How Grid Parity is going to change Global PV Markets

Ruggero Schleicher-Tappeser

sustainable strategies, Berlin

BSW AK Export, 2010-09-21, Berlin

English version, updated 2011-01

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Overview

1. What is Grid Parity?
2. The influencing factors
3. Frame conditions remain most important
4. The new roles of market participants
5. Captive production in markets with weak grids
6. Integrated systems: Standardisation lowers risks and costs
7. How to capitalise on hidden wholesale grid parity
8. Consequences for export strategies

WHAT IS GRID PARITY ?

What is grid parity?

Usual definition on the consumer level:

Costs of electricity from PV installation = price of electricity from the grid

grid parity retail (for households, commerce, industry)

Second step – grid parity on the power plant level:

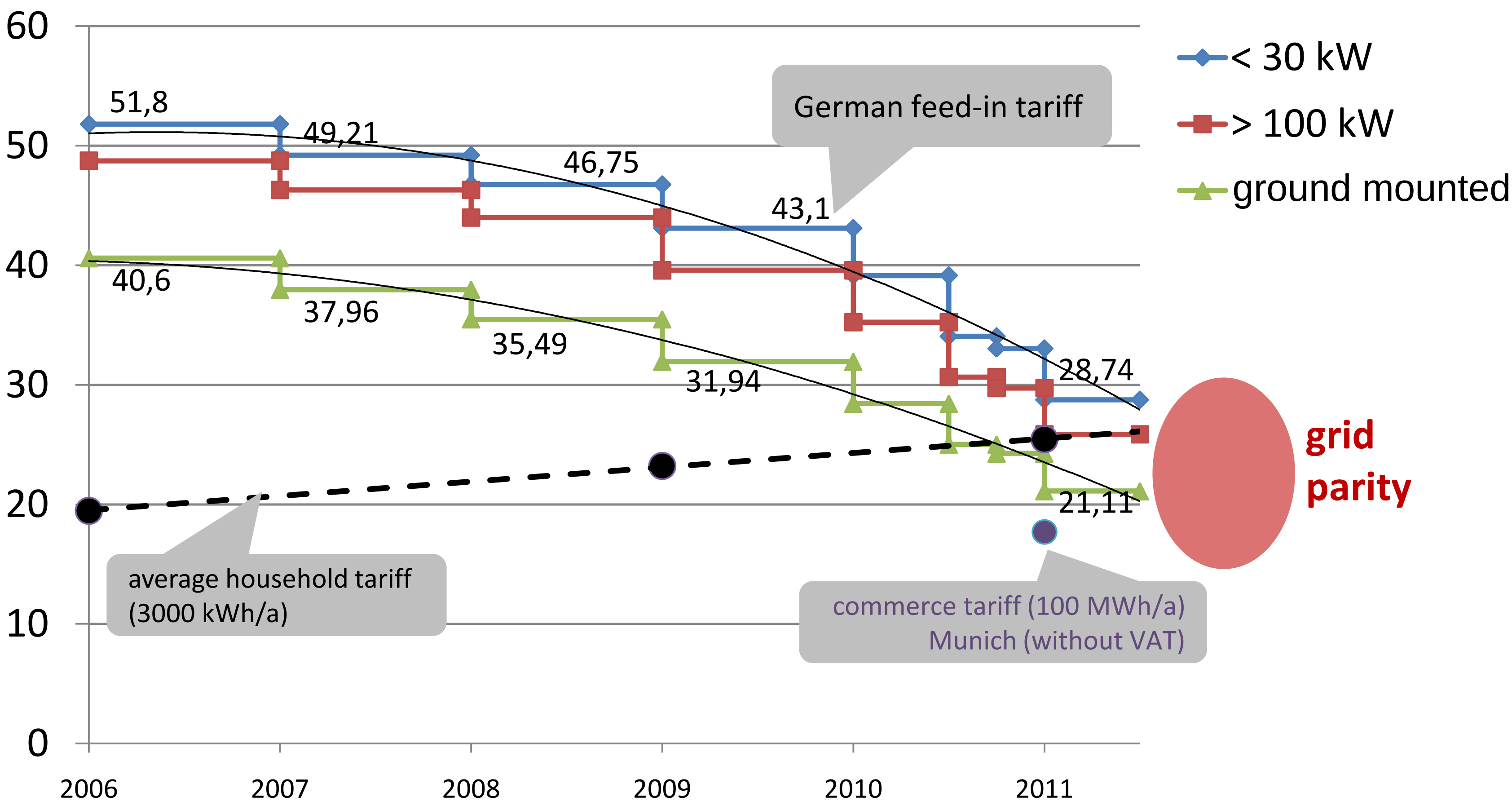
Costs of electricity from PV installation = wholesale price of electricity

grid parity wholesale (electricity exchange, power plants)

This regards average electricity costs

Grid parity, at first, has nothing to do with time-dependent prices

Rapidly decreasing German feed-in-tariffs: grid parity expected for 2012



ruggero@schleicher-tappeser.eu

Development in several steps

1. Today

- wholesale price < consumer tariff < cost of PV power

→ support required

2. Tomorrow: grid parity retail

- wholesale price < cost of PV power < consumer tariff

→ captive PV power production without support

3. Day after tomorrow: grid parity wholesale

- cost of PV power < wholesale price < consumer tariff

→ PV power plants without support

Grid parity Forecasts e.g. E&Y

Rank	Retail grid parity			Wholesale grid parity								
	Solar PV			Solar PV			Solar CSP			Onshore wind		
	Country	Year	Cost type	Country	Year	Cost type	Country	Year	Cost type	Country	Year	Cost type
1	US (New York)	2012	Max	Italy	>2030	Average	US (California)	2025	Min	UK	2017	Min
2	US (California)	2012	Min	US (California)	>2030	Min	Spain	2027	Min	Italy	2017	Average
3	Germany	2014	Max	US (New York)	>2030	Max	Italy	>2030	Average	US (New York)	2020	Average
4	Italy	2014	Average	Germany	>2030	Max				Germany	2025	Max
5	UK	2015	Max	Spain	>2030	Min				Spain	2027	Average
6	Spain	2017	Min	UK	>2030	Max				US (California)	2030	Max

Offshore wind: all >2030

THE INFLUENCING FACTORS

When will grid parity be reached? Influencing factors

- Electricitry prices in the country considered — €/kWh

- Solar radiation
- Performance of the installation

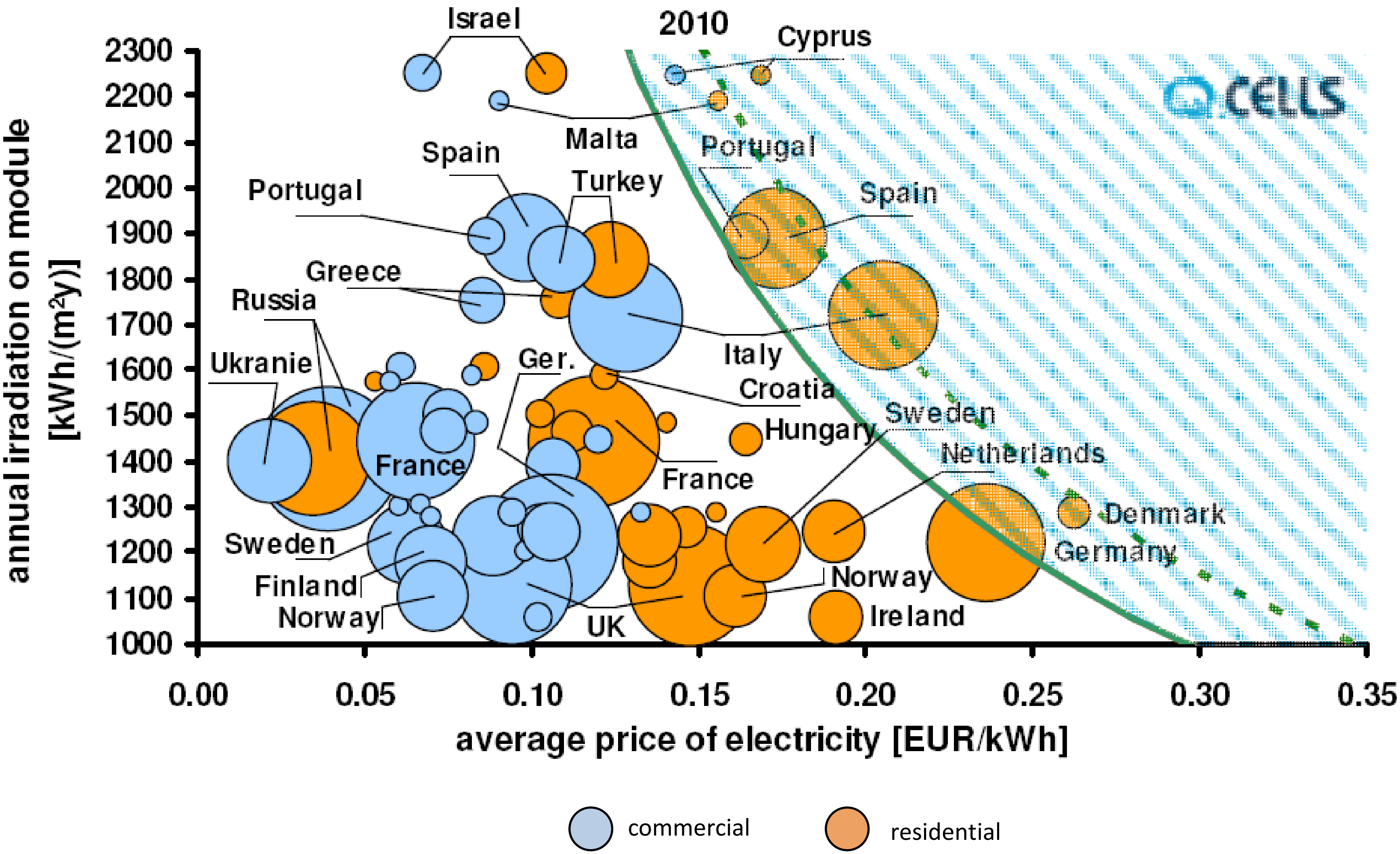
} kWh/kWp

- Investment costs PV
  - Project development, planning
  - Components
  - Installation
- Financing

