Economics of Hybrid PV-Fossil Power Plants

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26th EU PVSEC, Hamburg, 2011, 5 - 9 September

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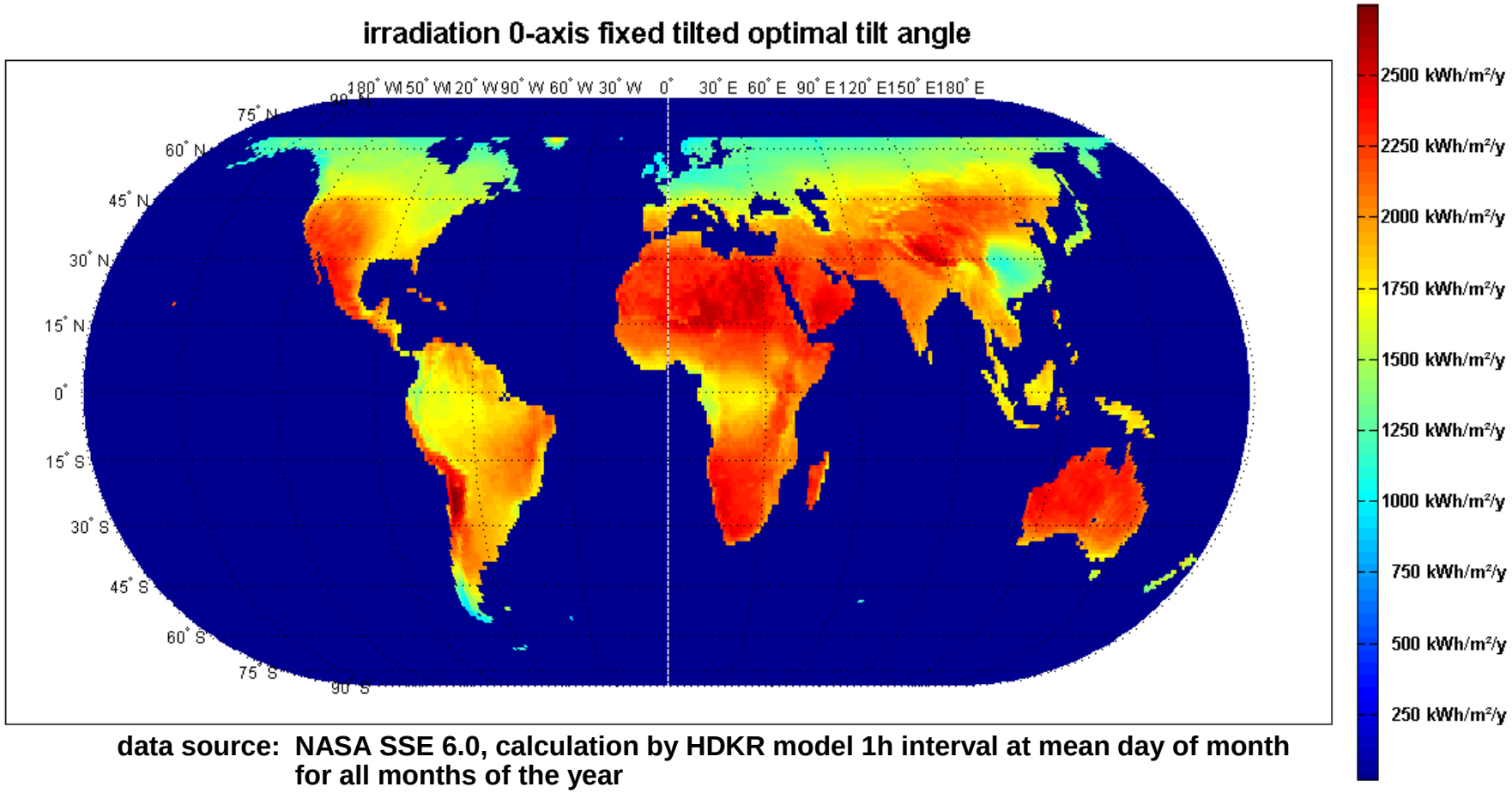
Outline

- **Fundamental PV Economics**
- **Fuel-Parity Concept**
- **Hybrid PV-Fossil: Global Demand Curve**
- **Conclusions**

Solar Resources: Fixed Optimally Tilted



data source: **NASA SSE 6.0, calculation by HDKR model 1h interval at mean day of month for all months of the year**

source: **Breyer Ch. and Schmid J., 2010. Global Distribution of optimal Tilt Angles for fixed tilted PV Systems, 25th EU PVSEC/ WCPEC-5, Valencia, September 6–10**

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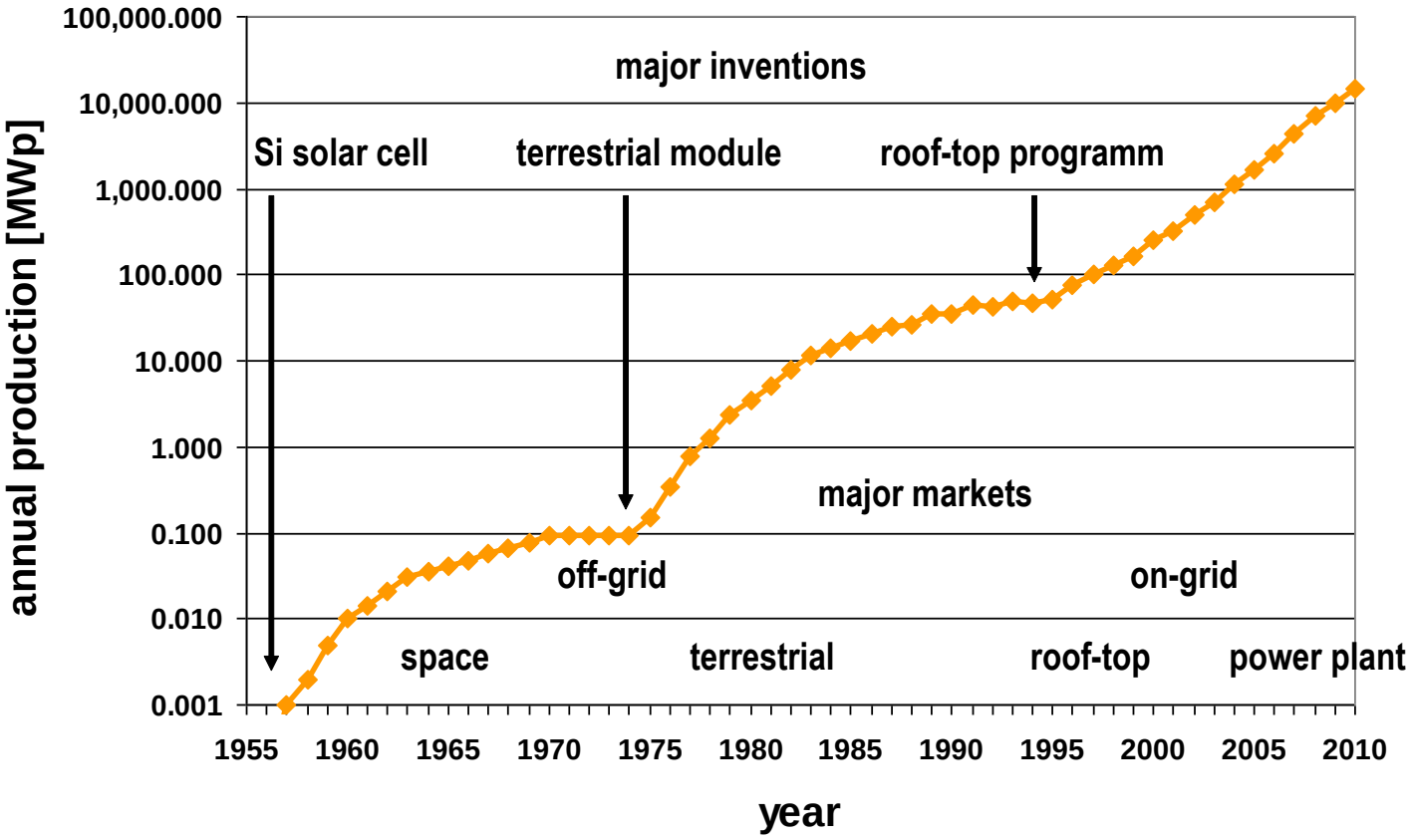
Historic PV Diffusion Phases



