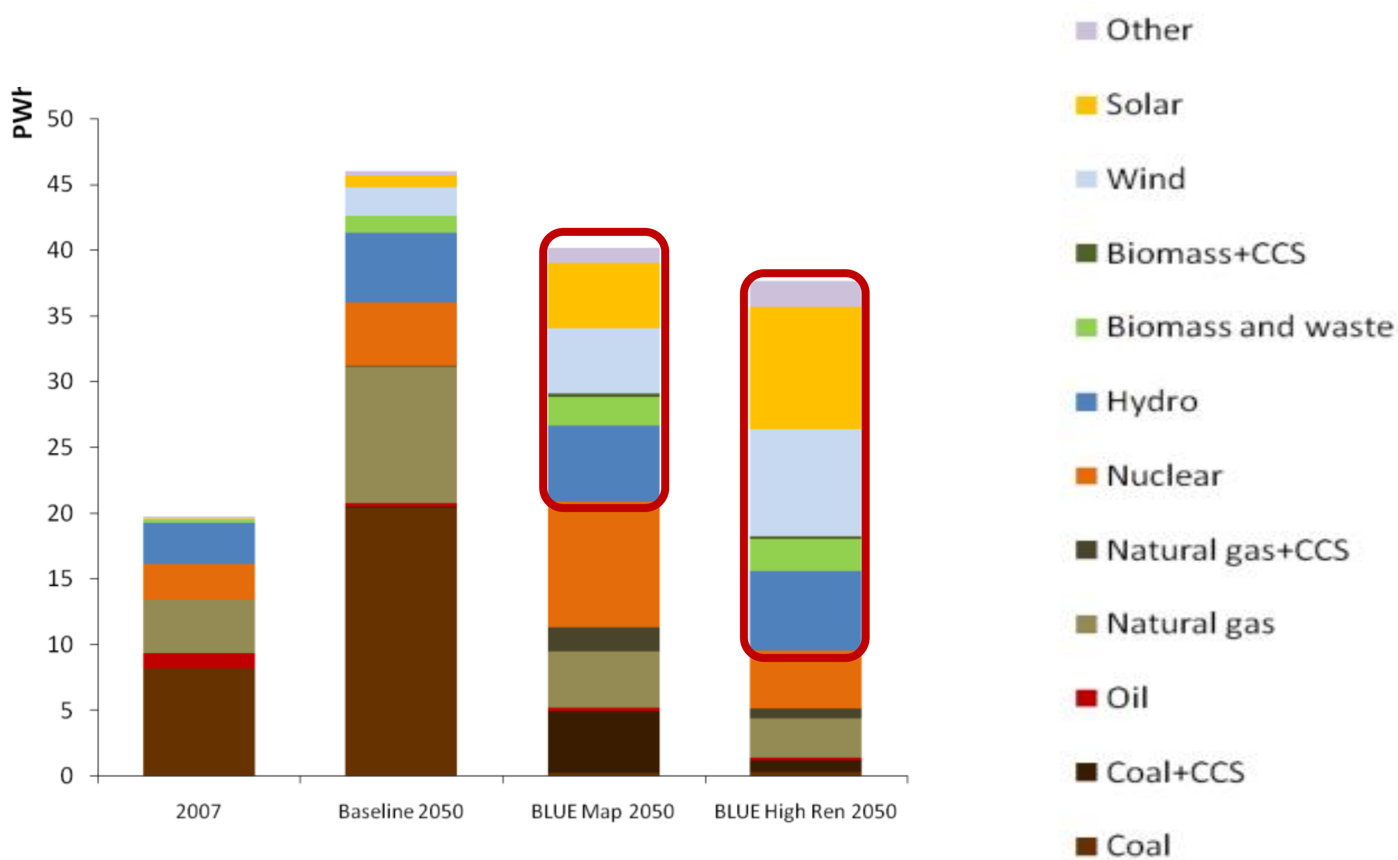
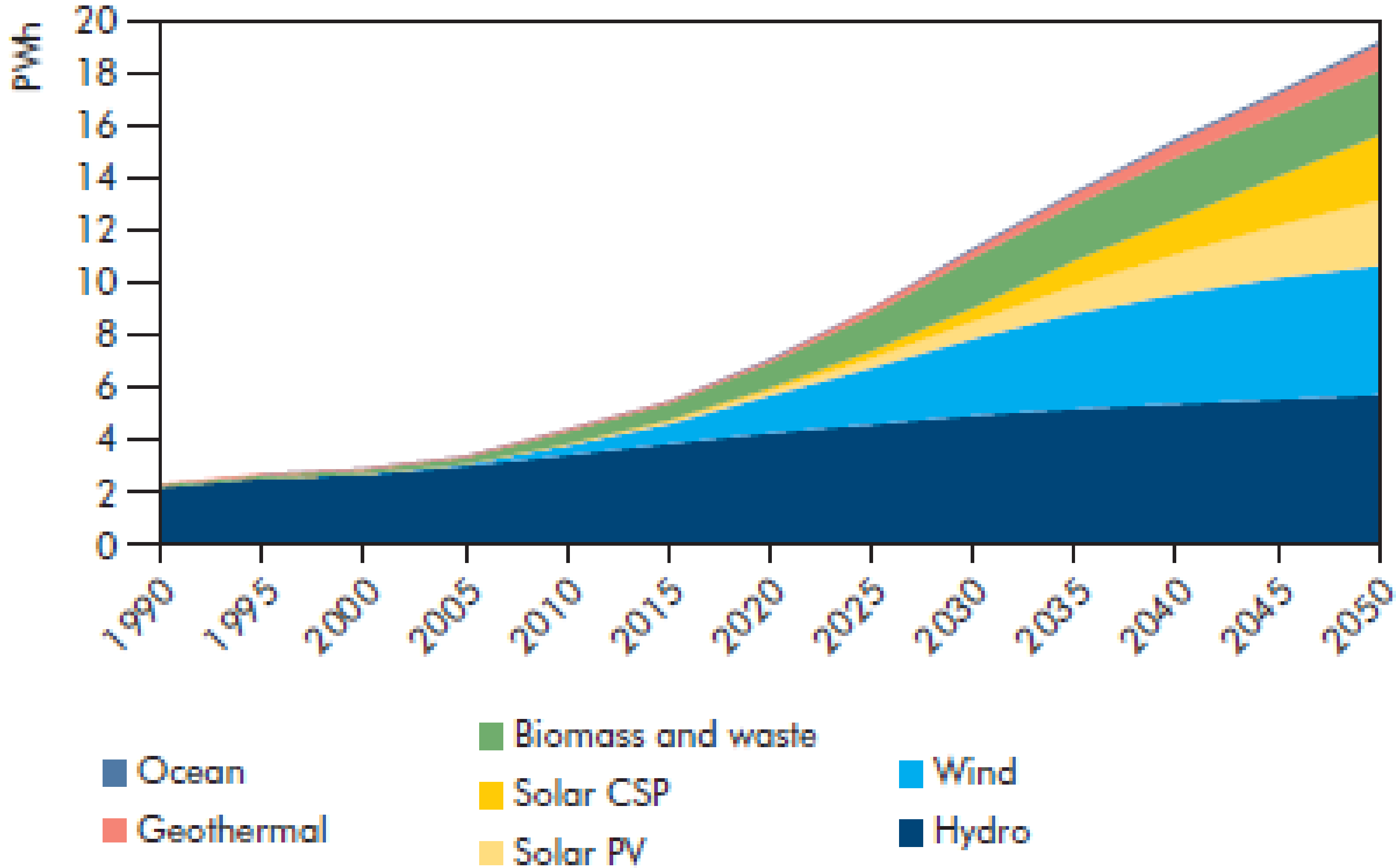
Scenarios & Strategies to 2050



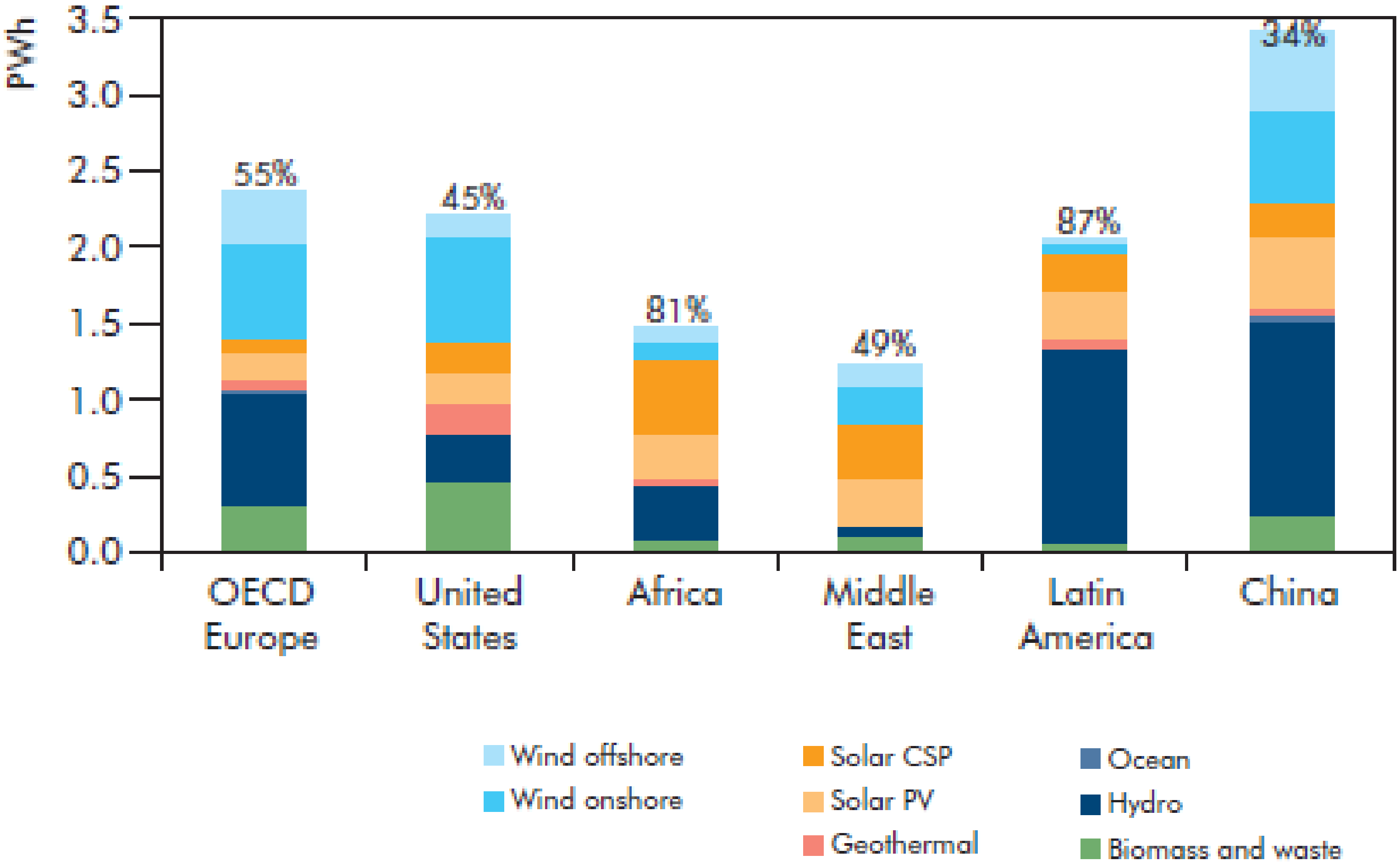
Renewables provide from almost half to three quarters of the global electricity mix in 2050

Growth of renewable power generation in the BLUE Map



Electricity generation from RE grows strongly. Wind, hydropower and solar provide the bulk of it.