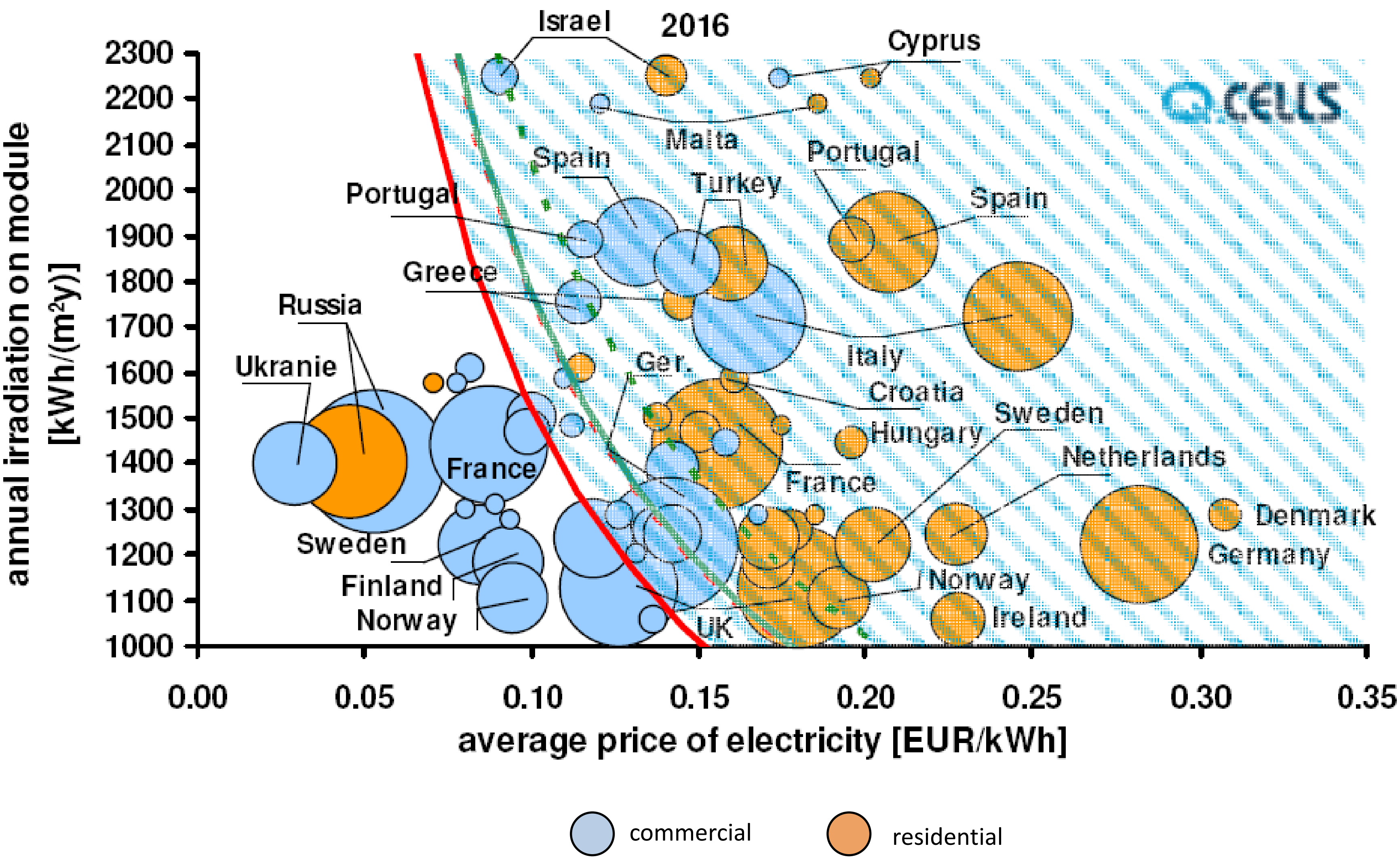
} €/kWp

kWh/kWp + €/kWp } €/kWh

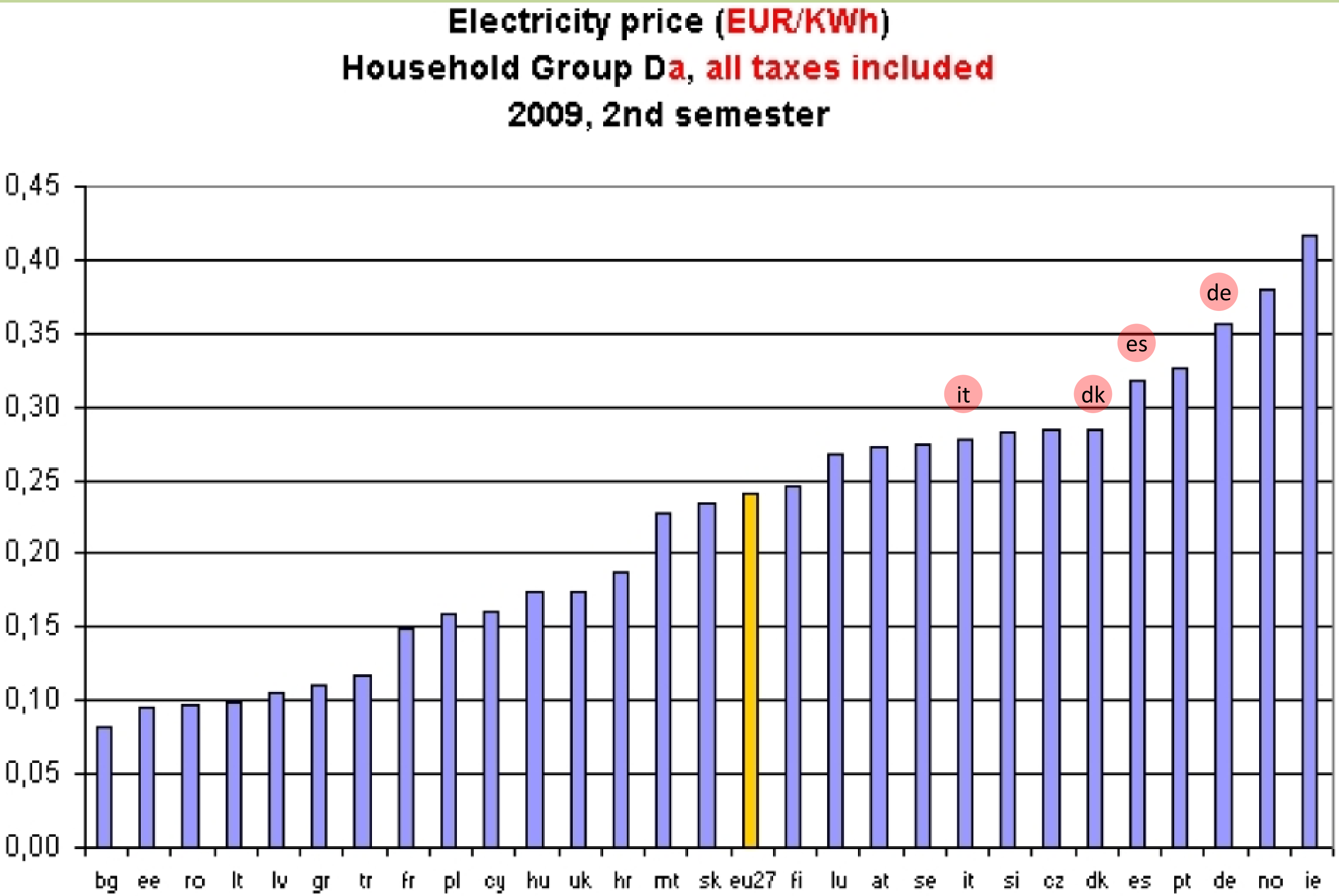
Grid parity in Europe 2010



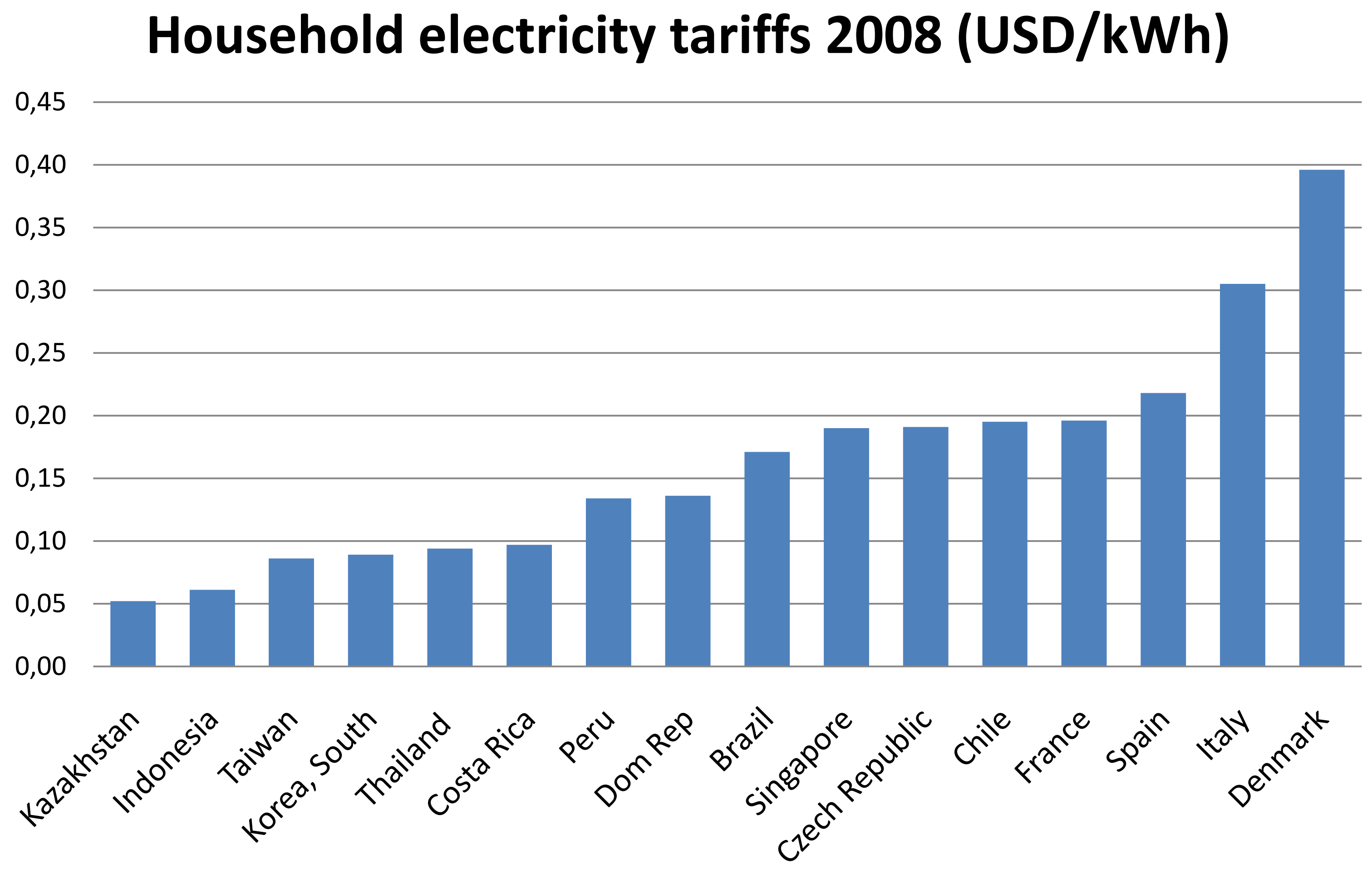
Grid parity in Europe 2016



Variation of household electricity tariffs in the EU