- constant high growth rates of >30% p.a. in all diffusion phases
- growth rate of 45% over last 15 years

source: Breyer Ch. et al., 2010. Research and Development Investments in PV – A limiting Factor for a fast PV Diffusion?, 25th EU PVSEC/ WCPEC-5, Valencia, September 6–10

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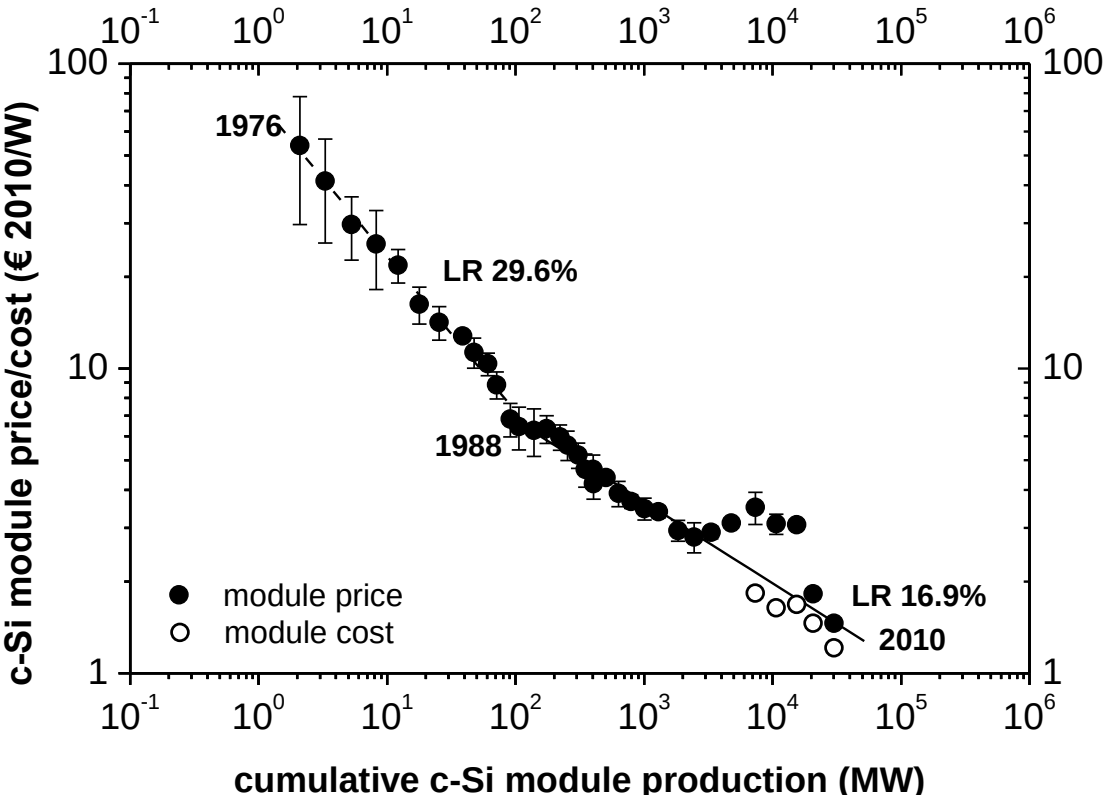
PV Learning Rate: Stable over 50+ years



- learning rates in comparable industries
  - ~40% DRAMs (by getting smaller)
  - ~35% flat panels (by getting larger)
- typical learning rates in power sector
  - ~10% renewable power (wind, STEG)
  - negative nuclear power
- similar learning rates for PV inverter
- technology base for ongoing cost reduction is fast growing

PV „BACK ON TRACK“ ON 17% LEARNING CURVE

doubling of cumulated production volume

⇩

-17% price reduction

source: Kersten F., Görig M., Breyer Ch., et al., 2011. PV-Learning Curves: past and future drivers of cost reduction, Poster 6CV.1.63

Breyer Ch. et al., 2010. Research and Development Investments in PV – A limiting Factor for a fast PV Diffusion?, 25th EU PVSEC/ WCPEC-5, Valencia, September 6–10