RE generation in 2050 for key countries/regions



The mix varies according to resources

IEA Solar Technology Roadmaps

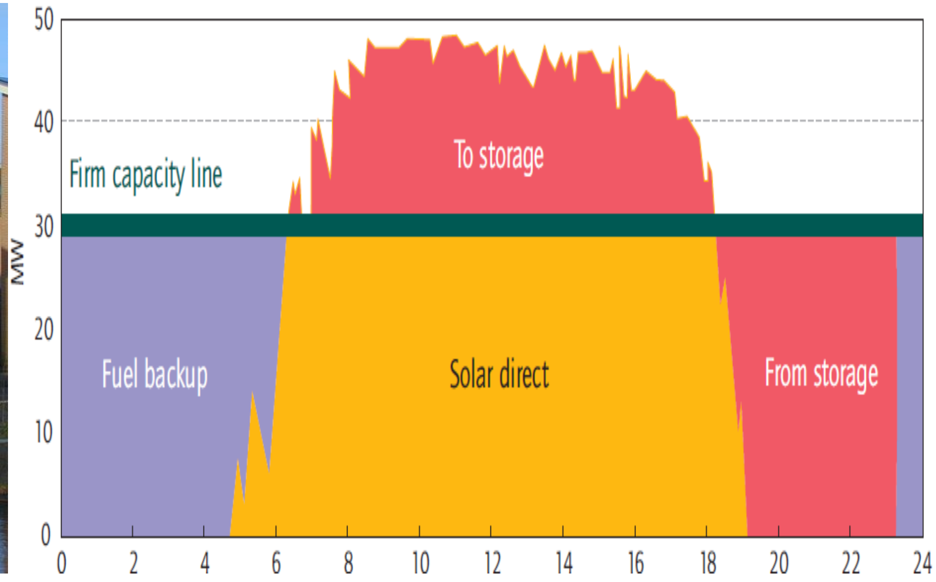
PV & CSP technology roadmaps

- **Launched by IEA's Executive Director Nobuo Tanaka in Valencia, 11 May 2010 (MSP Conf.)**
- **PV and CSP complementary to each other**
- **Solar electricity could represent up to 20% to 25% of global electricity production by 2050**
  - **Roughly half CSP, half PV**
  - **Producing up to 9000 TWh per year**
  - **Saving almost 6 billion tonnes CO_2 per year**
- **This decade crucial for effective policies to enable the development of solar electricity**
- **Need to plan and invest in grid infrastructure**

PV & CSP complementarities

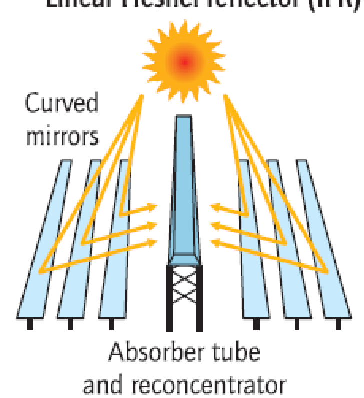
- PV takes **all** light
- PV almost **everywhere**
- Mostly at **end-users'**
- **Variable**
- Peak & mid-peak
- Grid parity (retail) **by 2020**

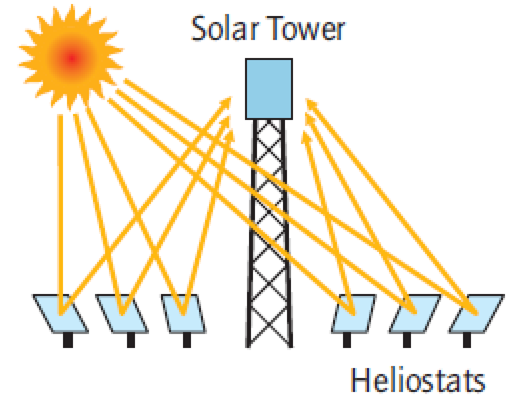
- CSP takes **direct** light
- CSP **semi-arid** countries
- Mostly for **utilities**
- **Firm**, dispatchable } { backup
- Peak to **base-load** } { storage
- Competitive peak power **by 2020**
- **HVDC lines** for transport

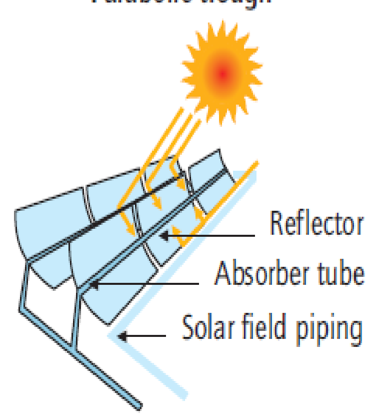


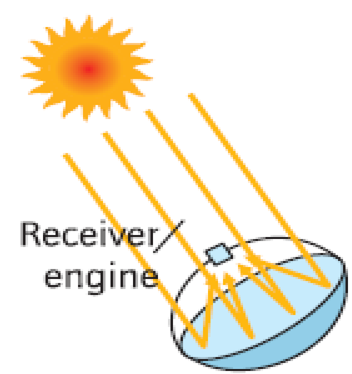
Firm & flexible CSP capacities can help integrate more PV

Receiver type \ Focus type	***Line focus*** Collectors track the sun along a single axis and focus irradiance on a linear receiver. This makes tracking the sun simpler.	***Point focus*** Collectors track the sun along two axes and focus irradiance at a single point receiver. This allows for higher temperatures.
Fixed Fixed receivers are stationary devices that remain independent of the plant's focusing device. This eases the transport of collected heat to the power block.	Linear Fresnel reflector (IFR)	Solar Tower
Mobile Mobile receivers move together with the focusing device. In both line focus and point focus designs, mobile receivers collect more energy.	Parabolic trough	Parabolic dish