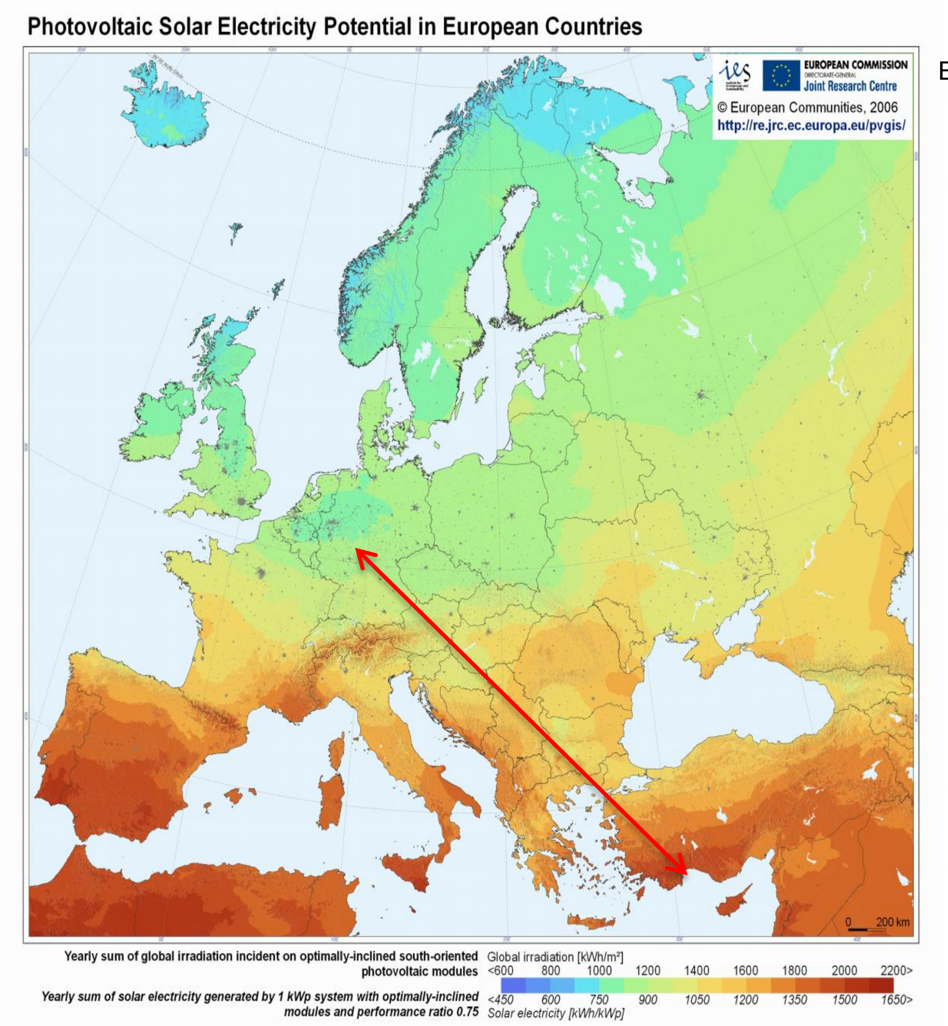


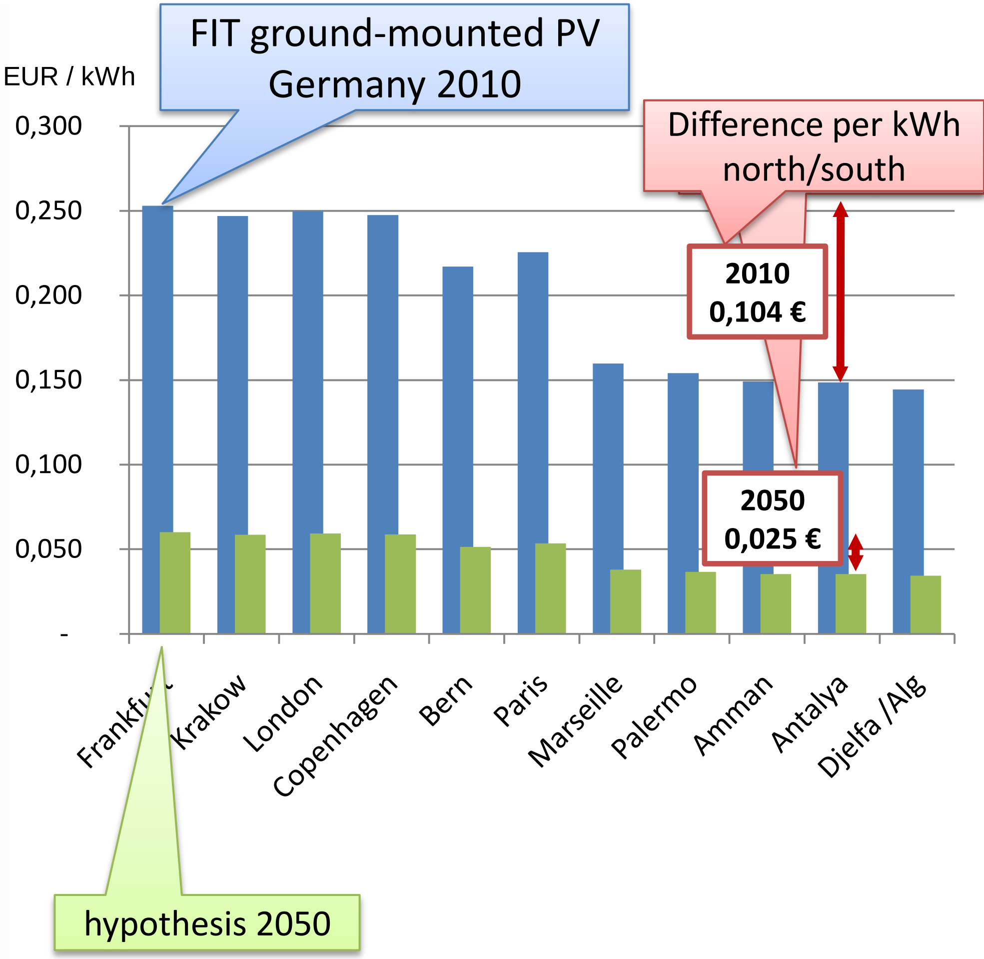
In many countries subventions keep electricity tariffs down



Source: EIA

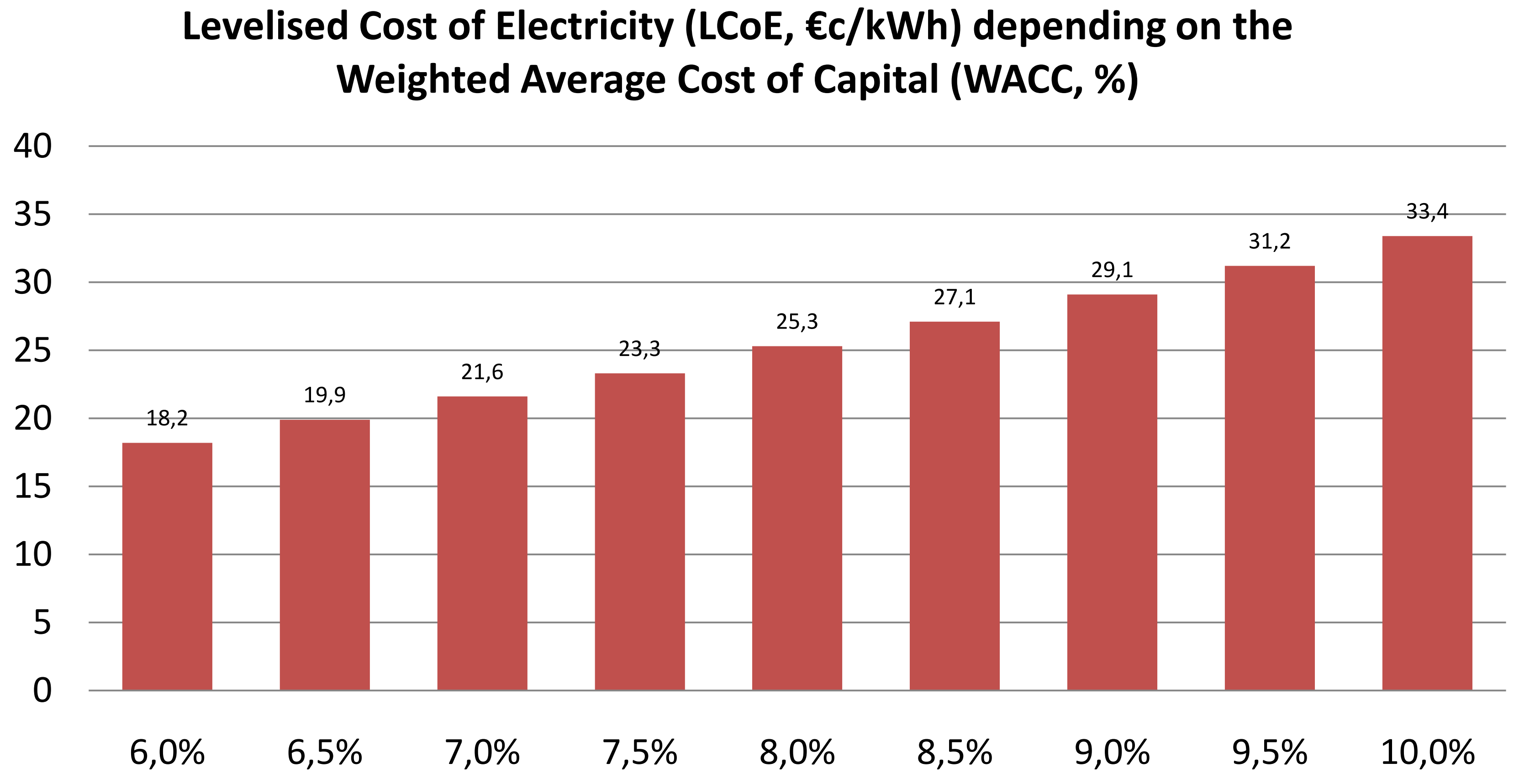
The influence of differences in solar radiation