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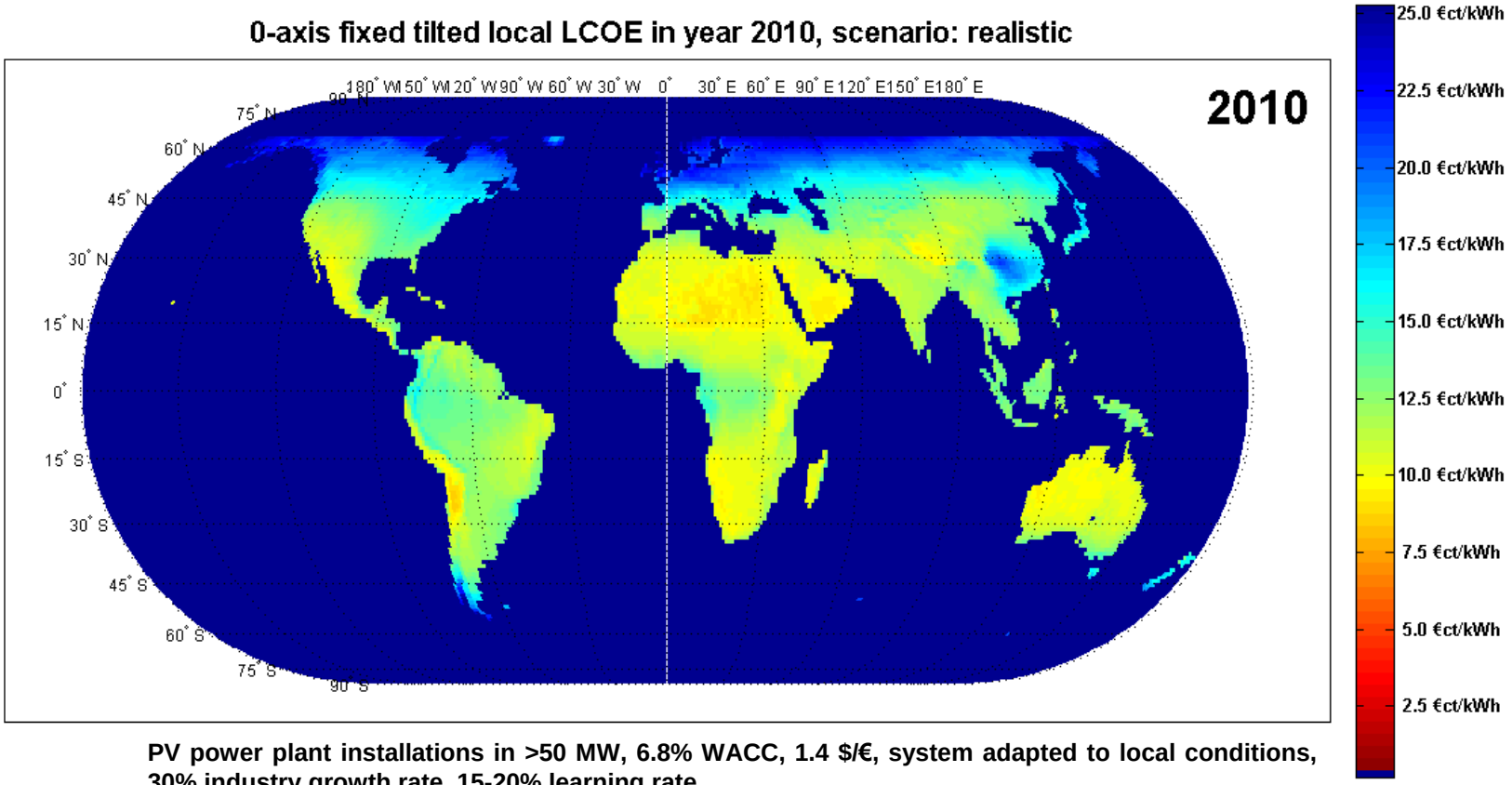
PV Cost Dynamics



PV power plant installations in >50 MW, 6.8% WACC, 1.4 $/€, system adapted to local conditions, 30% industry growth rate, 15-20% learning rate

source: **Breyer Ch. et al., 2010. Fuel-Parity: New Very Large and Sustainable Market Segments for PV Systems, IEEE EnergyCon, Manama, December 18–22**

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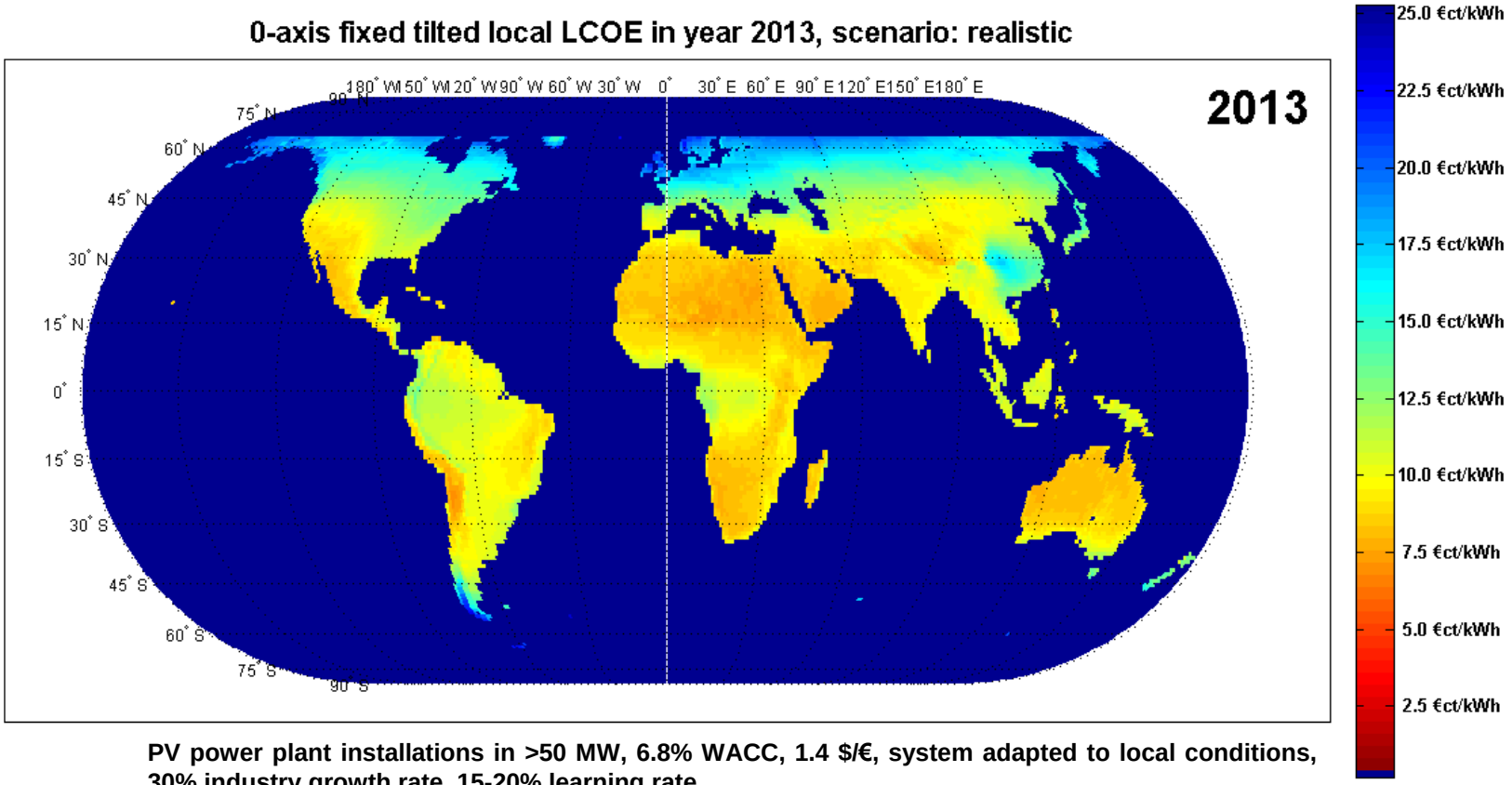