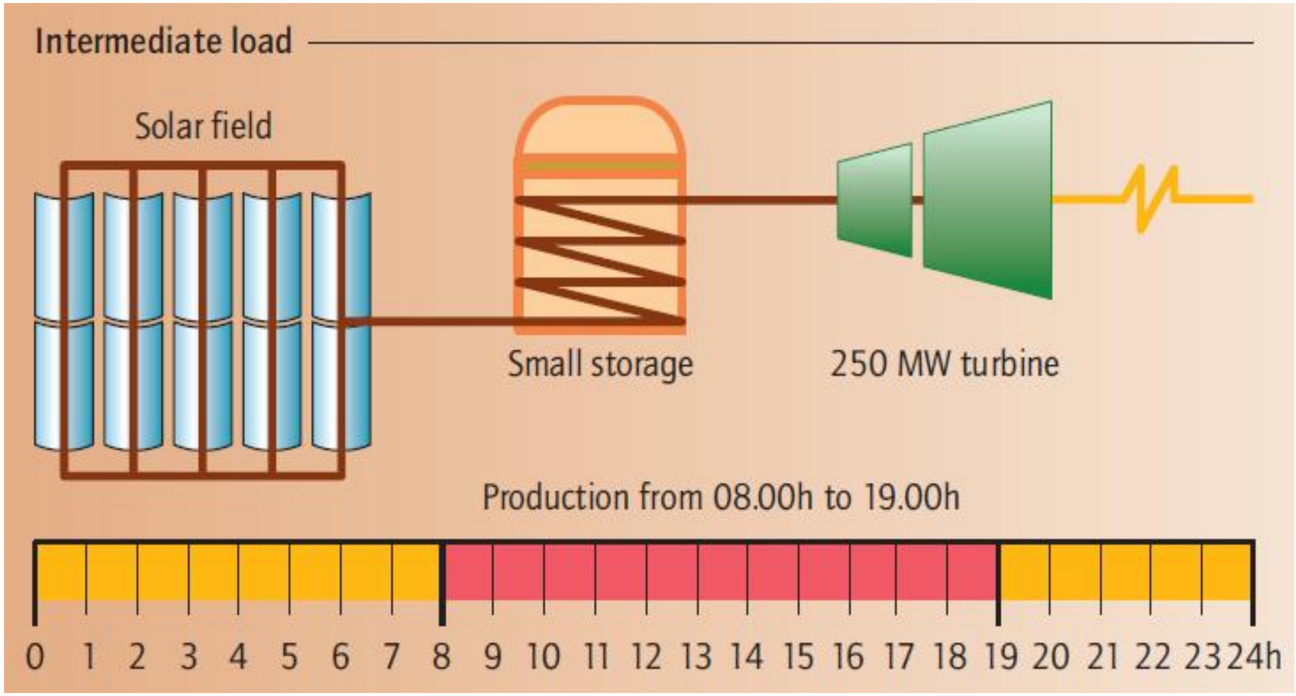




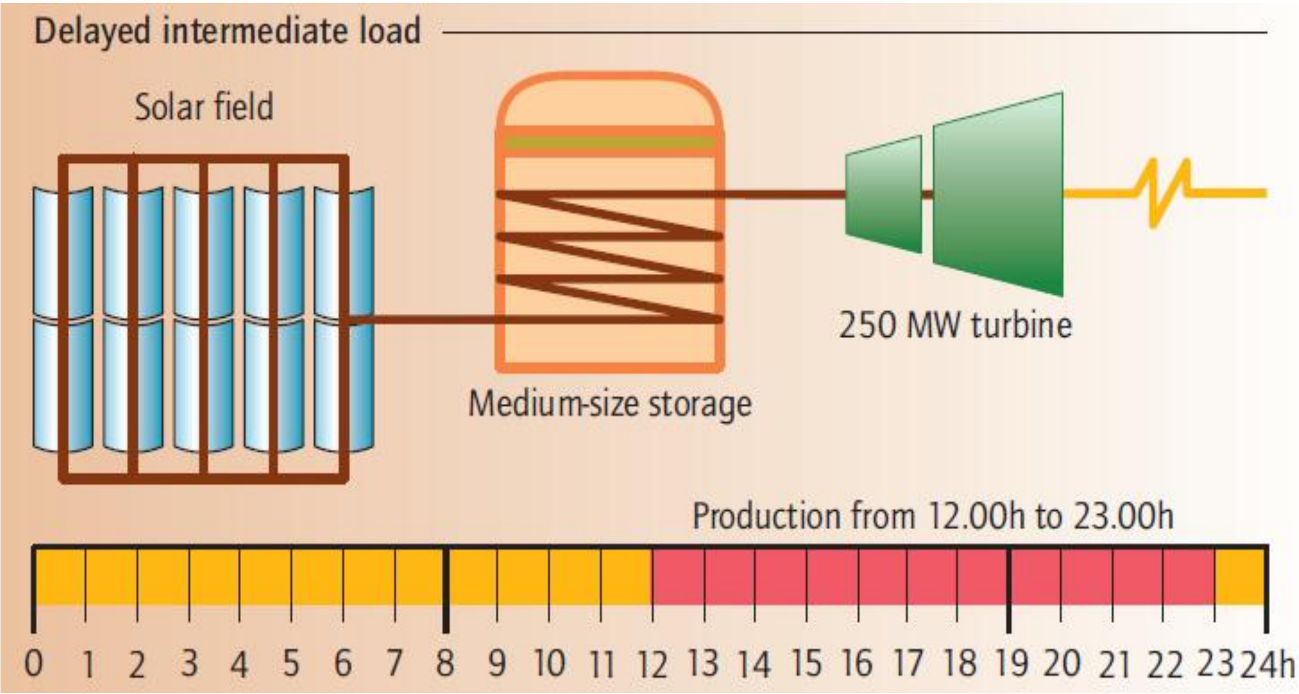


Uses of storage

Mid load

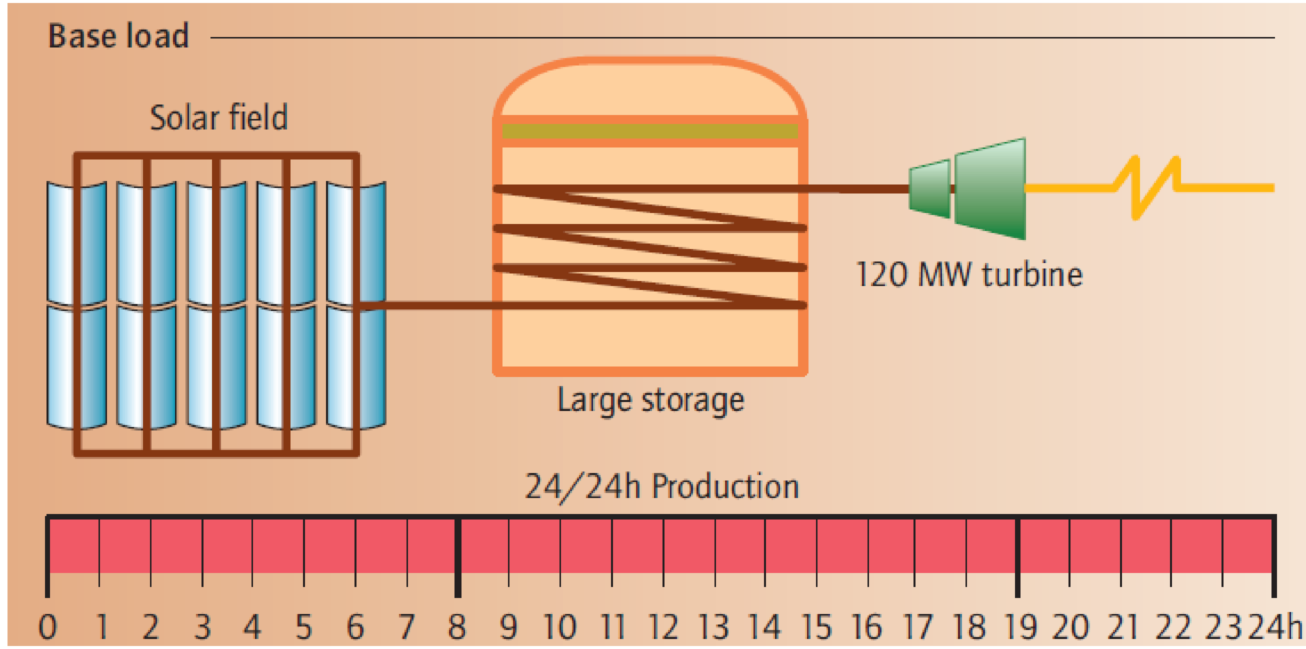


Delayed mid load

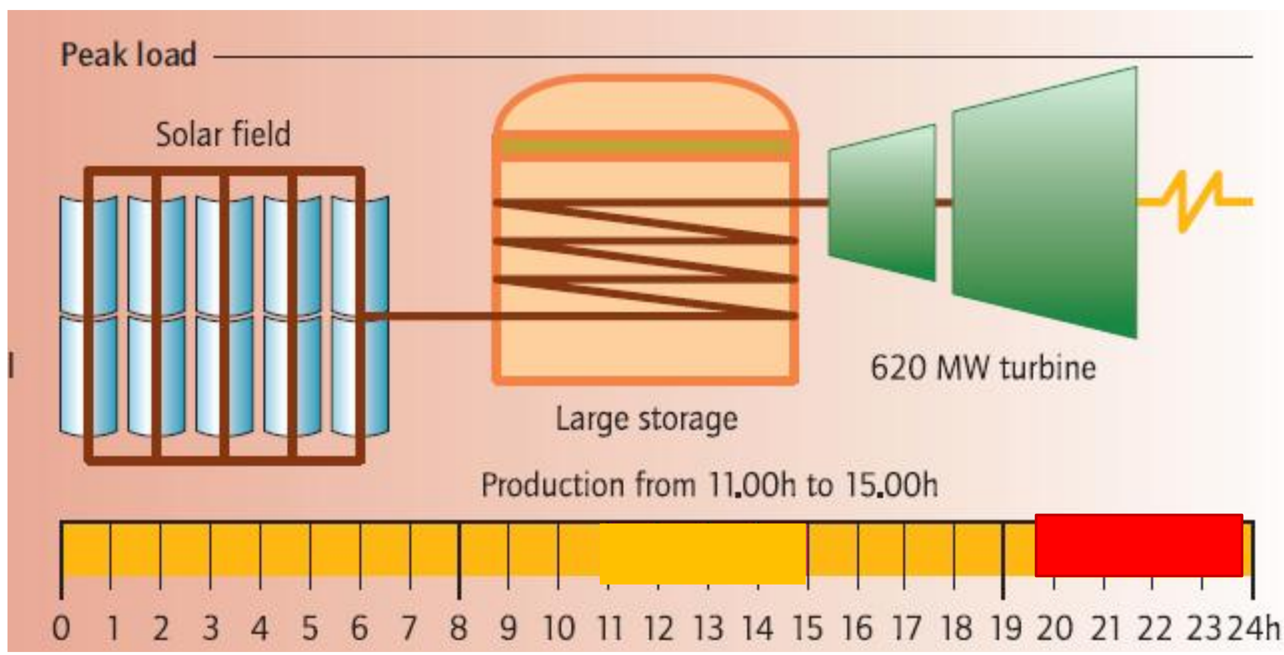


Uses of storage

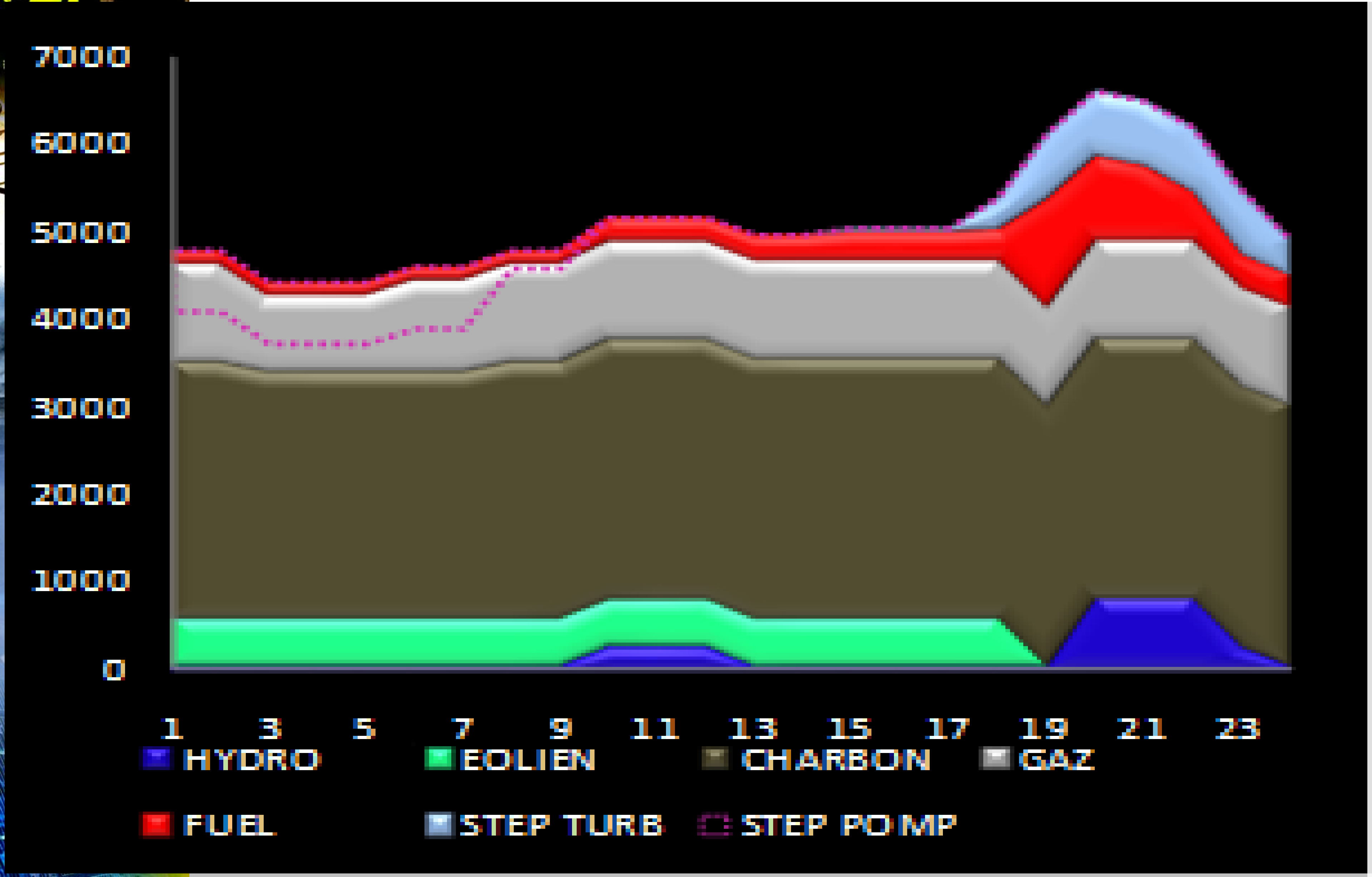
Base load



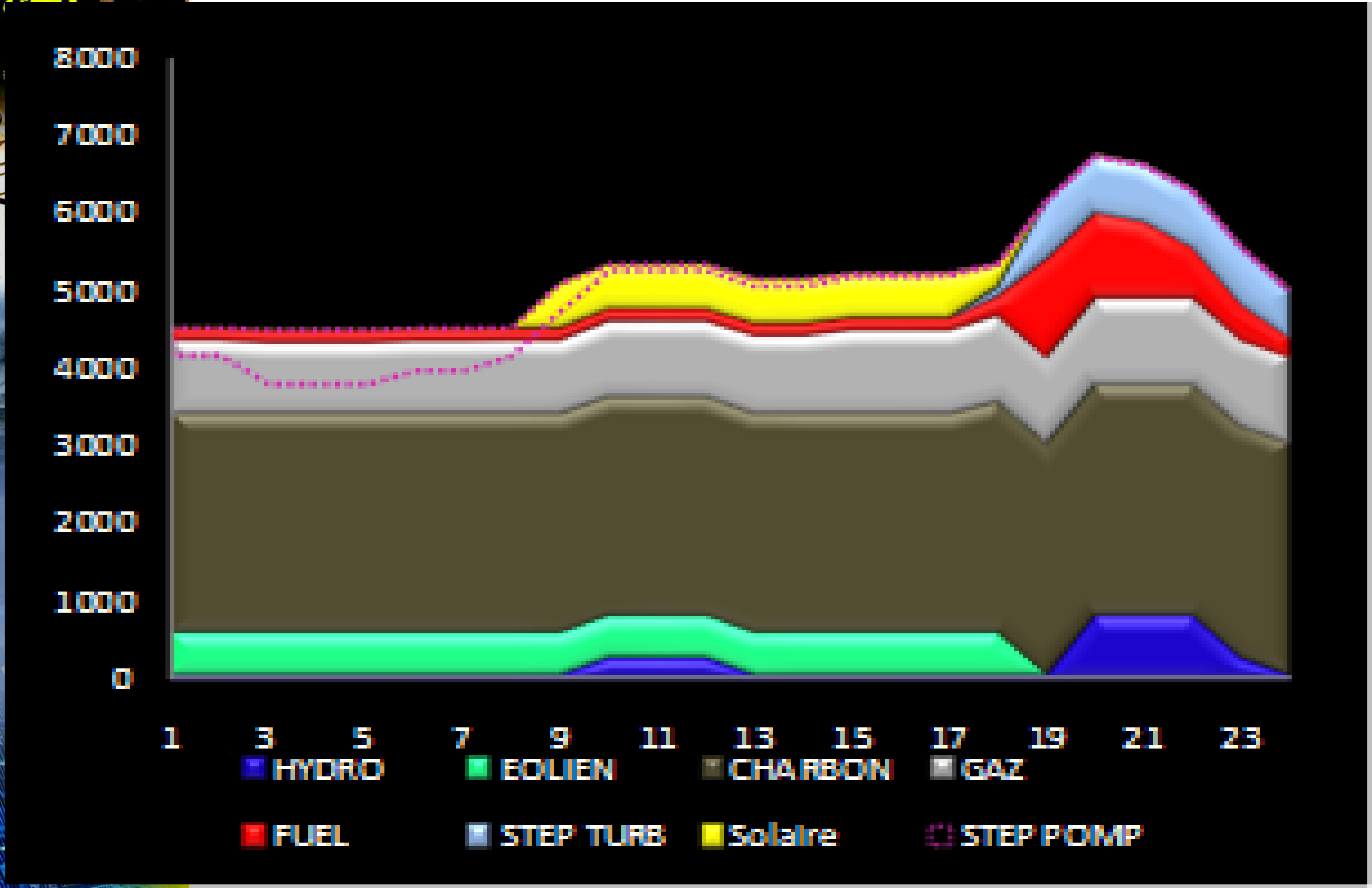
peak load



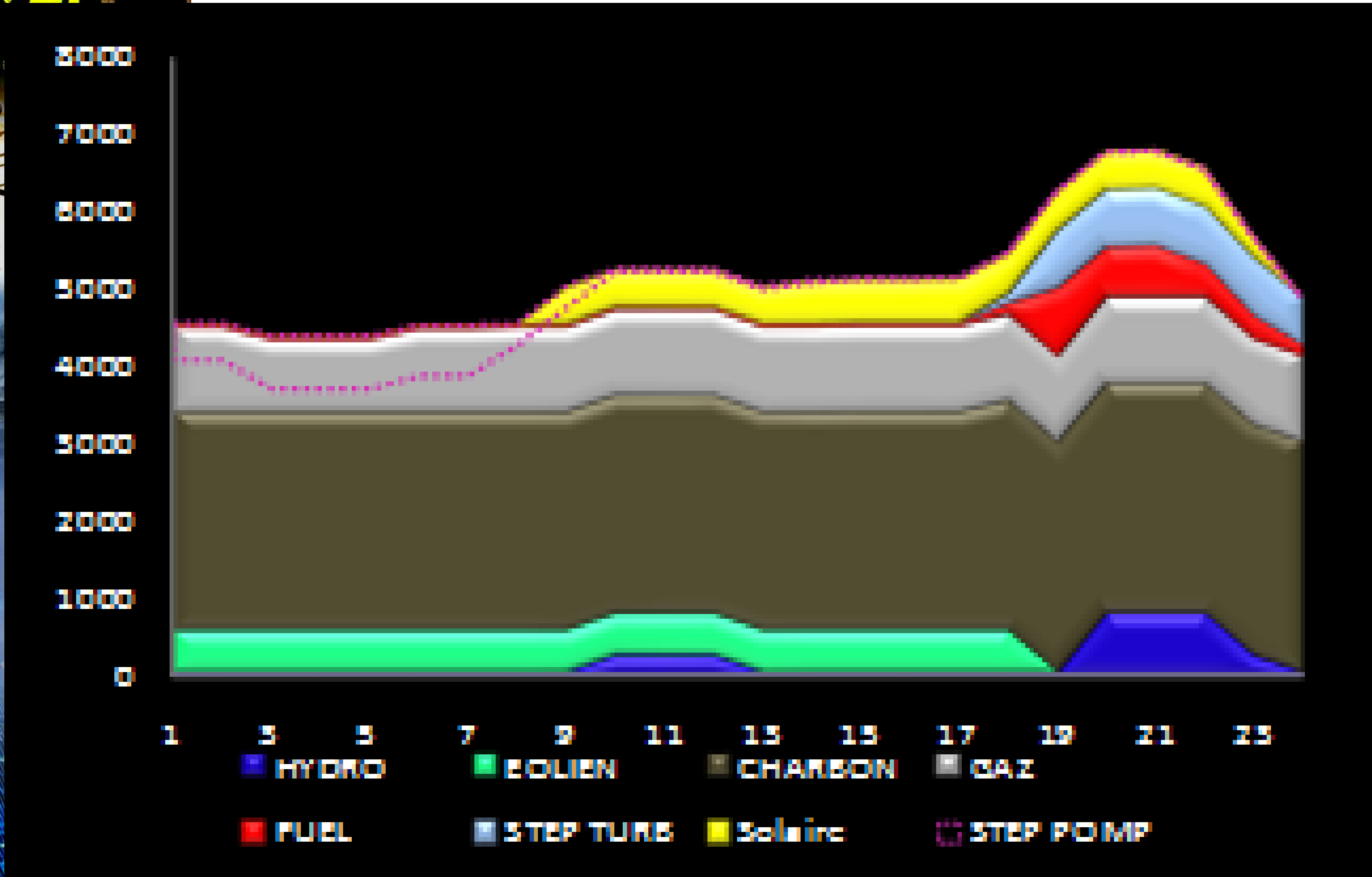
Morocco 2017: load curve & merit order



Morocco 2017: load curve & merit order with PV



Morocco 2017: load curve & merit order w. CSP



Temperatures and storage costs

Stored Heat =∑ mCp ΔT

Stored Heat is Proportional to *ΔT*

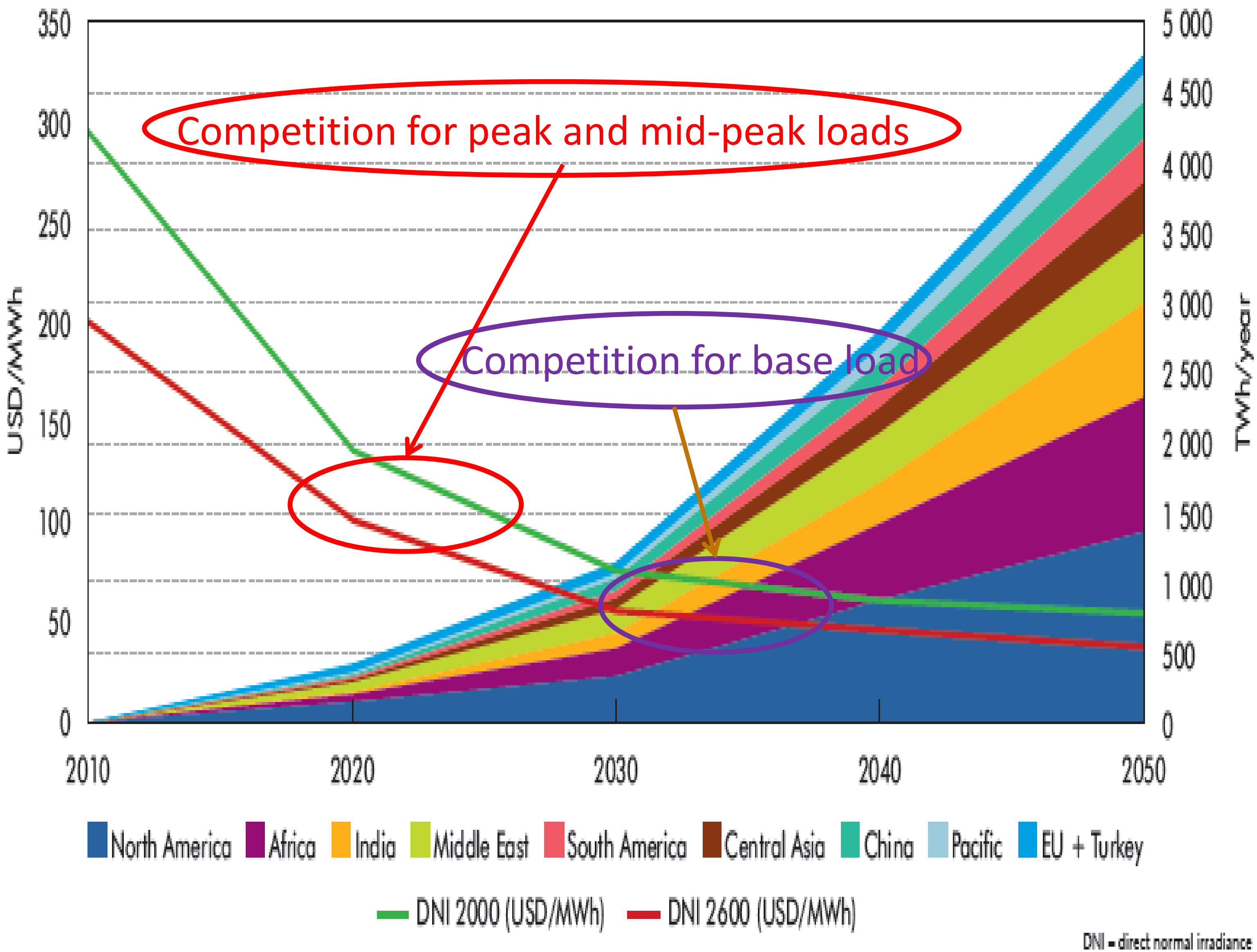