Data: http://sunbird.jrc.it/pvgis

The influence of capital costs



Example for a PV plant costing 3,43 USD/Wp

Challenges for financing

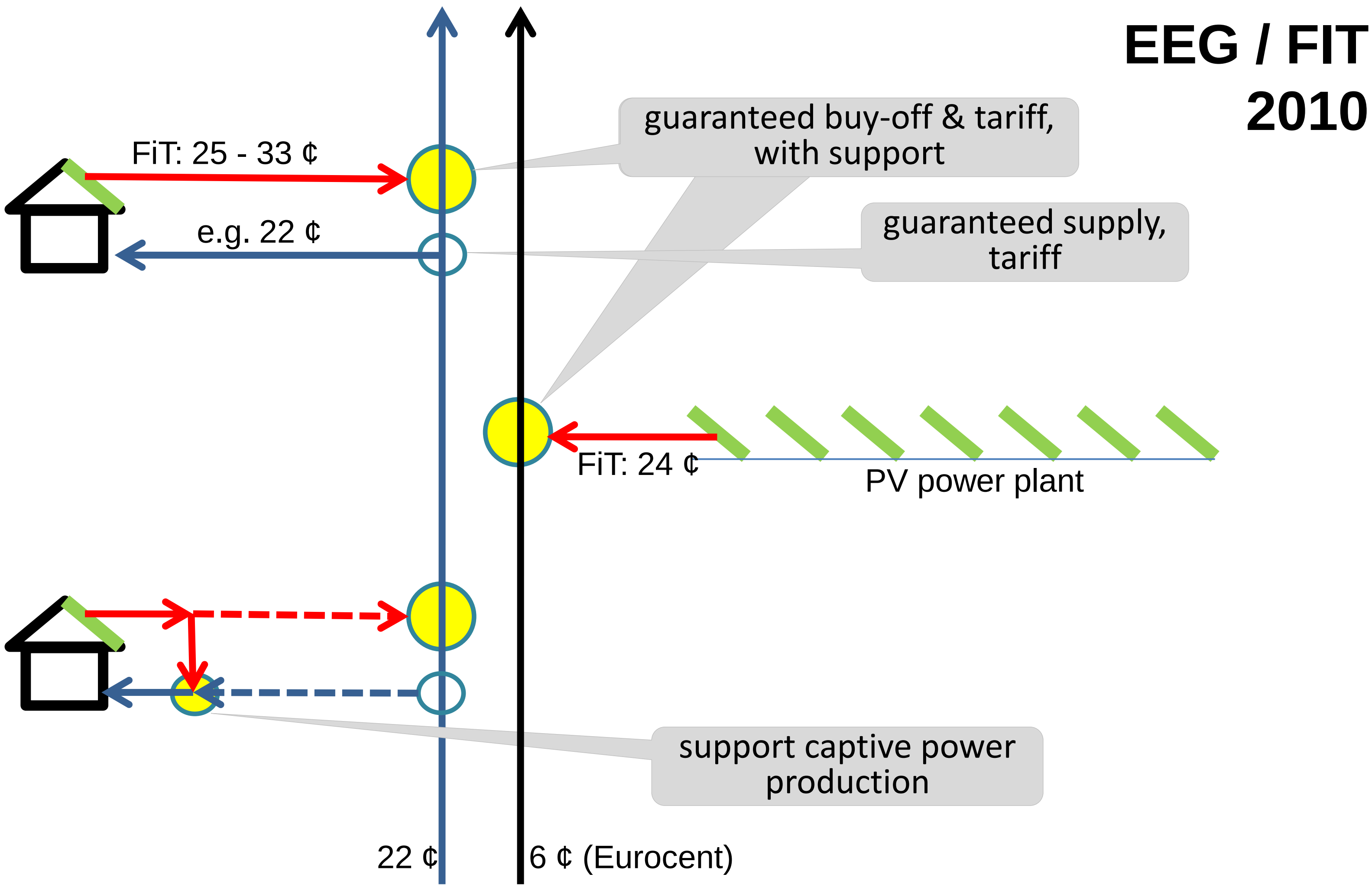
- Investment costs high / operational costs negligible
  → Financing extremely important for overall costs
- Time horizon > 20 years → risk assessment important, difficult in economies with high growth rates
- Relatively new and unknown technologies
  → difficult risk assessment for banks and investors
  → experience and high market penetration important
- Standardisation relatively low
  → high planning costs, specific risk assessment required, nearly no second hand market, long project duration
- Small projects, new actors
  → new business models required, new opportunities

ALSO WITH GRID PARITY: FRAME CONDITIONS REMAIN MOST IMPORTANT

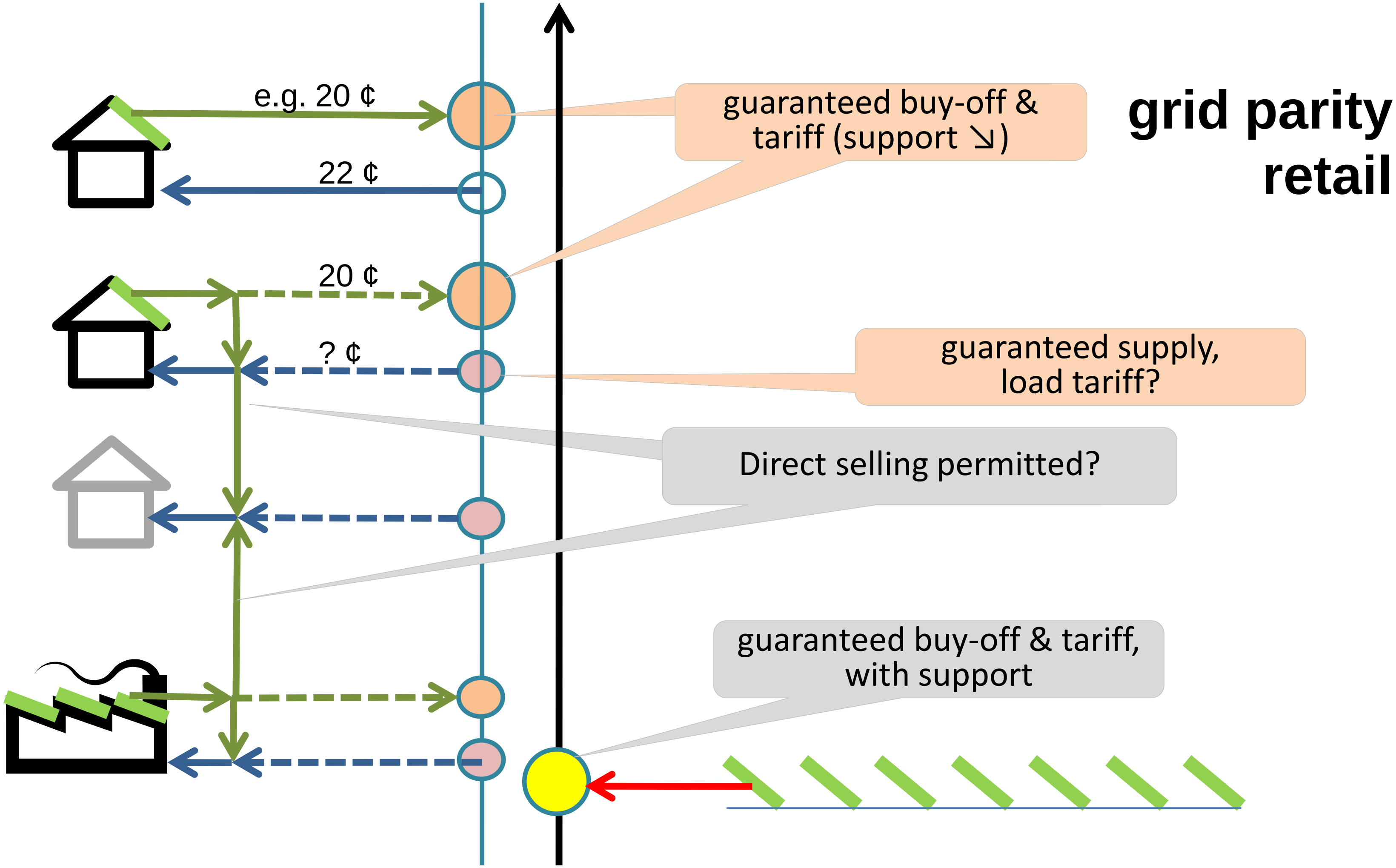
The effects of grid parity on the consumer level

1. Costs of PV electricity approach costs of electricity from the plug
   → decreasing costs of support
   (not yet zero, since PV power is not yet always at the right time in the right place)
2. Captive power production becomes interesting for consumers
   → electicity market being changed from the bottom
   (how quick, depends on regulation, technology, business models, market participants)

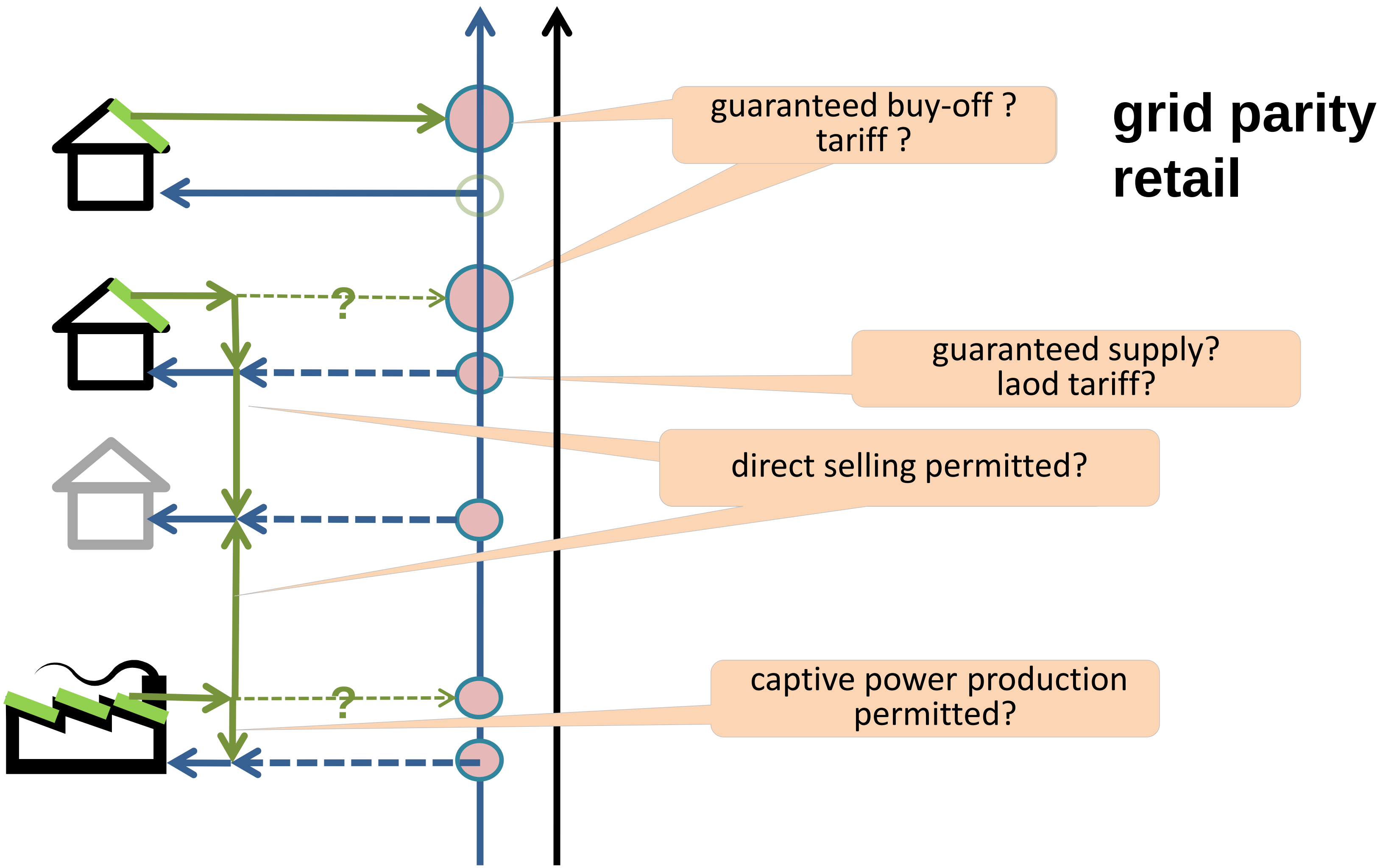
Stages on the way to competitiveness: markets with support – German FIT 2010