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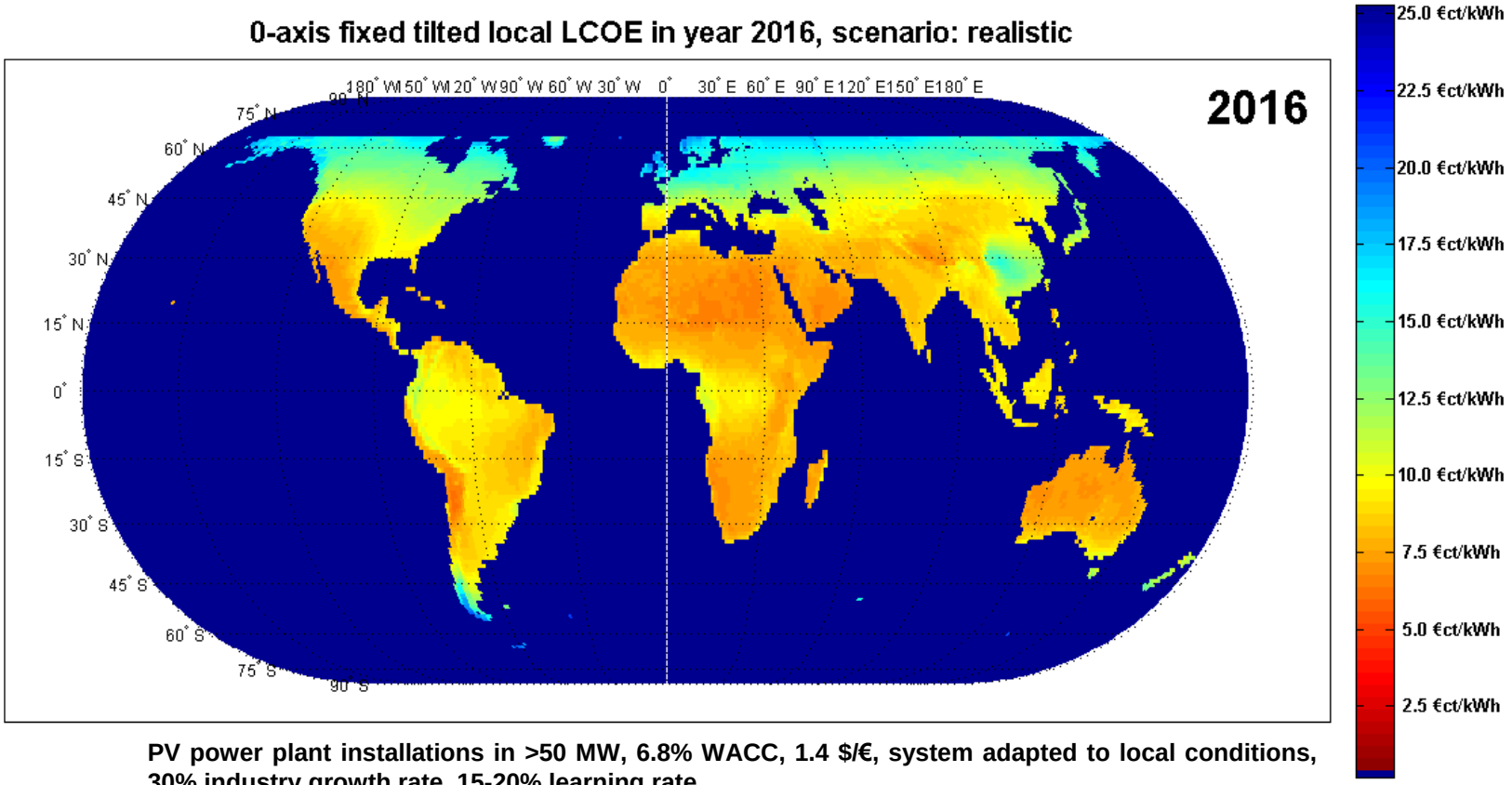

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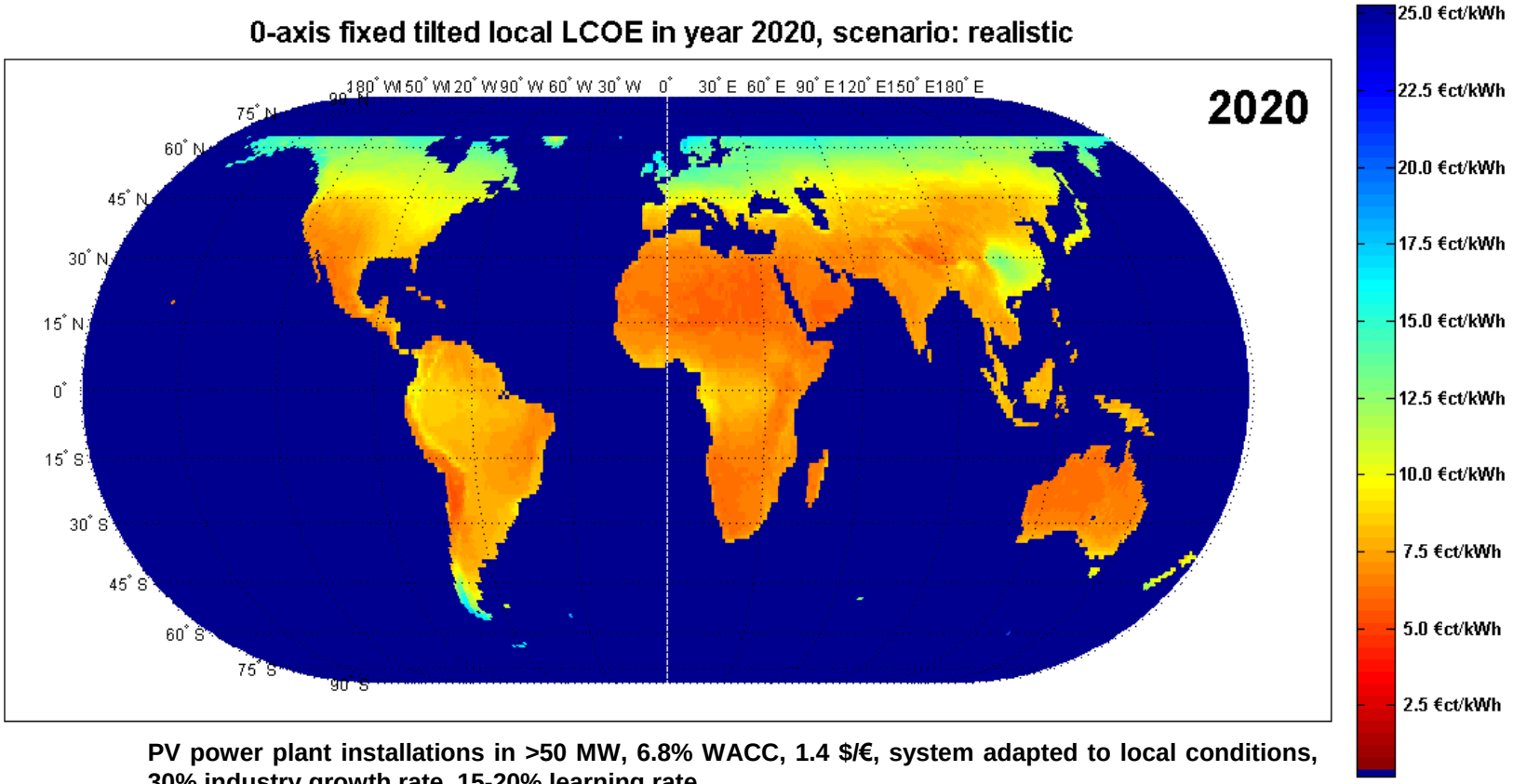