Large / Smaller ΔT ≈ 278°C/90°C

Low Temperature Storage Requires ≈ 3X mass

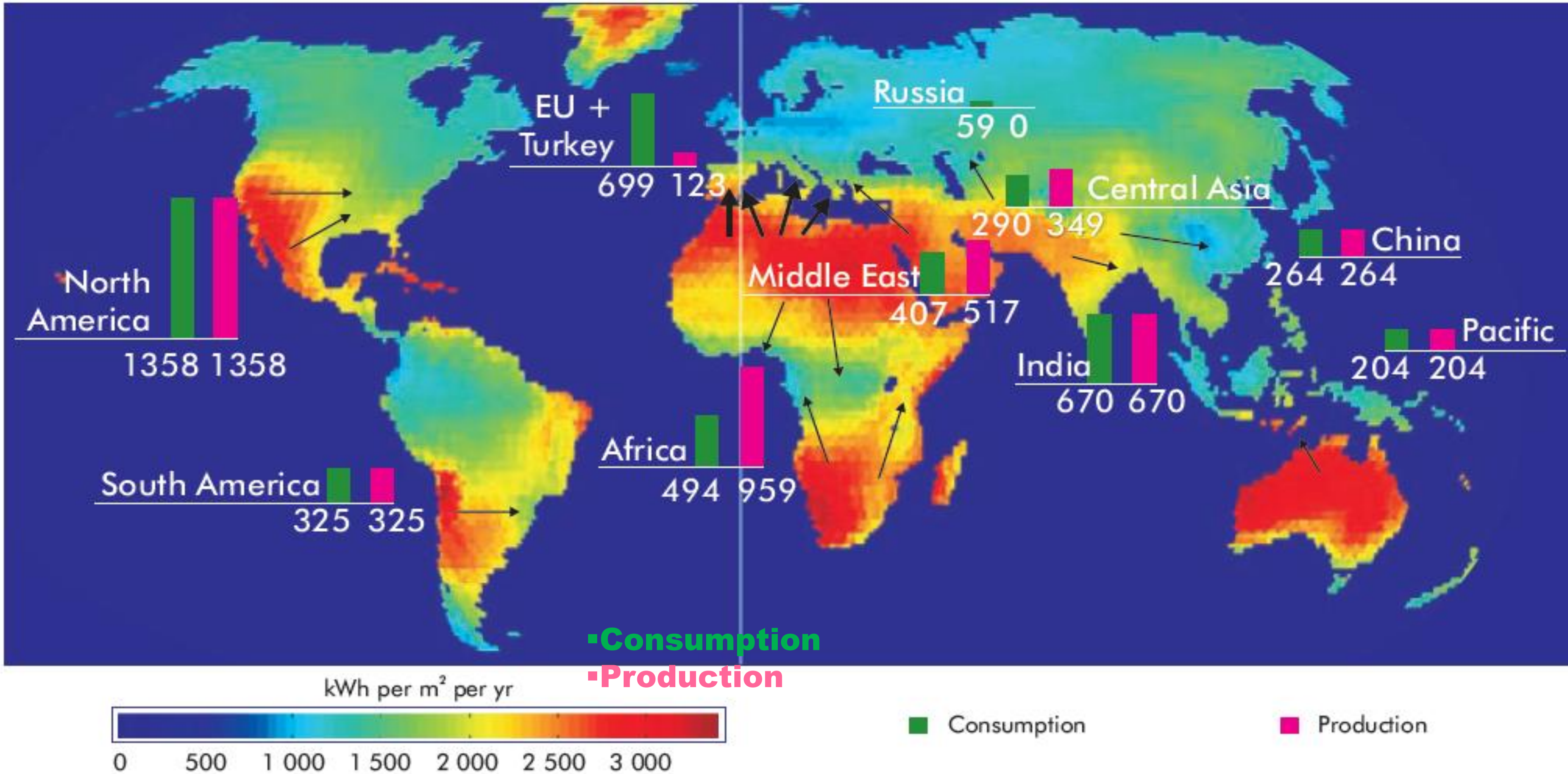
Low Temperature Storage ~ 3X Cost per MWt

Troughs	Tower
~378°C	566°C
288°C	288°C

CSP costs and global output



The CSP Roadmap: 2050



Repartition of the solar resource for CSP plants in kWh/m²/y, and of the production and consumption of CSP electricity (in TWh) by world region in 2050 as foreseen in this roadmap. Arrows represent transfers of CSP electricity from sunniest regions or countries to large electricity demand centres.

Sources: Breyer & Knies, 2009 based on DNI data from DLR-ISIS and IEA Analysis.