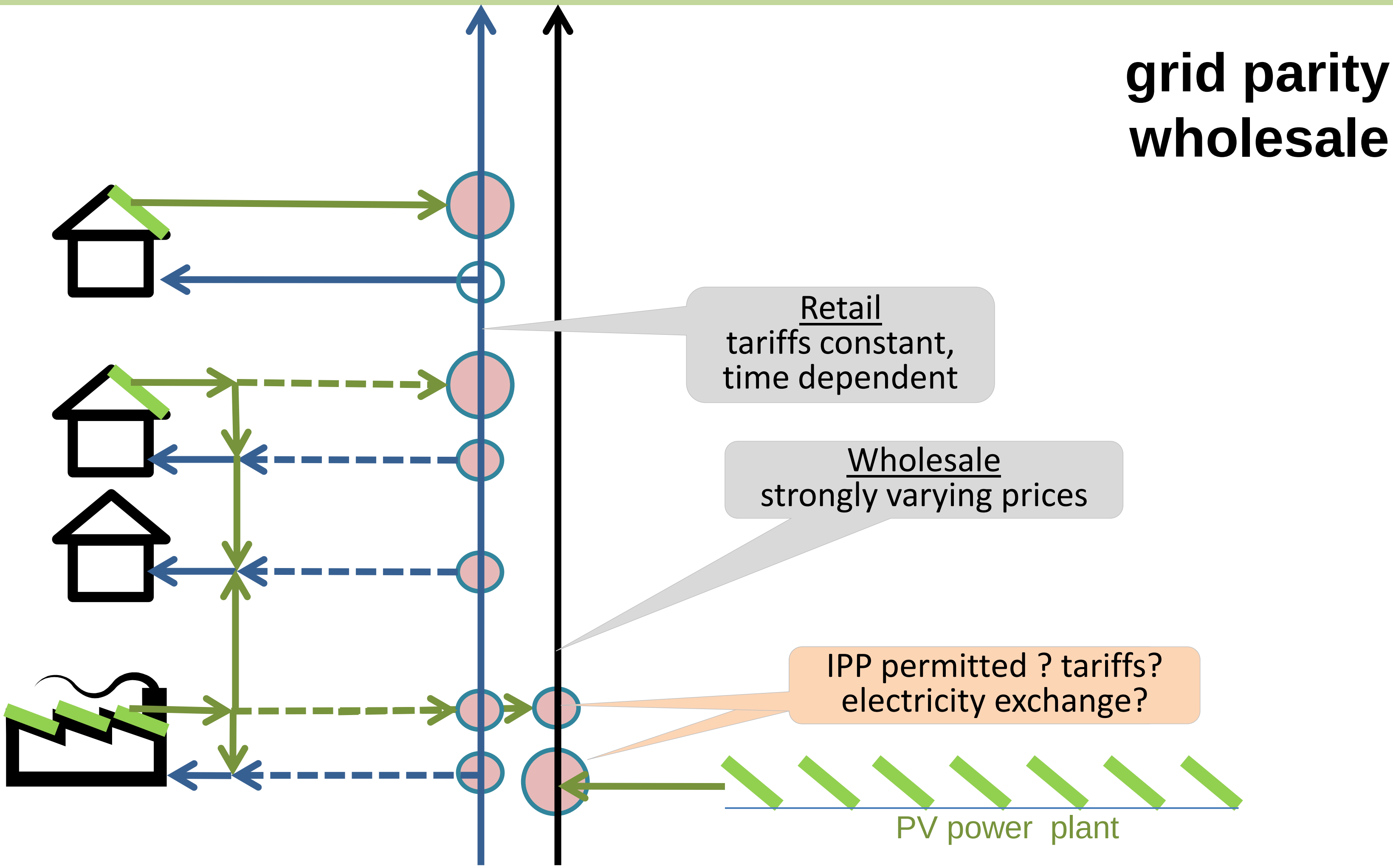
Grid parity retail in markets with support: Regulation and support remain most important



Grid parity retail in markets without support: Also here: regulation is most important



Grid parity wholesale in all markets



Grid parity on the consumer level: regulation is decisive

- <u>Attractiveness of captive power production</u> depends on regulation
- Investments in PV installations need <u>long-term ensured frame conditions</u>
- <u>Connection to the grid remains important</u>,
  Conditions must be set in a reliable way
  - ← supply of additional power from the grid
  - → feeding into the grid
- Particularly owners of small installations depend on the existence of <u>simple rules</u>
- Feed-in-tariffs are not getting obsolete with grid parity
  – but the support component can be reduced

Captive power generation, storage, load management

- With grid parity at the consumer level captive power production becomes an attractive alternative to buying power from the grid – as long as conditions for this supply do not change
- For captive power generation, the load curve of different groups of consumers (households, commerce, industry) is more or less appropriate
- The extent of captive power production can be raised through
  - load management (shift in time, use of thermal storage)
  - supplementary, less time-sensitive loads (e.g. heat pumps)
  - combination of different kinds of consumers, combined power plants
  - electricity storage
- The grid maintains a buffer function, which gets more expensive per kWh as the importance of captive power generation grows

Is captive power production positive for the overall electrical system?

- For the national economy, captive power generation makes sense if it
  1. contributes to relieving overloaded grids
  2. contributes to load management and thereby to the integration of RE power
  3. contributes to an increased reliability of supply
  4. strengthens competition and limits the influence of private oligopolies
  5. enhances the shared responsibility and commitment of citizens and companies for the transformation of the energy system
- The influence of captive power production on the grid depends on
  - the extent of captive power production
  - the growth of electricity consumption
  - the load curve of the remaining power demand

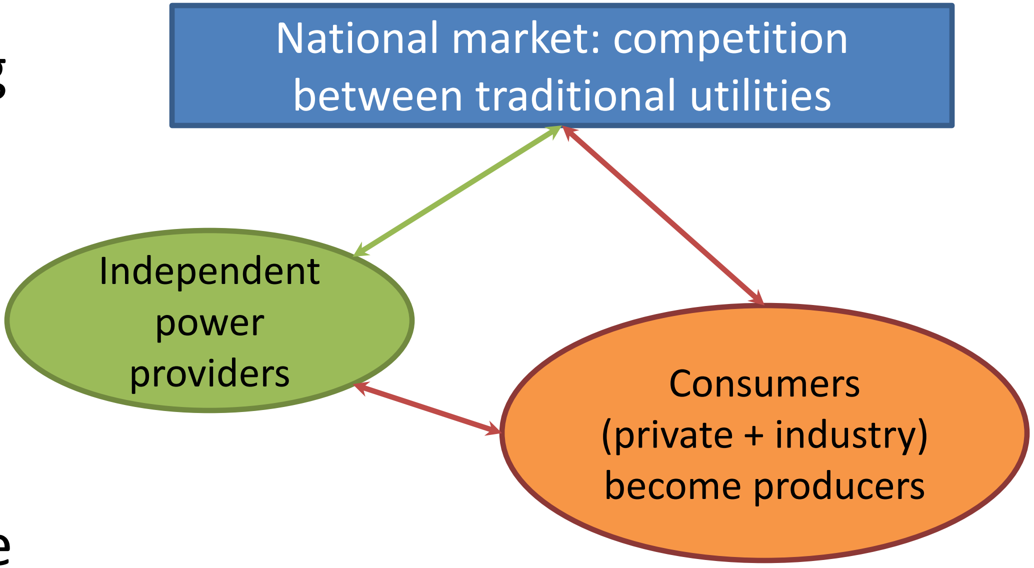
→ it can have stabilising and destabilising effects – appropriate stimuli (e.g. time dependent tariffs) can steer the effect

→ With an appropriate regulation, captive power production can become very advantageous from an overall economic point of view

NEW ROLES FOR THE MARKET PARTICIPANTS

PV grid parity brings new actors into the game

- New technologies bring an alternative at the level of the wall outlet
- A new market at this level puts into question existing regulation and the role of utilities
- Captive power production (production for own consumption) will increase, the market share of utilities will decrease



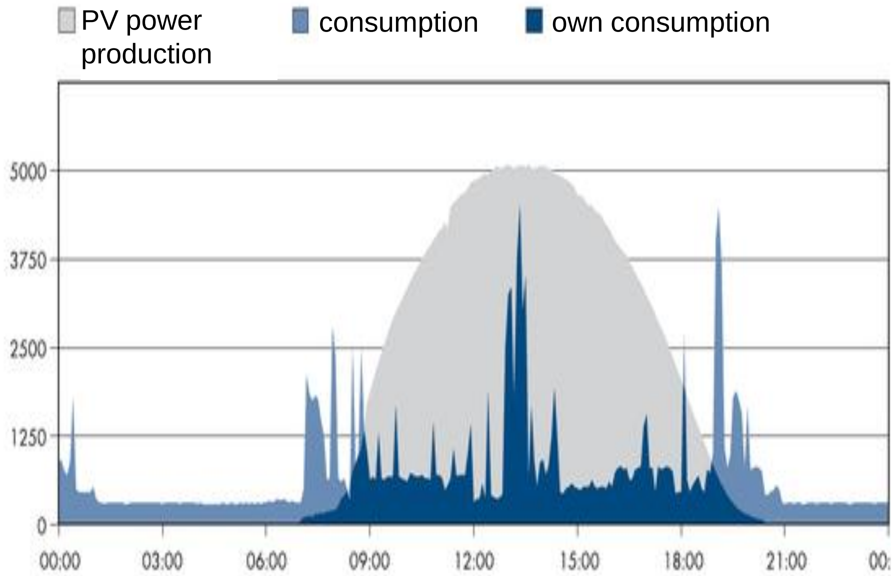
PV creates prosumers

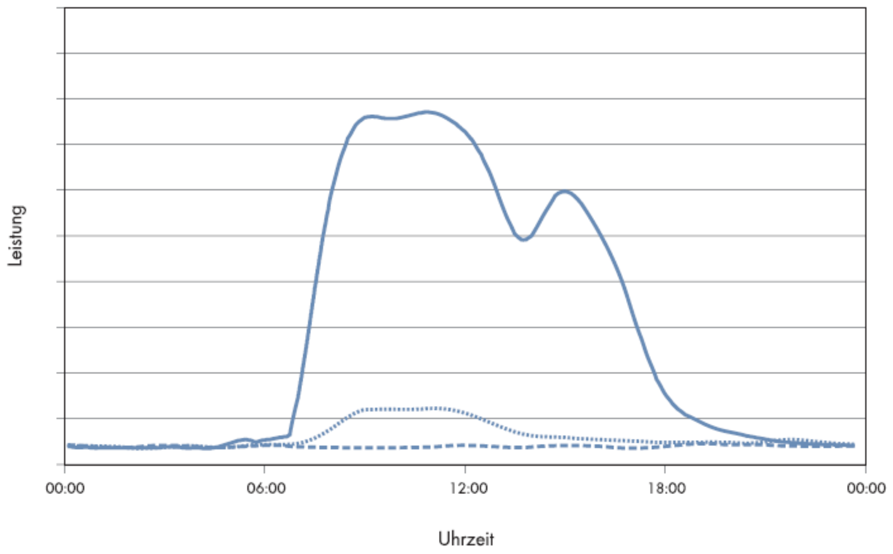
- When consumers become producers market conditions change fundamentally
- The until now very neat system limit between production and consumption is getting fuzzy
- The consumers with partial own supply will optimise their own system according to own criteria
- The point of departure for captive power production varies considerably between different groups of consumers:
  - Commerce, crafts, industry
  - Office building operators
  - Private households