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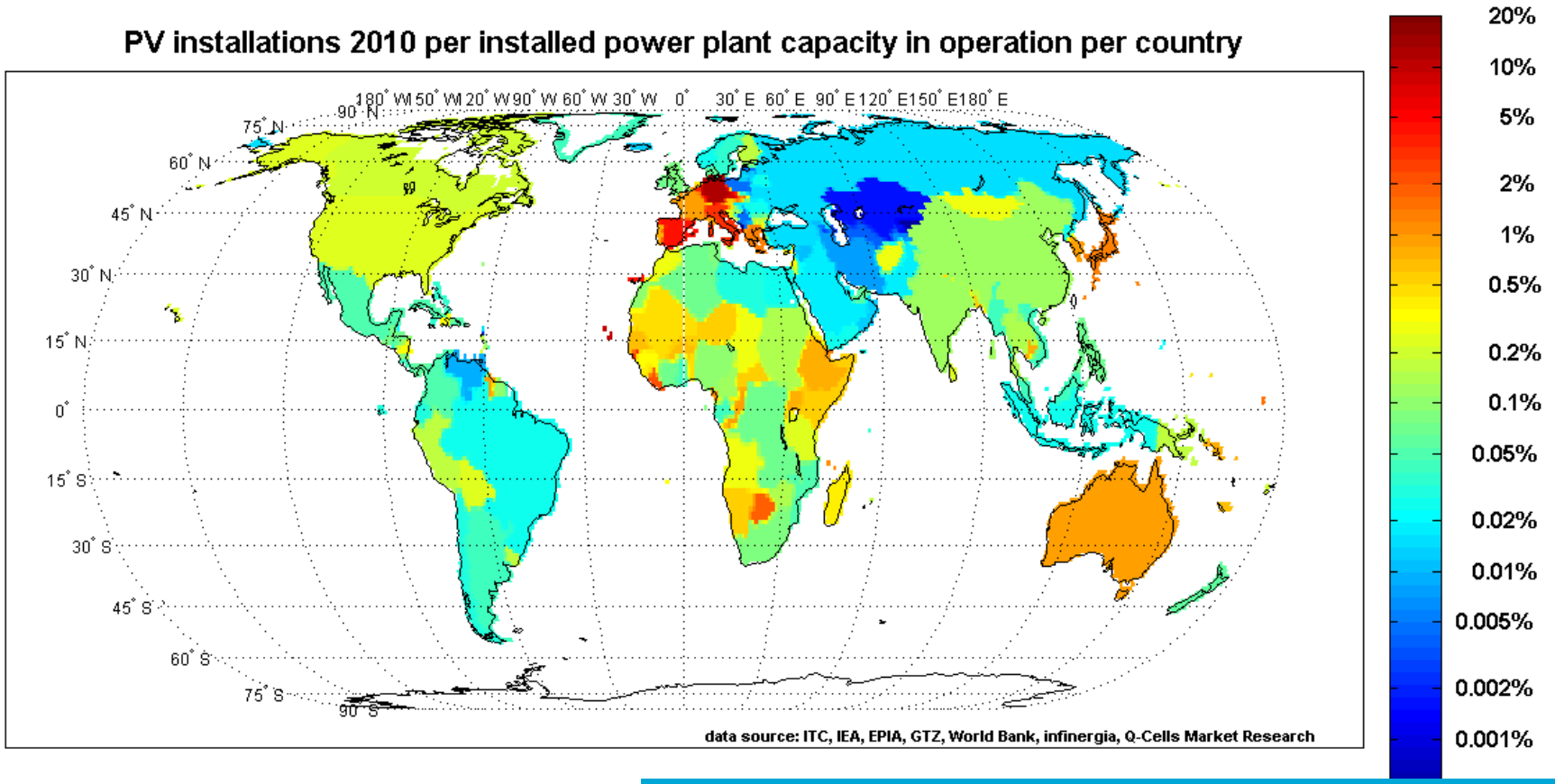
Relative Global Installed PV Capacity



source: Werner C., Breyer Ch., et al., 2011. Global Overview on cumulative installed Photovoltaic Power, Poster 6CV.1.8

Gerlach A.-K., Breyer Ch., et al., 2011. PV and Wind Power – Complementary Technologies, Poster 6CV.1.32

enormous market growth ahead,
since ~50%+ of conventional power capacity base could be supplemented by PV (there is NO competition to wind power)