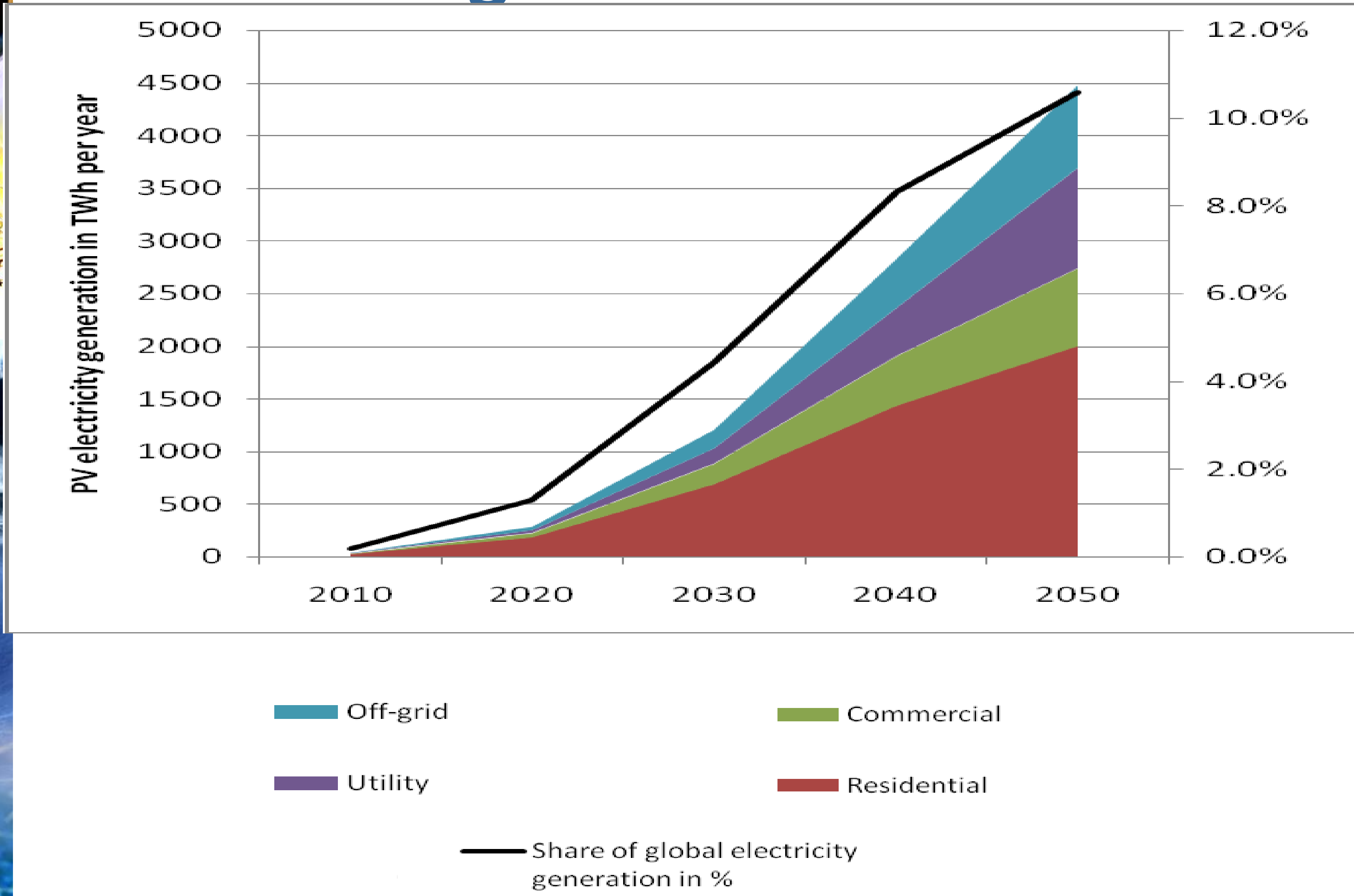
HVDC lines will extend CSP areas

Back-up and Hybridisation

- Back-up to « firm » electric capacities,
- Hybridisation to share the costs of the plant (except. solar field)
- SEGS plants in California (25% NG), CSP plants in Spain (10-15%), EAU…

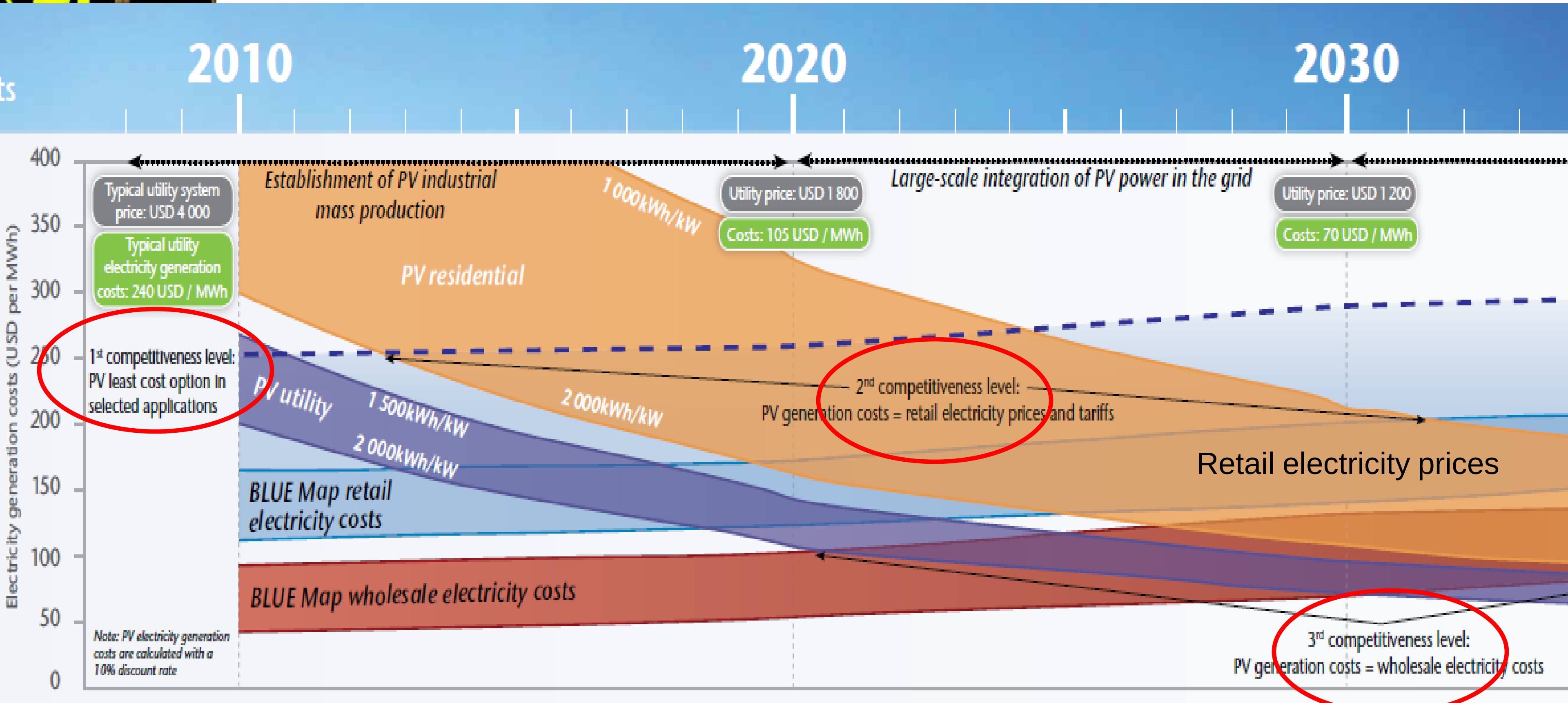
- ISCC plants (with N. Gas): Algeria, Egypt, Iran, Morocco…
- Solar pre-heating of feed water: Australia Florida… (a few %)
- Main steam substitution: towers in supercritical coal plants, from 30% to 70%: *China, India, Morocco, RSA????*

Solar PV Targets



If sound policies are put in place, PV can provide 5% of global electricity generation in 2030, 11% in 2050