Captive power production → new roles: The Consumers

Private households	• need reliable frame conditions, simple procedures • little margins for optimisation without batteries	potential limited
Office building operators	• good matching with load curve • large margins for optimisation • integration with facility management • appropriate time horizon	potential large
Services, commerce	• large potential with cooling • load curves favourable	potential large
Industry	• large consumption, low tariffs • depending on load curve • depending on availability of space	potential large

Differing potentials for own consumption





Private household

clouldess summer day, 4 persons,

PV installation 5 kWp

Commerce

working day 8-18h

BDEW Lastprofil G1

Captive power production → new roles: Utilities and energy service providers

Municipal utilities	- reduces electricity sales + proximity to clients, close coordination of production and supply concepts + integration into smart grid concepts + opportunity: new service offers for system optimisation, facility management + opportunity of reducing the grid load	potentially rather interested
Large utilities, operators of large conventional power plants	- reduces electricity sales - hinders centralised control - threatens monopolistic role - many central functions become obsolete • change of business model needed	not interested
Gas utilities	+ gas power plants ideal as buffers for PV & wind power - minor: use of peak PV power for heat generation	neutral
Energy service providers	+ needed: system optimisation, facility management + system integration is opportunity for contracting + complex systems need special competences	interested

Captive power production → new roles: other and new players

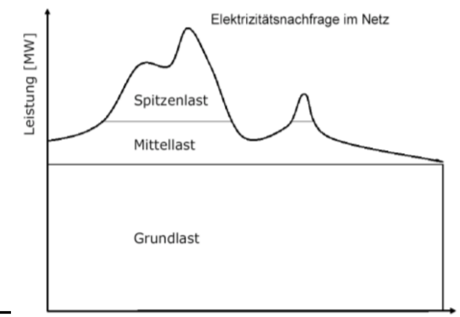
System providers facility management	+ growing markets + new system requirements, more comprehensive systems	interested
IT-Industry	+ new markets for controls, communication, smart grids	interested
Producers of storage systems	+ new markets for batteries + new markets for heat storage / integration with heat pumps etc.	interested
Producers large power plants, large el. systems	– reduces sales, threatens large power plant business • could reduce needs for transmission systems	not interested adversaries
Architects engineers	+ new opportunity system integration in buildings • integration with heat systems	need to learn
Plant constructors	• higher requirements for energy management in industry plants	need to learn

ruggero@schleicher-tappeser.eu

Change of the control logic of the electricity system

Traditional
Large power plants
fossil and nuclear

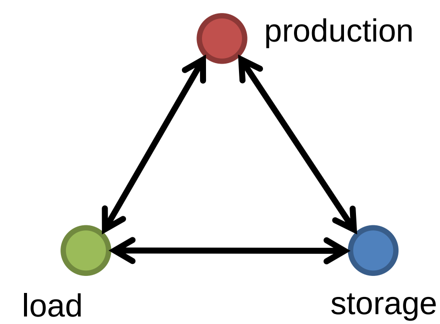
- Production follows demand: base / middle / peak load
- Load management only with large consumers
- Central Control



Transformation

Supply 100% REN
Integrated optimisation of the whole system

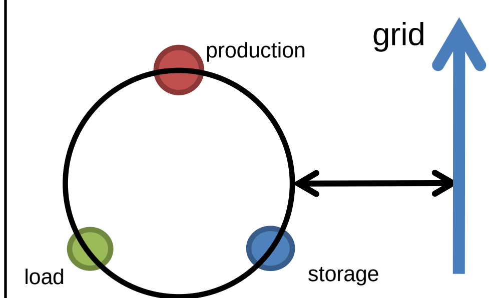
- Fluctuating production with wind and sun dominates
- Load management, storage
- Complexity requires optimisation on several levels



Contribution

Captive power production
Optimisation on the consumption level

- Optimisation subsystem
- Partial buffering of fluctuations at the local level
- Facilitation of optimisation at higher levels



Challenges for the regulation

- Guaranteed buy-of for PV power
- Guaranteed tariffs, especially for smaller installations
- With high shares of captive power production: Avoid or let pay expensive peaks in residual power demand
- Innovative market design (capacity markets, storage markets, European markets, regional markets?)
- Integration of the prosumer's systems into the overall optimisation (smart grids)

CAPTIVE POWER PRODUCTION IN MARKETS WITH WEAK GRIDS

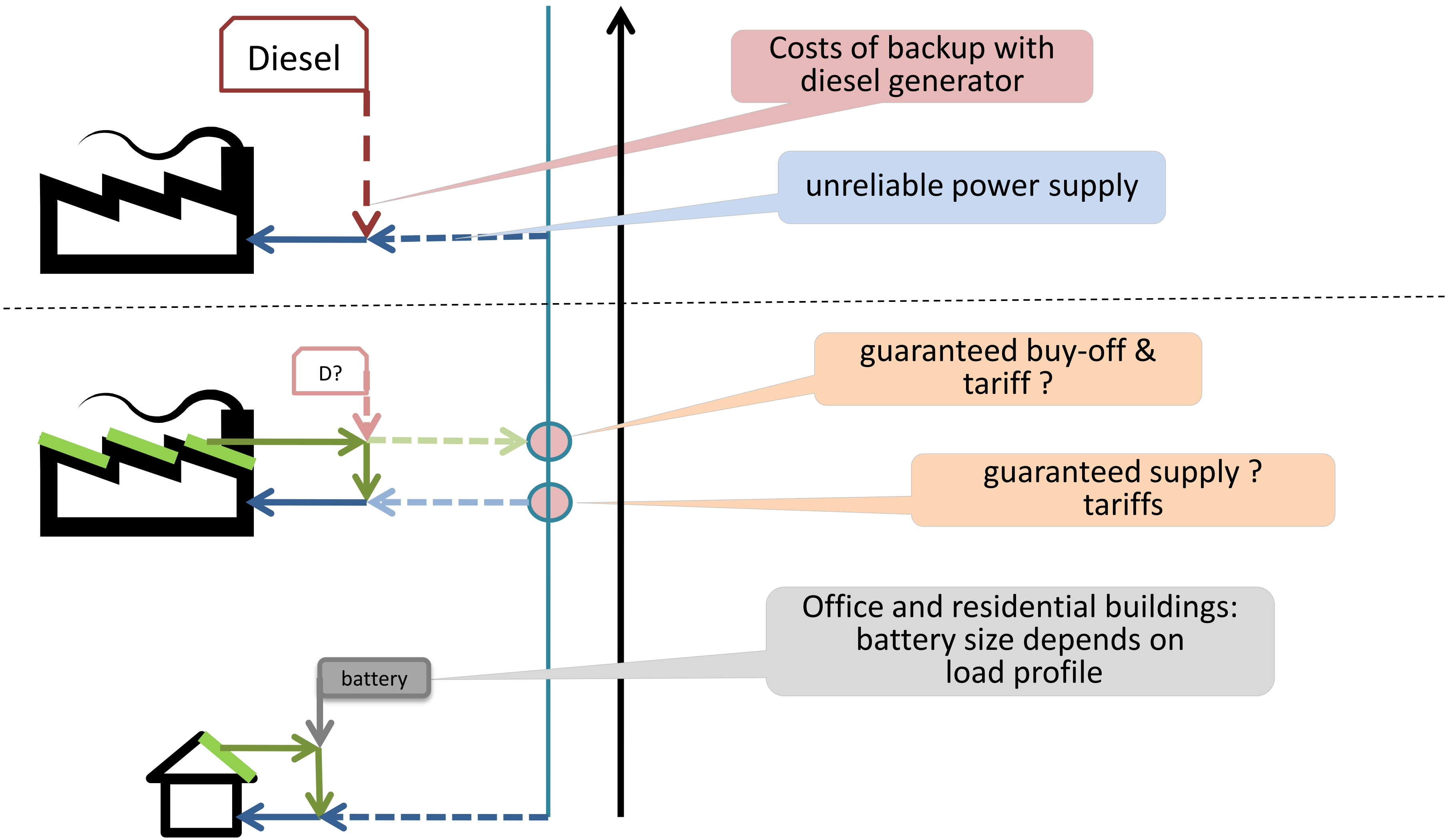
Markets with weak grids: real power costs are higher than tariffs

- In many countries with strong solar irradiation, subsidised power tariffs are retarding the reaching of grid parity
- In many of these countries, often due to high growth, grids are weak and unreliable

→Backup power generation and production losses raise the real costs of electricity

→Calculating with real electricity costs, grid parity is often already reached

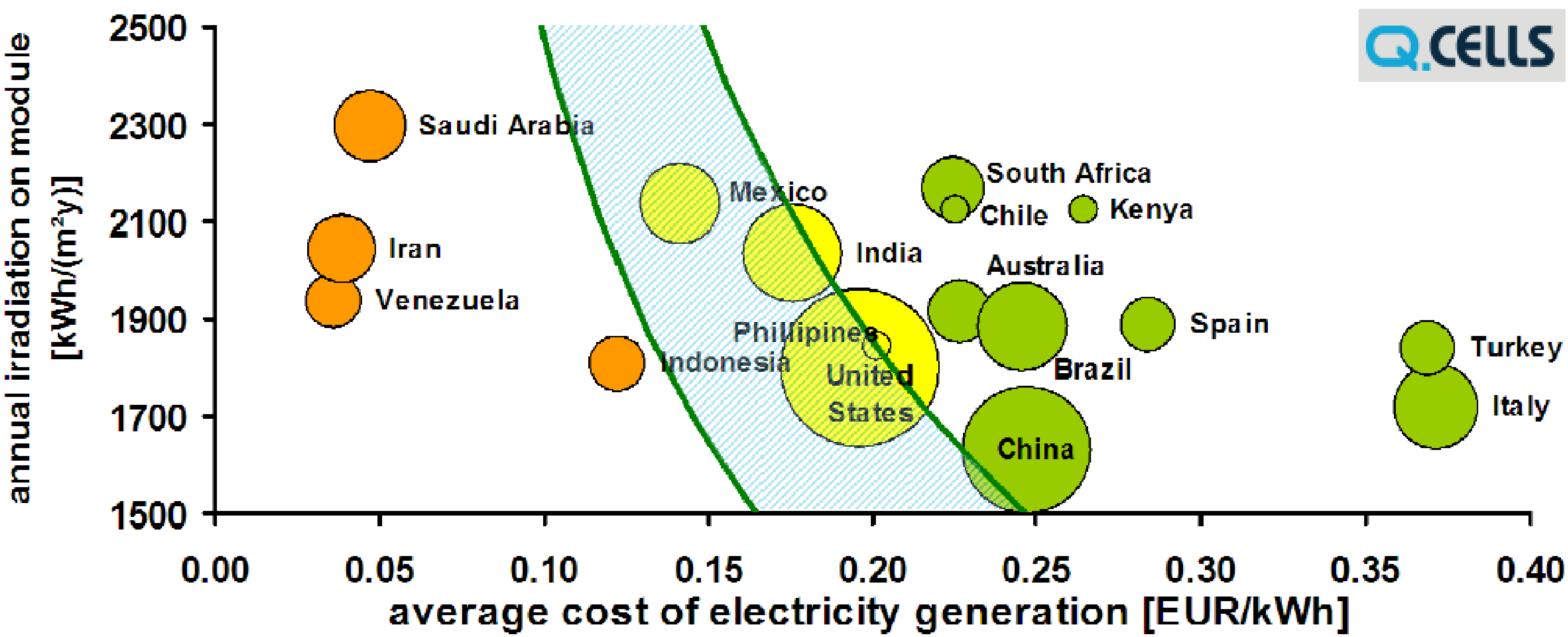
Captive power production in markets with weak grids