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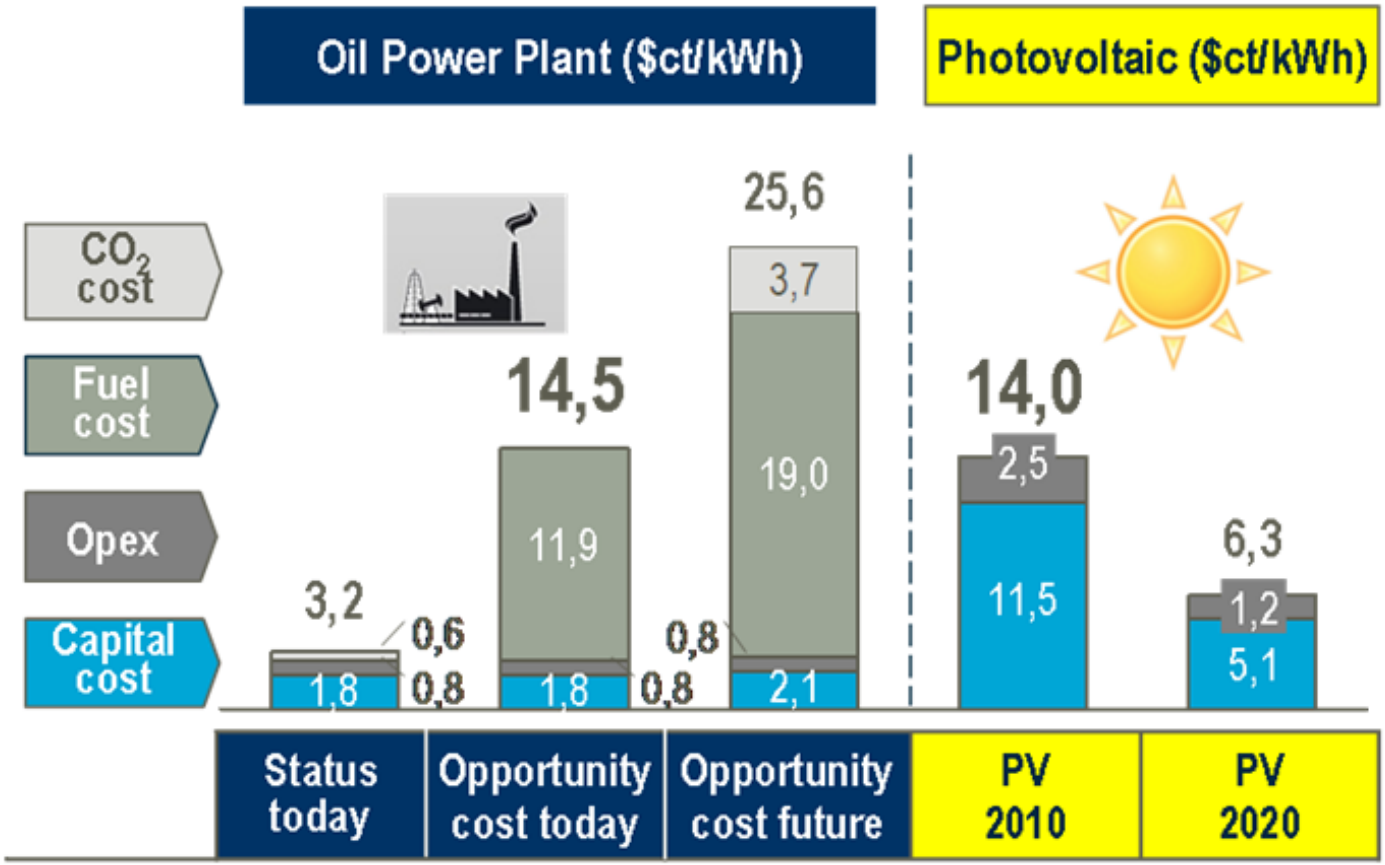
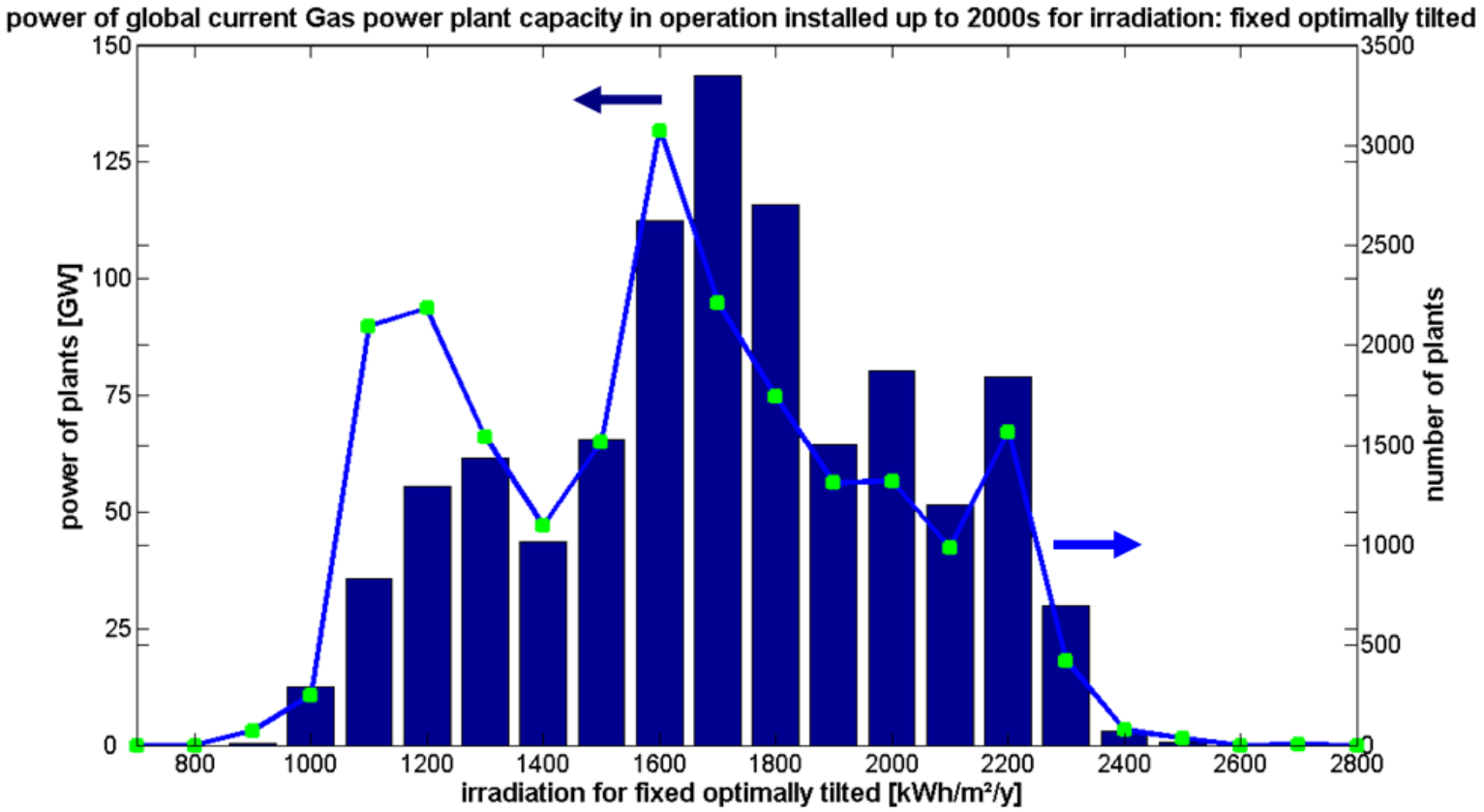
PV Oil Fuel-Parity in Sunny Regions



* oil production cost 4 $/barrel, world market price for opportunity cost today 80 $/barrel and in future 160 $/barrel, PV Capex 2000 €/kWp (2010) and 1000 €/kWp (2020), 5% WACC

Solar Location of Gas Power Plants



- georeferenced power plants are sorted by irradiation
- 1,100 GW gas power plants by end of 2000s, being equal to about 25% of global power capacity