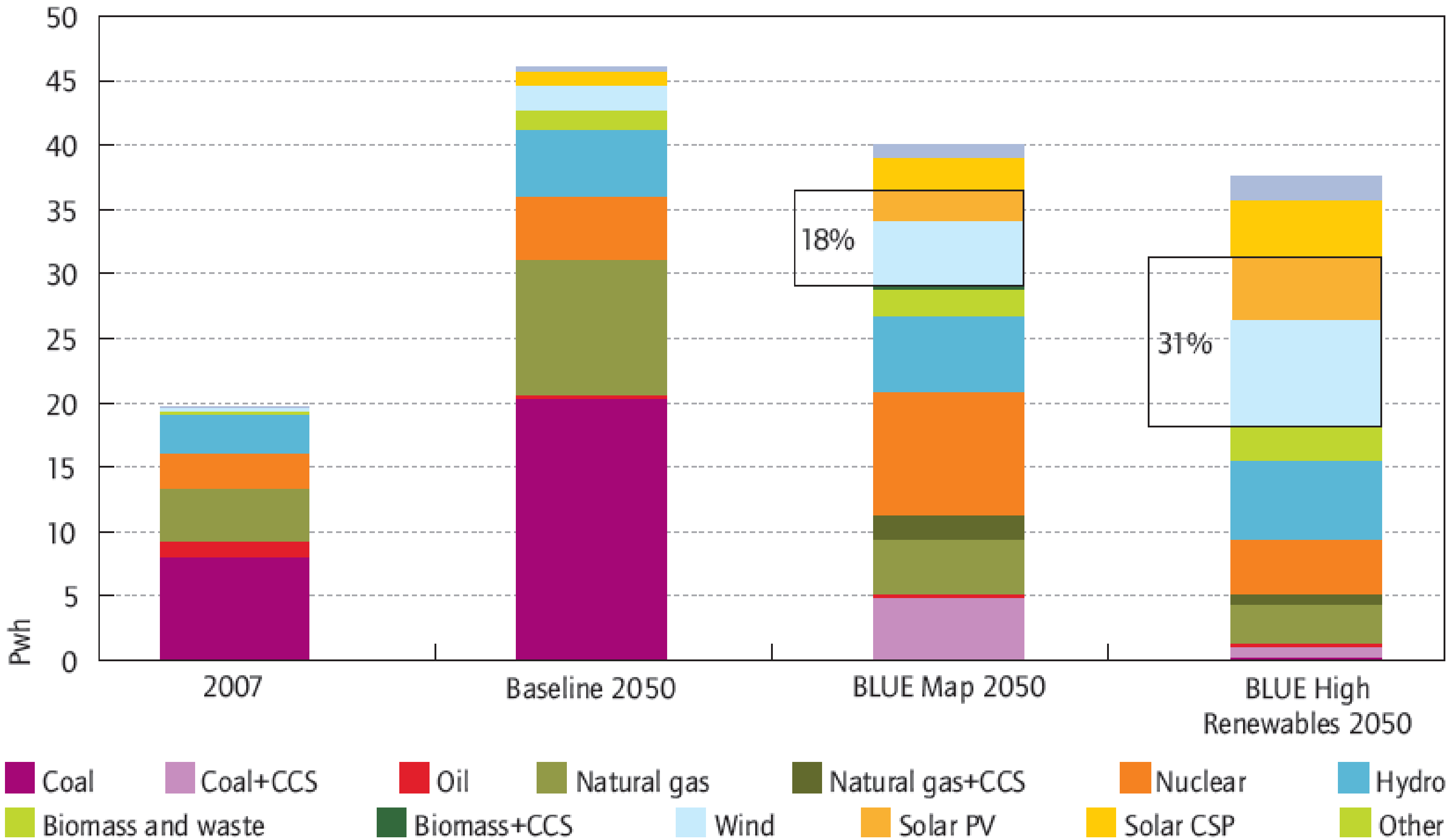
PV deployment and competitiveness



Source: IEA Solar PV Technology Roadmap

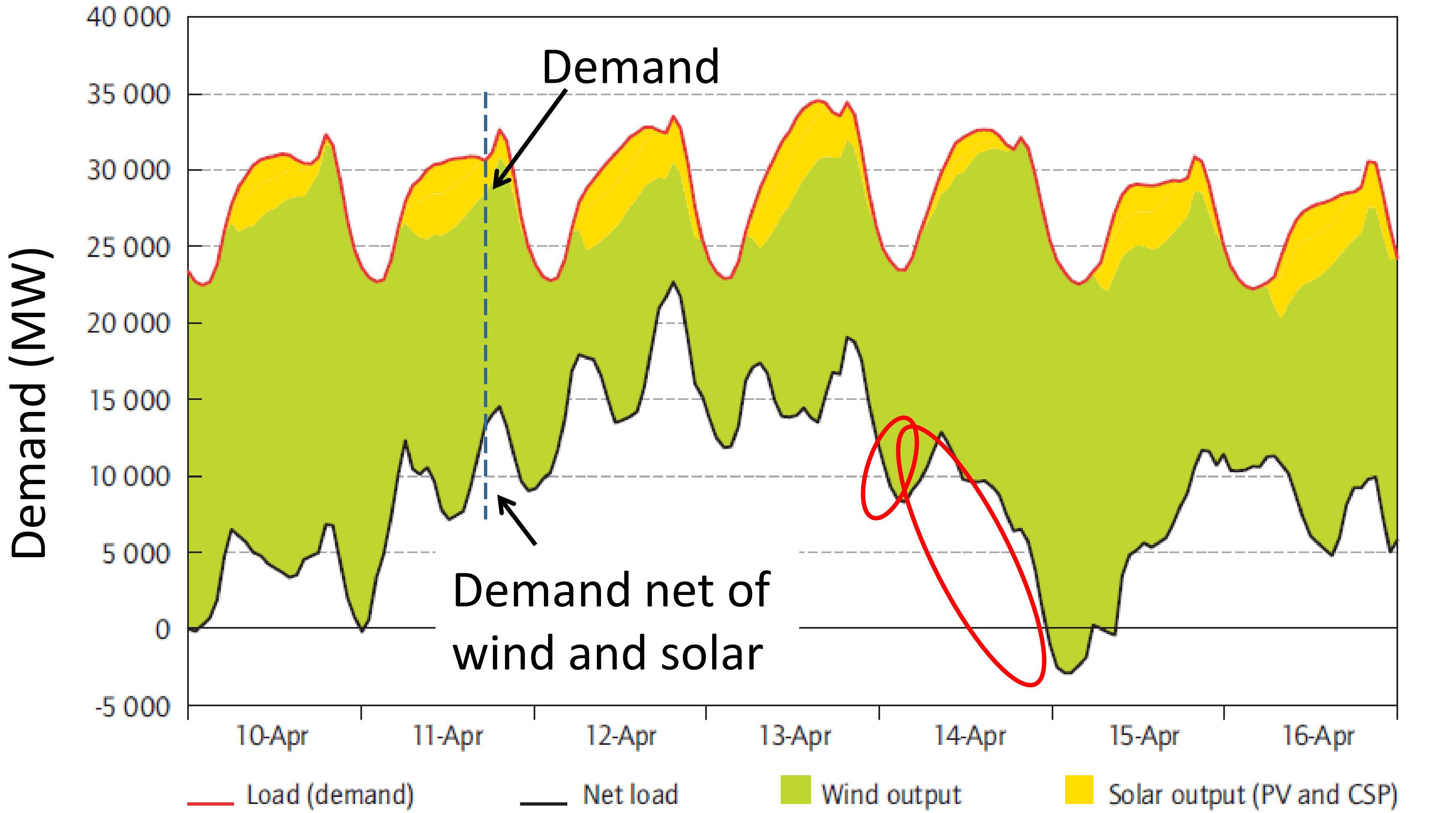
- **Thanks to a steep learning curve, deployment-led cost cuts will progressively make residential PV, then utility-scale PV competitive and a cheap GHG mitigation option**

Variable RE in 2050



Emerging challenges: grid integration

Variability is not new, but it does get bigger



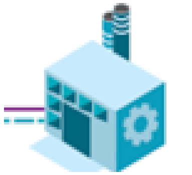
Source: *Western Wind and Solar Integration Study*, GE Energy for NREL (2010)

Flexibility is key

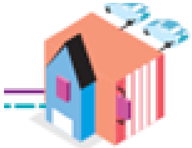
There are 4 flexible resources

- Dispatchable power plants
- Demand side Response (via smart grid)
- Energy storage facilities
- Interconnection with adjacent markets