Captive power production in India: high potential

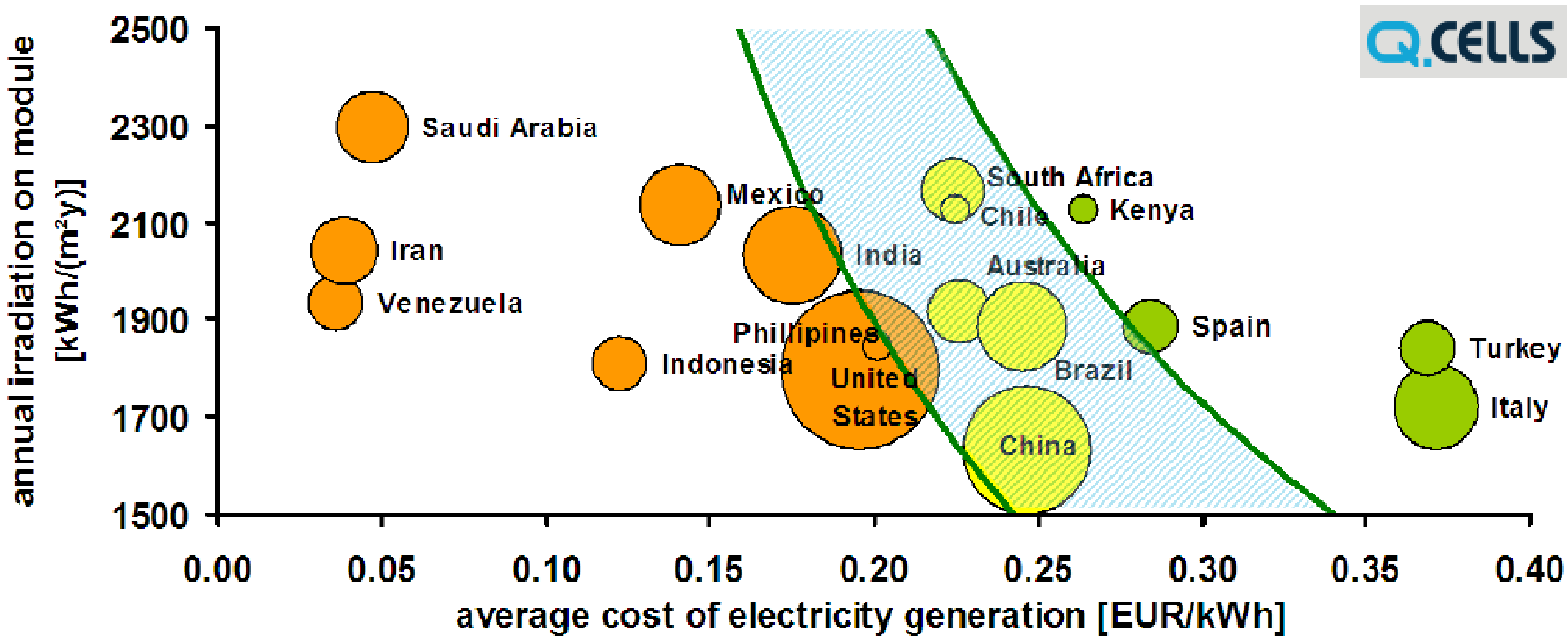
- Captive power production covers 30% of industrial power consumption in India
- Wind energy in India is mainly used for captive power generation in industry (70% of the clients in 2008)
- Typical situation: industry in Pune
  - 3,5 million inhabitants, high economic dynamics, much industry
  - 12-14h power cuts per day, unplanned, over months
  - power tariff : 0,10 €/kWh
  - Costs of backup power generation with Diesel generators 0,13-0,15 €/kWh (10-12h/day for continuous processes)
  - High indirect costs and efficiency losses
  - Tens of thousands working by night when power is more reliable and cheaper
- High reliability of solar radiation during largest part of the year

Fuel Parity:
PV versus Diesel Generators



assumptions: 2.0...3.0 €/Wp Capex, 6.4% WACC, 25 years lifetime, 75% performance ratio, Diesel full load hours analogue PV, 35% Diesel efficiency, 1.4 $/€, Diesel price data of GTZ

Fuel Parity:
PV+ Storage versus Diesel Generators



assumptions: 2.0...3.0 €/Wp Capex, 6.4% WACC, 25 years lifetime, 75% performance ratio, redox-flow storage, 150 $/kW and 150 $/kWh Capex, 73% full cycle storage, 50% direct PV power supply and 50% storage, 150% of annual mean day storage size, 1.4 $/€, Diesel price data of GTZ

PV captive power production in regions with weak grids: the consumers

private households	• Brauchen verlässliche Rahmen-bedingungen, einfache Verfahren • haben oft Batterien für Backup	potential large frame conditions vary
office building operators	• good matching with load curve • backup often needed anyway • often high cooling requirements • large margins for optimisation • integration with facility management • adequate time horizon for investment	potential very large
services, commerce	• backup often needed anyway • if cooling needed: large potential • load curve rather favourable	potential very large
industry	• backup often needed anyway • high consumption, low tariffs • depending on load curve • depending on availability of surfaces	potential very large

Captive power production in weak grids: utilities and energy service providers

<u>Utilities</u>	+ relieves grids + in sunny countries well predictable + improves supply in conditions of strong growth - threatens often existing monopoly role - threatens often practiced cross-subventions	potentially rather interested
Conventional power plant operators & producers	- reduces sales and turnover - can put into question central control approach when percentage is rising	not interested
Gas utilities	+ gas power plants ideal as buffers for PV & wind power - minor: use of peak PV power for heat generation	neutral
Energy service providers	+ needed: system optimisation, facility management + system integration is opportunity for contracting + complex systems need special competences	interested

Industrial captive power production in regions with weak grids: challenges

- New business models need to be developed for different kinds of cases
- Most interesting actors:
  - industries with constant and partially influenceable load curve during the day
  - industry zones with good activity mix (risk distribution)
- Precondition: appropriate surfaces for PV. Hybrid systems – including wind or biomass – bring more flexibility
- Integrated approach: adaptation of industrial processes in such a way that load management becomes possible
- Cooperation: agreements with utilities for optimal coordination

STANDARDISATION CAN LOWER RISKS AND COSTS

Avoiding the complexity trap

- Stronger system integration can lead to higher planning requirements and risks difficult to assess
- Especially small installations need a high degree of standardisation of technology, of operating procedures, of administrative frame conditions
- The PV industry is ripe for differentiated industrial structures with several standardisation levels
- Internationalised mass production of standard components can open new opportunities on higher levels
- The European industry has experience and better opportunities with all kinds of complex system integration

Standardisation can lower risks and costs

Standardisation of components:

- reduces perceived risks related to components
- facilitates re-selling (second hand markets)
- lowers the risk of a reduced lifetime of installations

Standardisation of the installation design:

- reduces planning costs and planning risks
- shortens deadlines and reduces efforts needed for permits

Both:

- reduce costs and risks
- improve market transparency
- Improve risk transparency, facilitate risk assessment, improve bankability, reduce capital costs

Integrated functional units

- Integration of control and storage (electricity and heat)
- Adaptation of functions to fluctuating power production
- Optimal dimensioning of components
- Minimisation of requirements and risks concerning installation and maintenance
- Simplification of transport, reuse and sales

For all countries:

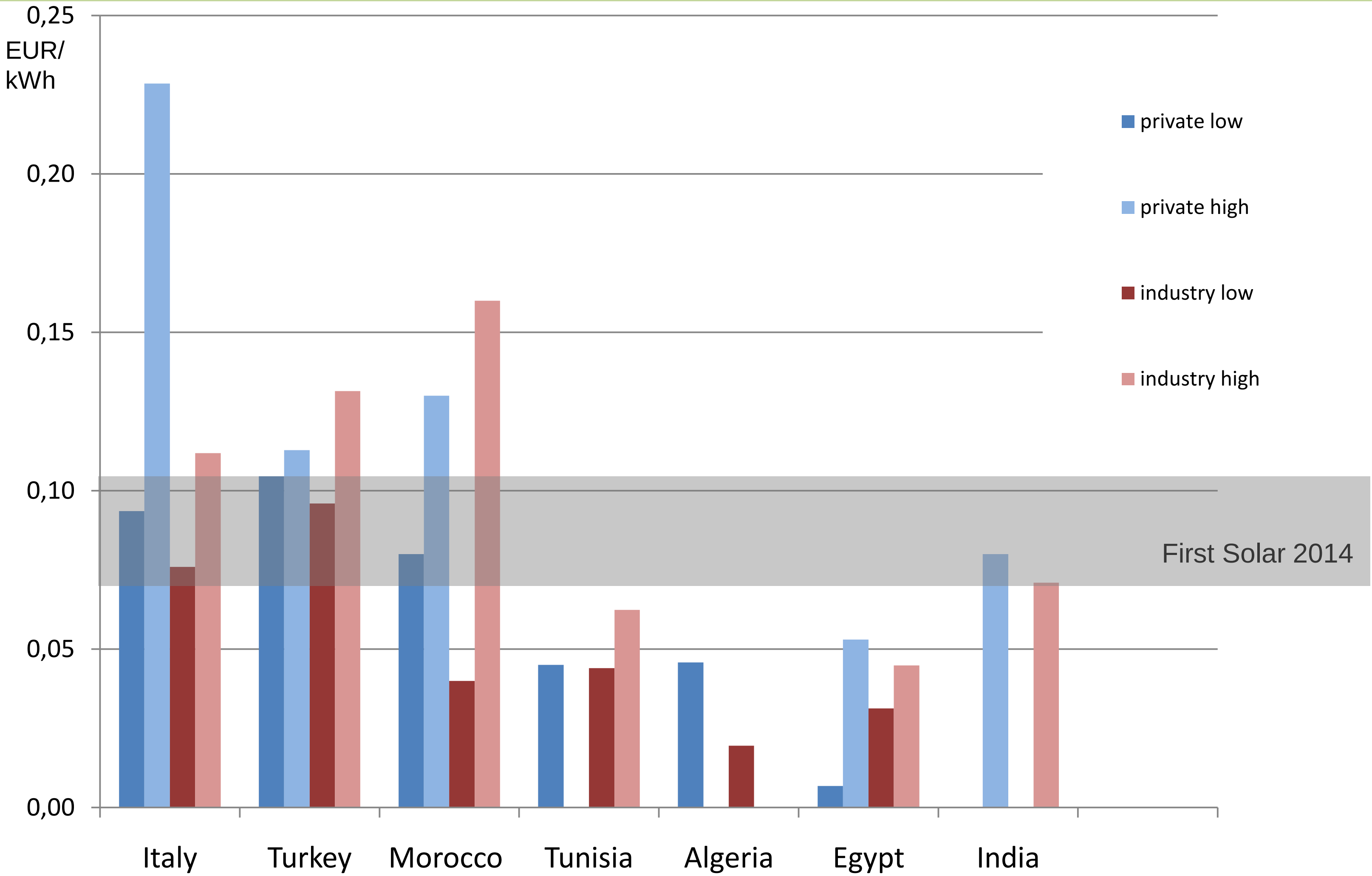
- PV lamps of all kinds
- Mobile telephone repeaters
- Energy centre in private homes
- Solar refrigerated warehouses
- …