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Major Requirements for Hybridization

technical

- **close location of PV and Fossil sub-plant, OR interconnected by nearby power lines**
- **flexible Fossil power plants, at least 24 hours ahead**
- **sophisticated energy meteorology**

economic

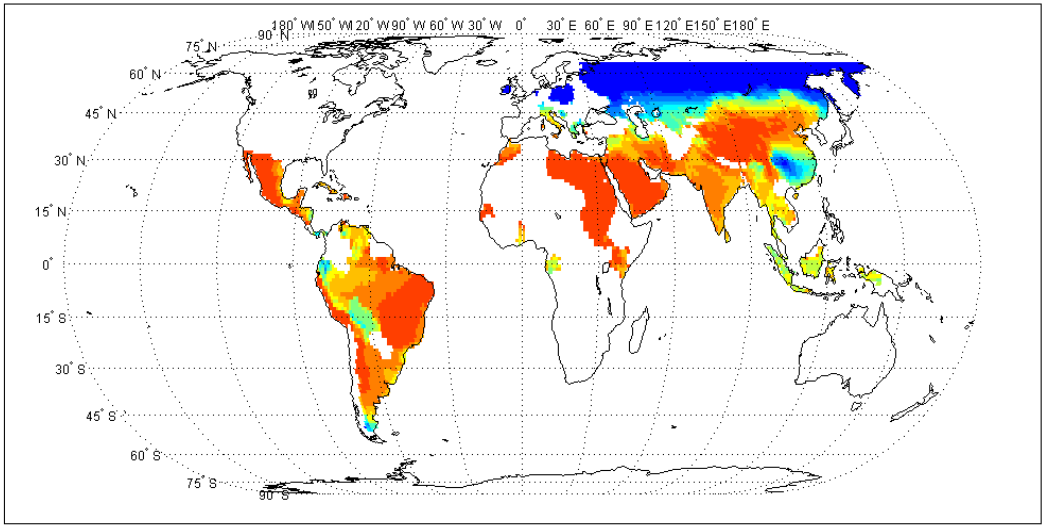
- **$LCOE_{fossil} > LCOE_{PV} + FLh\text{-}effect_{fossil}$**
- **substituted fossil fuels can be sold on the world market**
- **fossil power plants to be upgraded need to be in operation at daytimes today**

PV Fuel-Parity for Oil and Gas in 2010s

Results:

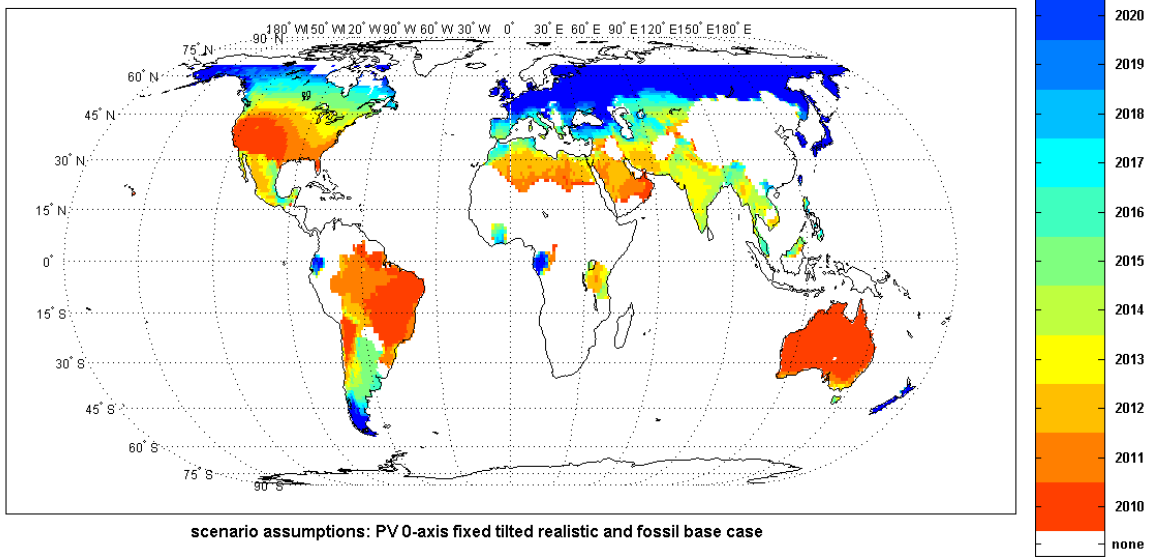
- **Oil LCOE for fuel only (least marginal cost) are higher than PV LCOE in early 2010s in most regions in the world**
- **Gas LCOE for total plant cost begin to be higher than PV LCOE in early 2010 (note: current gas to oil fuel price coupling is lower than for the historic average)**

Parity of PV and Oil fuel LCOE for local FLh >2000 h



scenario assumptions: PV 0-axis fixed tilted realistic and fossil base case

Parity of PV and Gas total LCOE for local FLh >2000 h



scenario assumptions: PV 0-axis fixed tilted realistic and fossil base case

Scenario assumptions:

- **only power plants in countries of at least 2000 FLh regarded**
- **fuel price scenario of 80 $/barrel, escalating by 3% p.a. in real terms**
- **coupling of gas and coal price to oil price according to historic average**
- **realistic but competitive PV Capex**

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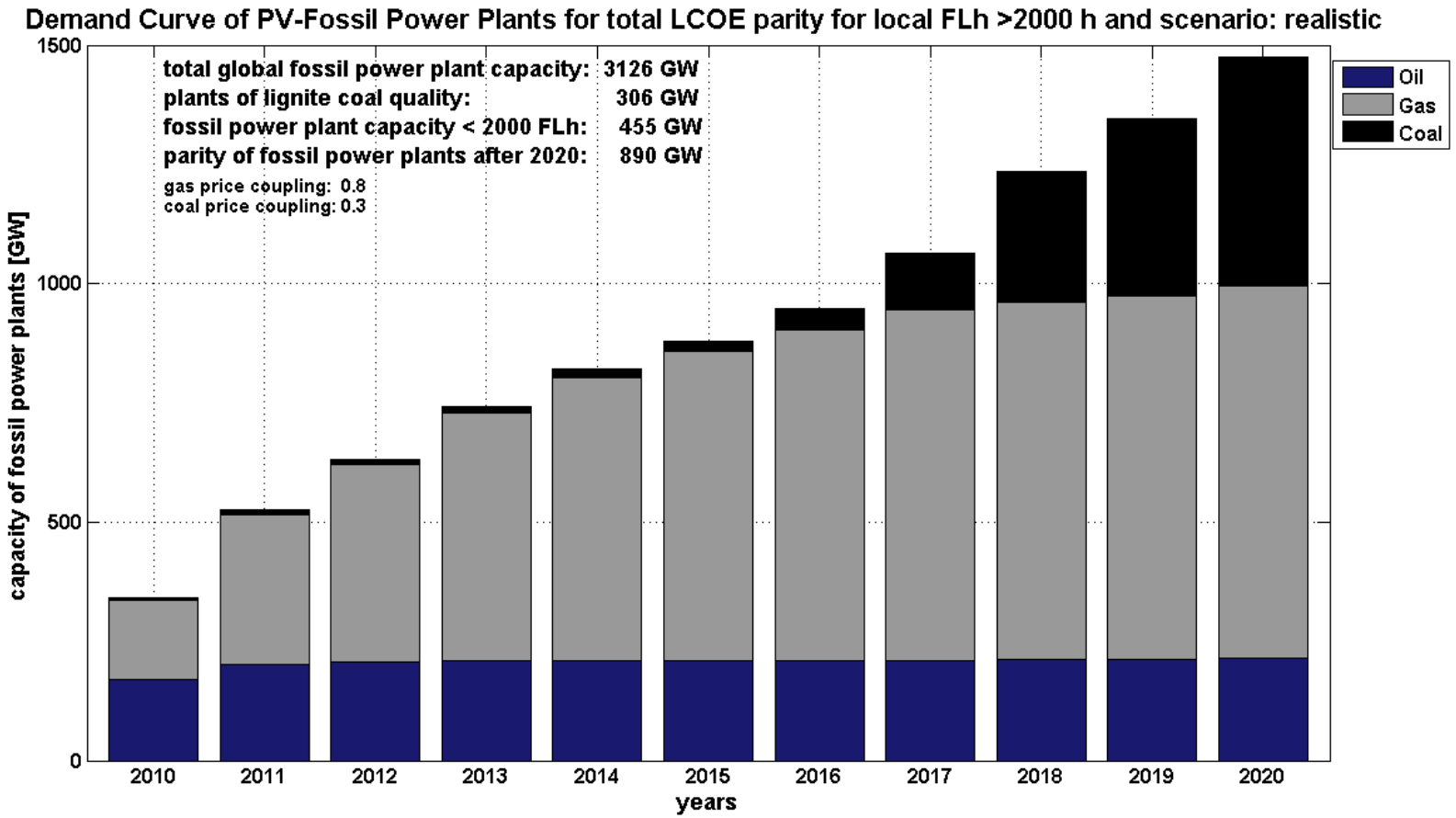
Hybrid PV-Fossil: Global Demand for the 2010s