A biomass-fired power plant

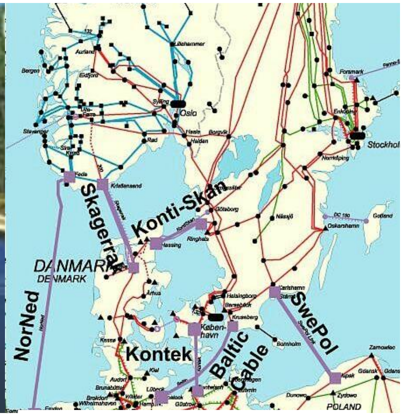


Industrial



residential

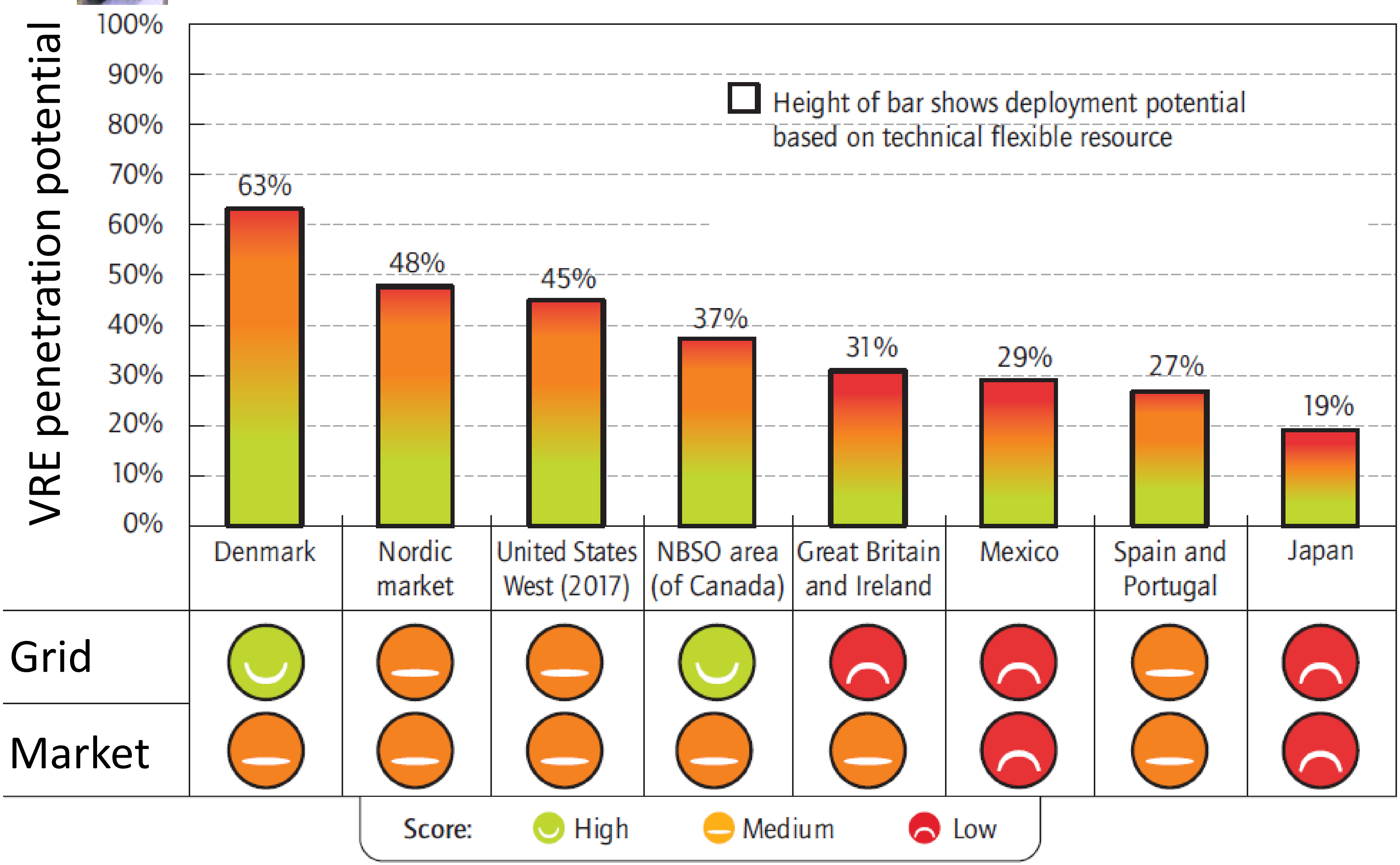
A pumped hydro facility



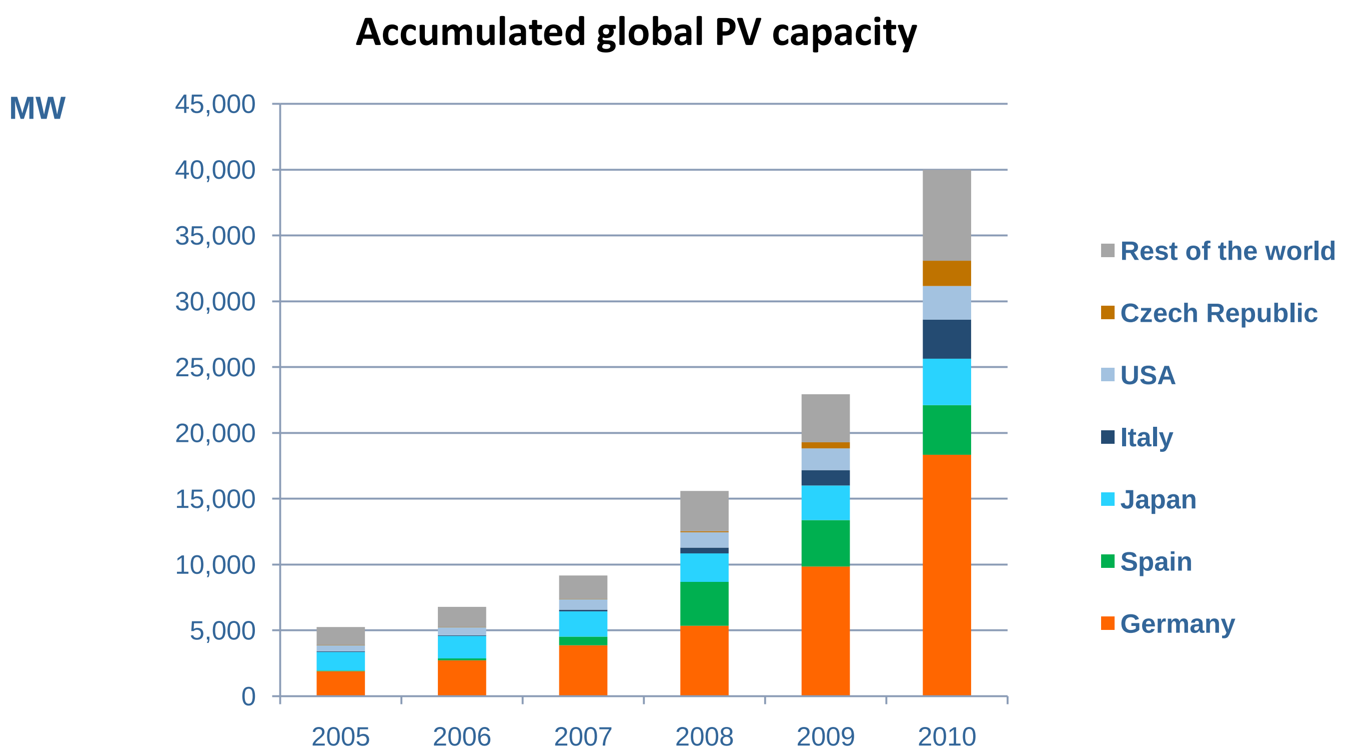
Scandinavian interconnections

Grid integration of var-RE

Snapshot of present penetration potentials



Current PV boom

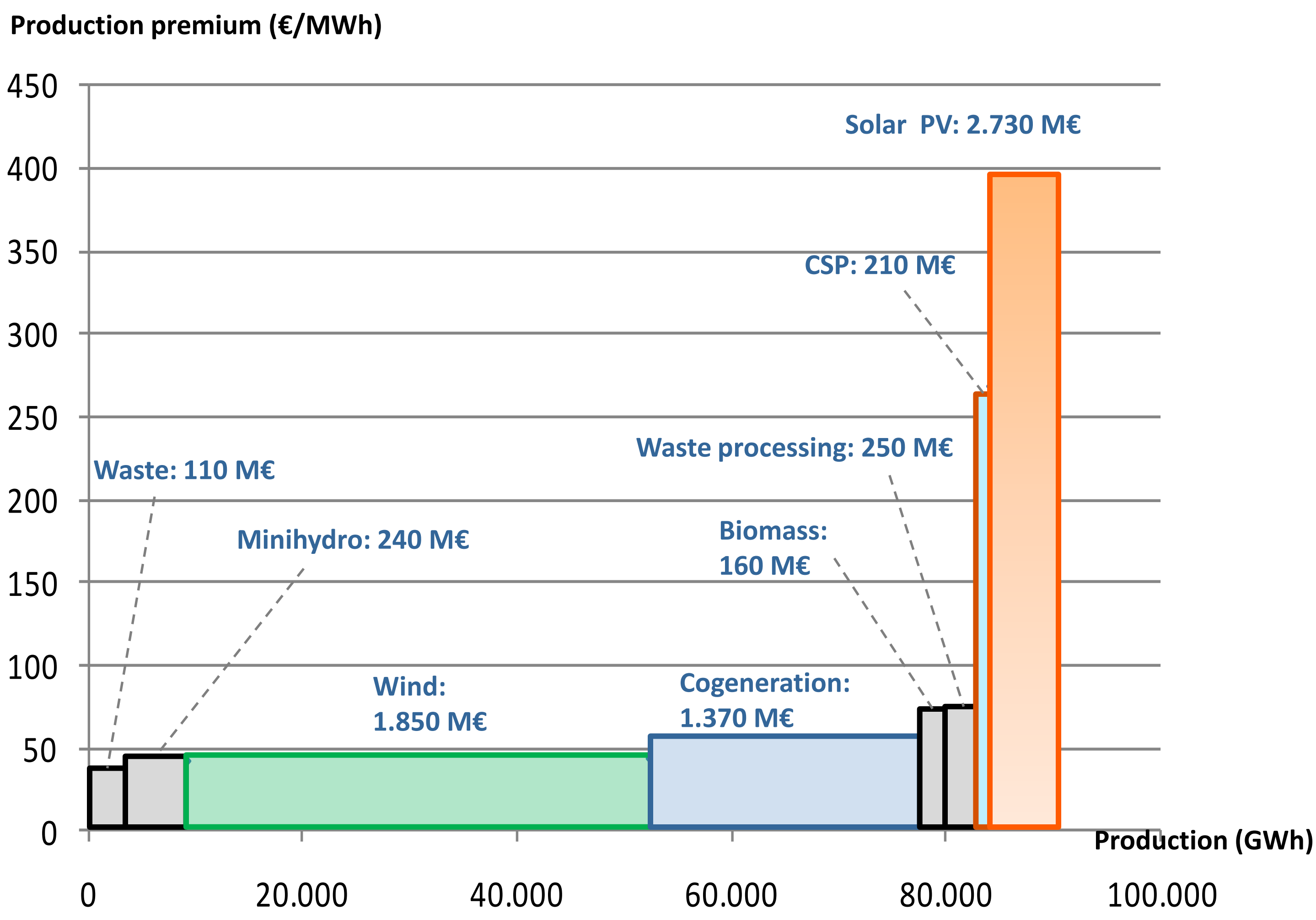


Sources: IEA PVPS, BP Statistical Report, BNEF

- **Unexpected PV growth raises policy cost concerns in several EU countries**
- **Czech Rep., France, Germany, Italy, Spain**

Impacts on total support costs: Spain

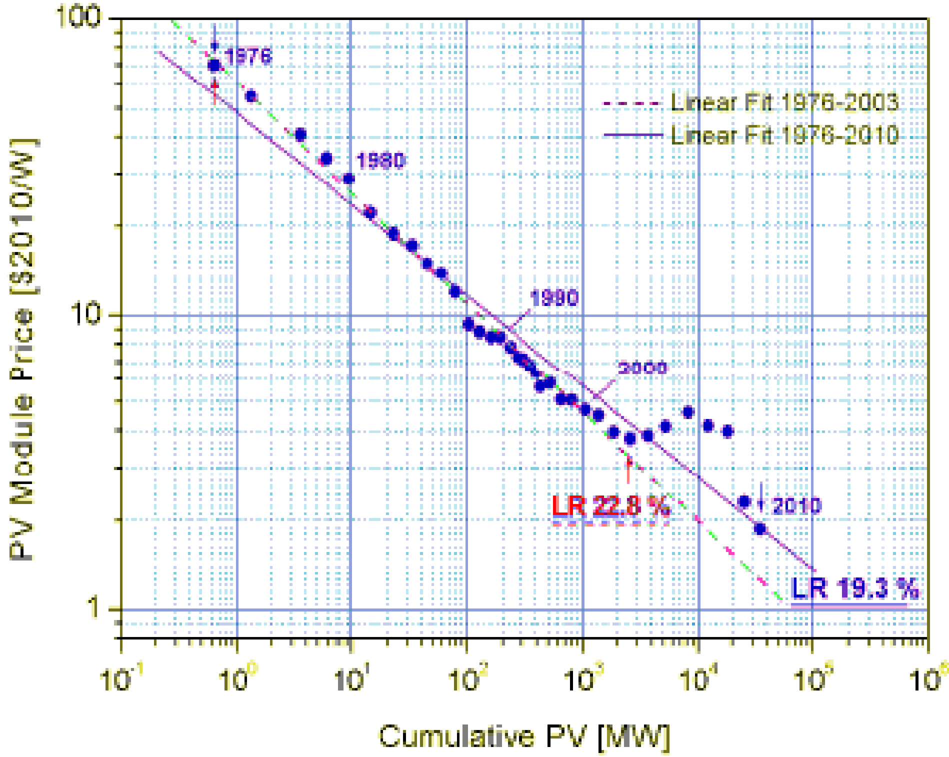
Support received *vs.* production, 2010



Source: UNESA estimations (September 2010)

Are incentives following cost reduction quickly enough?

PV learning curve



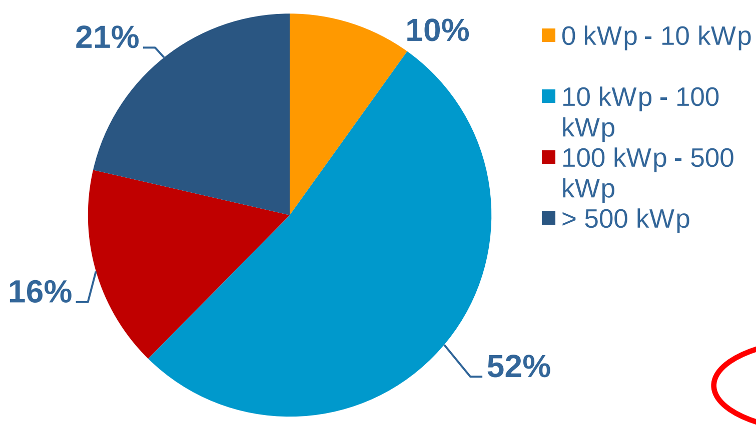
Source: Breyer and Gerlach, 2010

- **Policies are not adapting quickly enough**
- **Country price differences mainly reflect incentives**