For sunny countries with weak grids:

- Solar charging stations
- Solar laundries
- Process units food industry (drying, baking,…)
- Process units chemical industry

HOW TO CAPITALISE ON HIDDEN WHOLESALE GRID PARITY

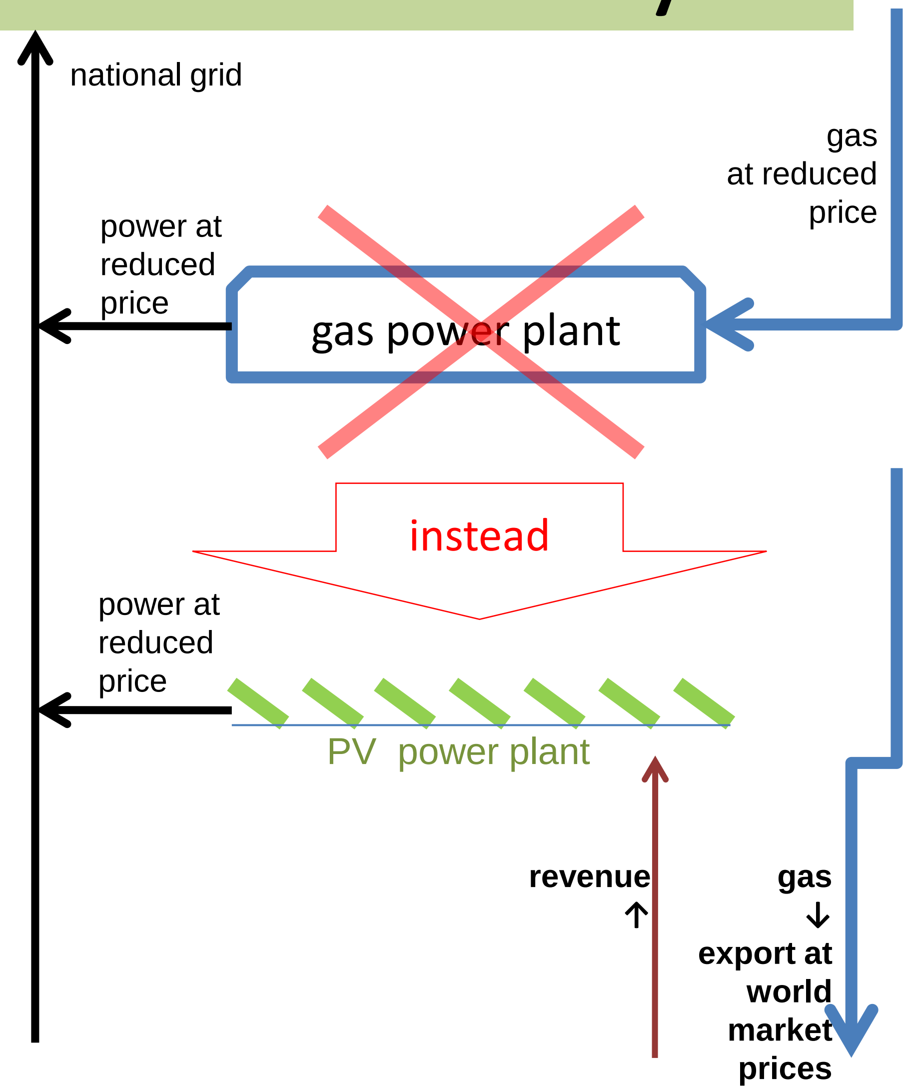
Subsidised tariffs distort markets



Solar power transition: exporting gas instead of solar electricity

Also for gas producing countries with low electricity prices, PV power can be most useful immediately:

- PV power plants using free sunshine instead of new gas power plants burning gas at reduced prices
- Economised gas can be exported at world market prices
- Revenue from export can be used for selling PV power to the grid at reduced prices
- Gas export using existing pipelines or LNG



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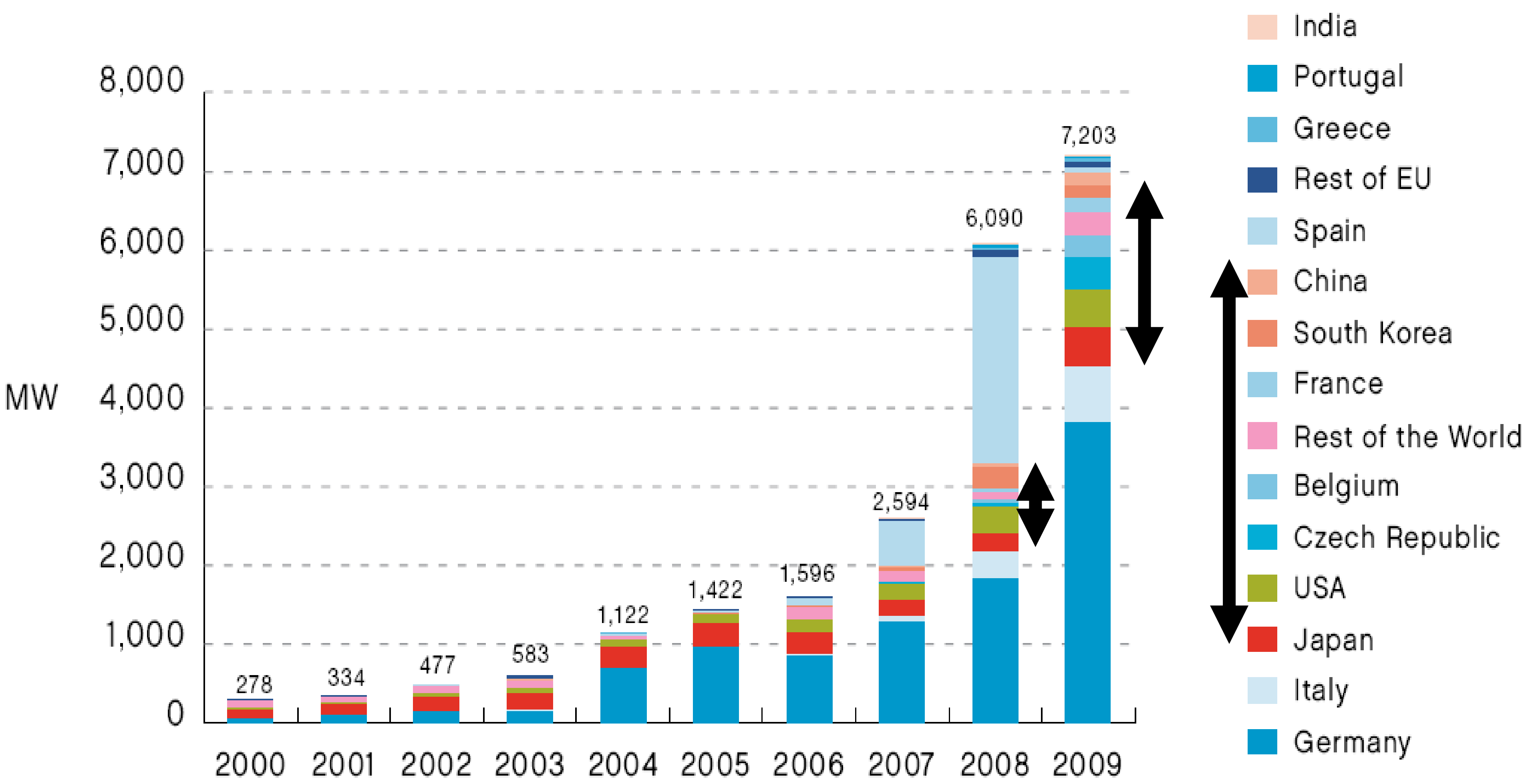
CONSEQUENCES FOR EXPORT STRATEGIES

New markets are growing rapidly



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Interesting new markets with captive power production: parameters

- Parameters for reaching grid parity
  - Solar irradiation
  - Power tariffs
  - PV system price (including permissions and financing)
- Supplementary parameters
  - Strong / week grids
  - Planning horizon
  - Reliable frame conditions
  - Growth of power consumption

Tighted debate on centralised / decentralised systems

- PV brings a considerable potential for decentralisation and new actors: starts to put into question the traditional energy business, more than wind
- The period of grace for PV is over – some large utilities and power plant builders are pushing harder for centralised solutions:
  - wind offshore, CSP, ocean energy
  - continent-wide grids, not for balancing varying production but "for producing energy where it costs less"
- A confrontation „totally centralised" / „totally decentralised" is destructive, we need a balanced combination, a multi-tier approach
- The PV industry must increasingly <u>win allies in other sectors</u>, beyond the renewable energy industry: IT, energy and building technology, construction industry, facility management, vehicle industry…
- The German PV industry should not rely too much on exporting: it must <u>convince new countries</u>, <u>create local employment</u>; propose an EU industry policy

Grid parity: challenges for the solar business

equipment producers	-	
component producers	• standardisation of components (international) • storage, controls, IT become important • integrated standard systems (specific markets) • find allies in other branches • create added value in new markets (local content)	
system integrators / project developers	• more complex systems with load management and storage • cooperation with other specialists: facility management, plant construction, production control, energy efficiency • new players, concentration process	getting more important
craftsmen	• understanding more complex systems • quality	
Investors	• assessment of complex systems	getting more important

Conclusions

- Grid parity will not change the situation from one day to the other – we will see a gradual transition
- Grid parity opens new opportunities for a more independent distributed power supply – new actors, new motivation for an energy system change, more competition
- Precondition: a better integration of fluctuating power production in local systems
- Regulation remains most important
- Mainly commercial installations are interesting in this context
- Very interesting opportunities in sunny countries with new business models
- The key: system integration

Open questions

- Which markets are particularly hot?
- Where will grid parity promote quickly a decentralised power supply?
- Where will centralised utilities and monopolies hinder the development?
- Which technologies can rapidly promote a decentralised power supply?
- Will long-distance transport become an Alternative to power and storage management?
- How can financing of decentralised systems be facilitated?
- How quickly will the new markets develop?

THANK YOU VERY MUCH

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