$\text{total LCOE}_{\text{fossil}} > \text{total LCOE}_{\text{PV}} + \text{FLh-effect}_{\text{fossil}}$

more optimistic assumptions would lead to up to 2,300 GW economic upgrading potential

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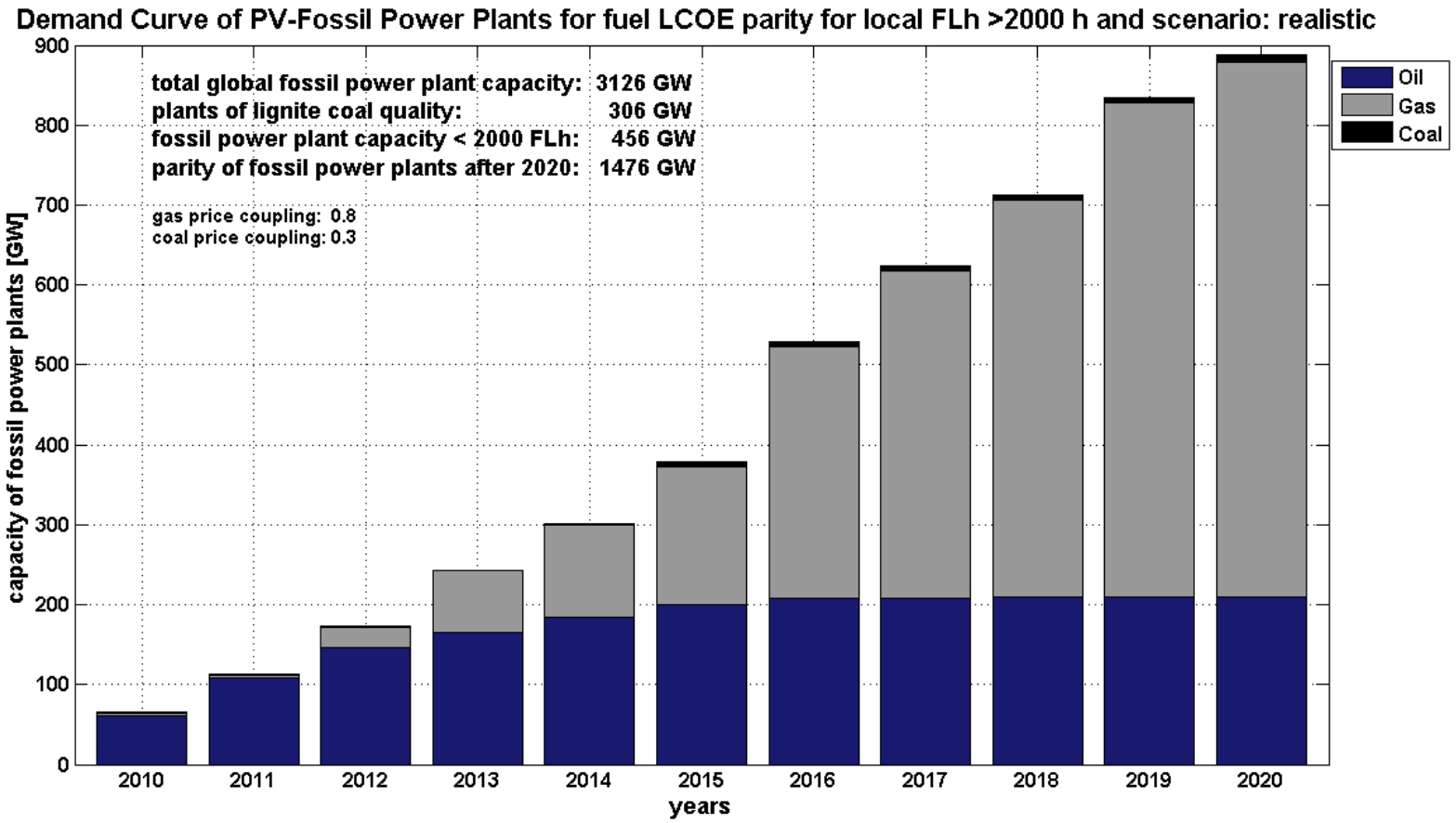
Hybrid PV-Fossil: Global Demand for the 2010s



fuel $LCOE_{fossil}$ > total $LCOE_{PV}$ + $FLh\text{-}effect_{fossil}$

more pessimistic assumptions would lead to at least 700 GW economic upgrading potential

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Conclusions

- ongoing fast PV cost reduction is very likely
- global PV electricity supply still neglegible, BUT fast growing
- upgrading of fossil fuel power plants by PV possible
- market for hybrid PV-Oil plants has already started
- market for hybrid PV-Gas plants on the close horizon
- market for hybrid PV-Coal plants at the end of the 2010s
- market for hybrid PV-Fossil plants: 700 – 2300 GW by 2020

THANK YOU.

in particular to our colleagues: Chris Werner, Friederike Kersten, Oliver Beckel and Dominik Huljić

all referenced papers can be found at www.q-cells.com or www.reiner-lemoine-institut.de

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