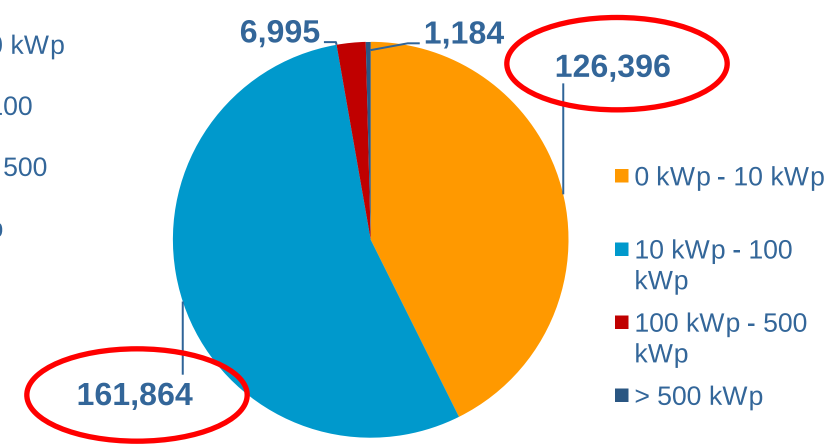
Small-scale systems: Germany 2010

- **Difficult to predict and monitor hundreds of thousands of investors**

German PV 2010 share of new installed capacity by size of installation

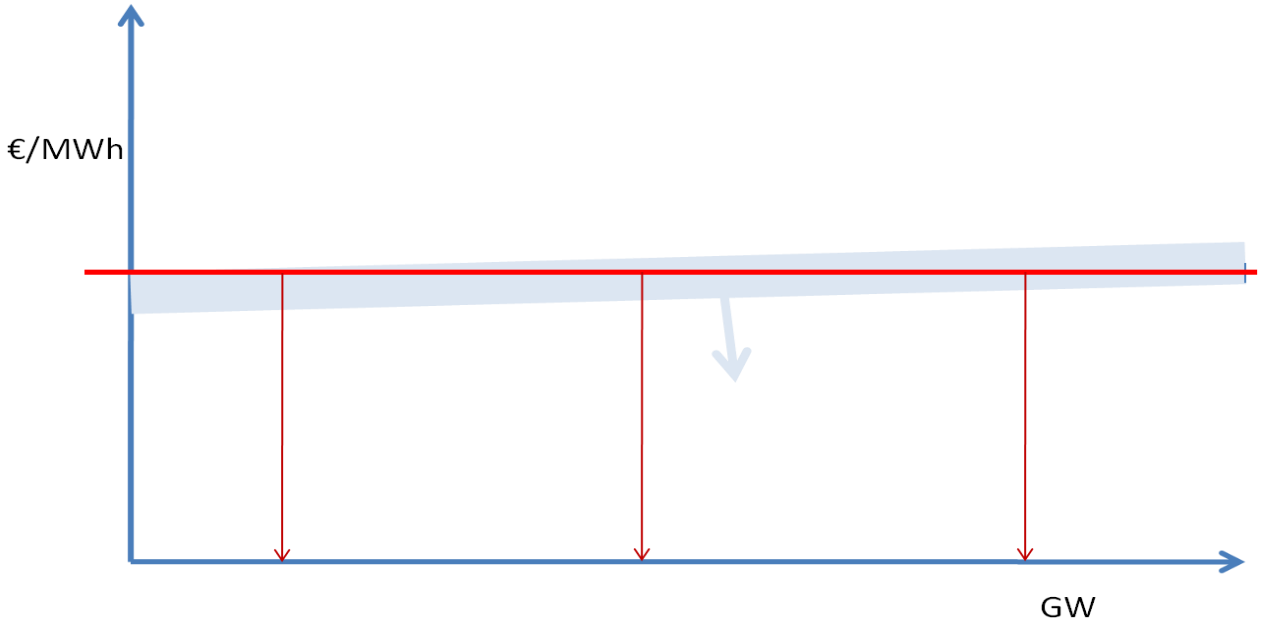


German PV 2010 number of new installations by size



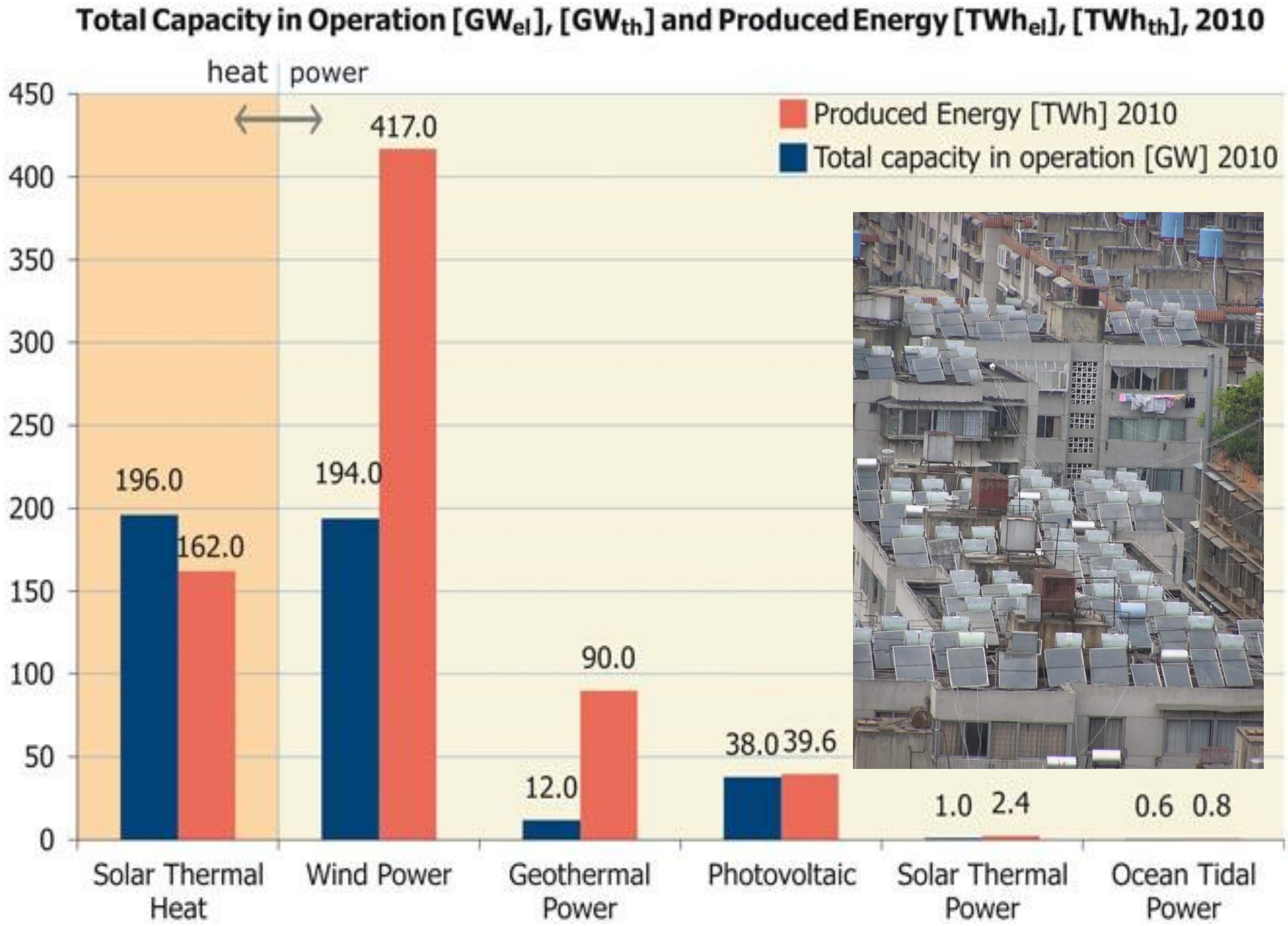
Source: Bundesnetzagentur , 2011

Will quantity caps be required?



- **Controlling overall costs by controlling the level of incentives appear difficult and risky**
  - **Uncertain and fast-changing costs, large potential**
  - **Political risks for FITs**
  - **But Germany may succeed**

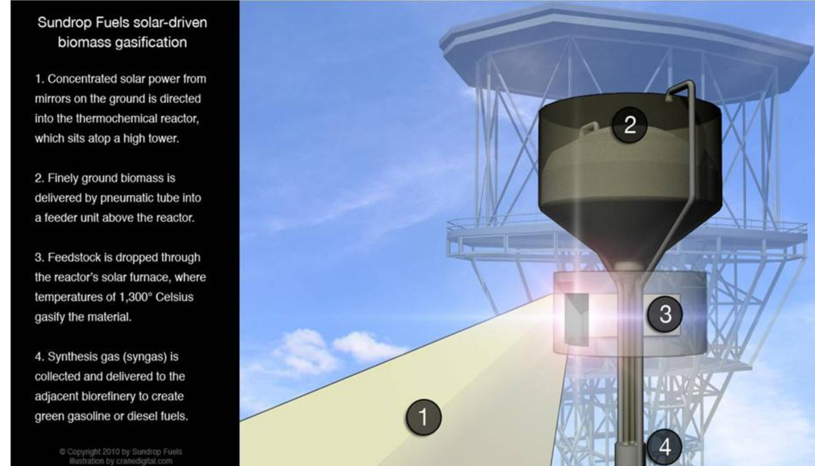
Solar heat: the current leader

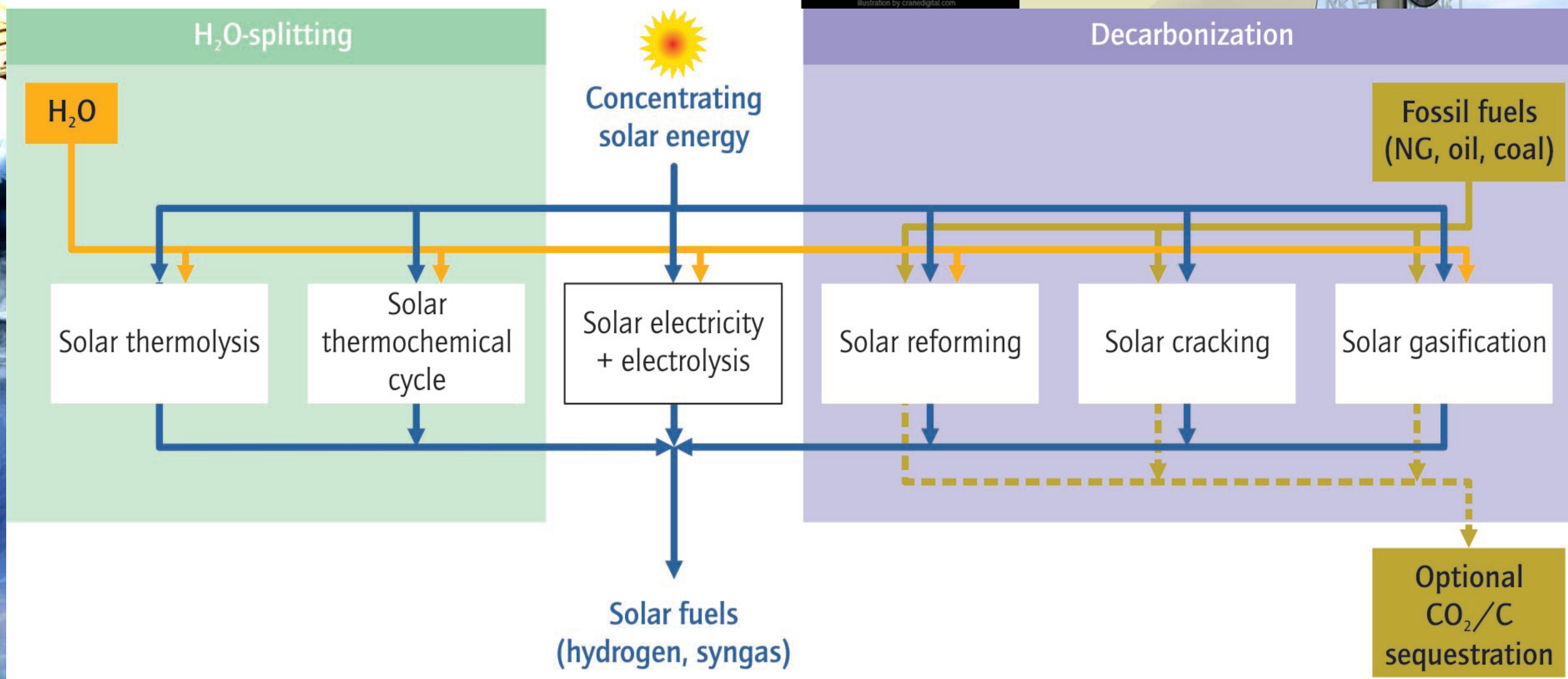


Source:PSI/ETH-Zürich

Solar fuels

Sources:PSI/ETH-Zürich/SundropFuels

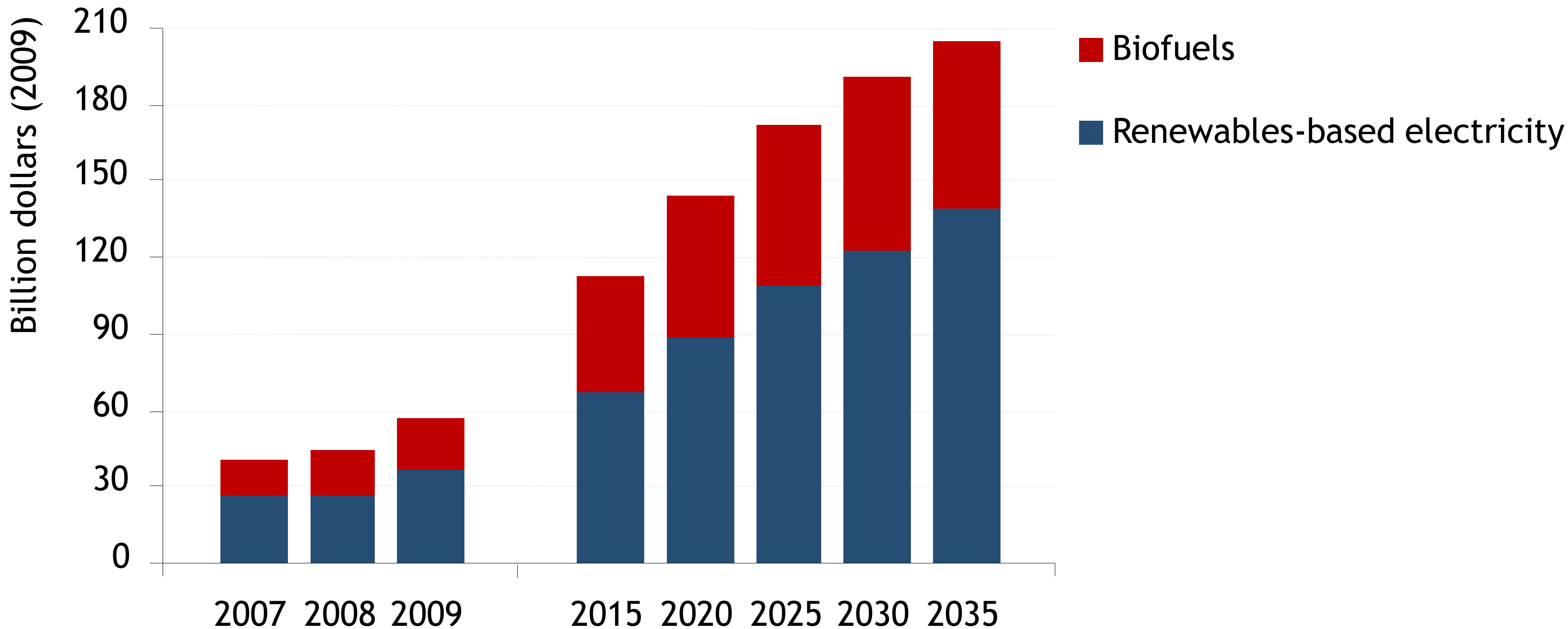




Another possible synergie between solar and coal for RSA: producing liquid fuels with lower CO_2 emissions

At global level, government support will continue to grow

Annual global support for renewables in the New Policies Scenario



Government support remains the key driver – rising from $57 billion in 2009 to $205 billion in 2035 – but higher fossil-fuel prices & declining investment costs also spur growth

Solar publication: a primer

- Publication in September
- All technologies, all sectors, all countries, all timescales

- **Markets and Outlook**
  - **Electricity**
  - **Buildings**
  - **Industry**
  - **Transport**
  - **Testing the limits**
  - **Policies**
- **Technologies**
  - **Photovoltaics**
  - **Heat**
  - **STE/CSP**
  - **Solar fuels**

A global approach

- **Solar energy has the potential to become the largest source of electricity, and contribute to heating, cooling, process heat, transport fuel**
- **The bulk of the forthcoming growth of energy demand is in sunny countries**
- **Solar may also change million lives with access to modern energy services**
- **Efforts/benefits need to be shared globally**
  - **“Spend wisely, share widely”**