Day 2:
From scenarios to policy and market development

IRENA Global Atlas
Spatial planning techniques
2-day seminar

Dr. David Jacobs – IET (International Energy Transition)

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Scenarios

Strategies:

1. Target setting
2. The availability of flexibility in the power sector?
3. The availability of grid infrastructure?
4. The availability of space (spatial planning)?

Instruments:

5. Designing finance mechanisms for different market segments
6. Financing support mechanisms
7. Reducing administrative barriers

Project development:

8. Resource mapping for investors and project developers
9. Monitoring and reviewing (target achievement)

RE Market

Resource assessment and target setting

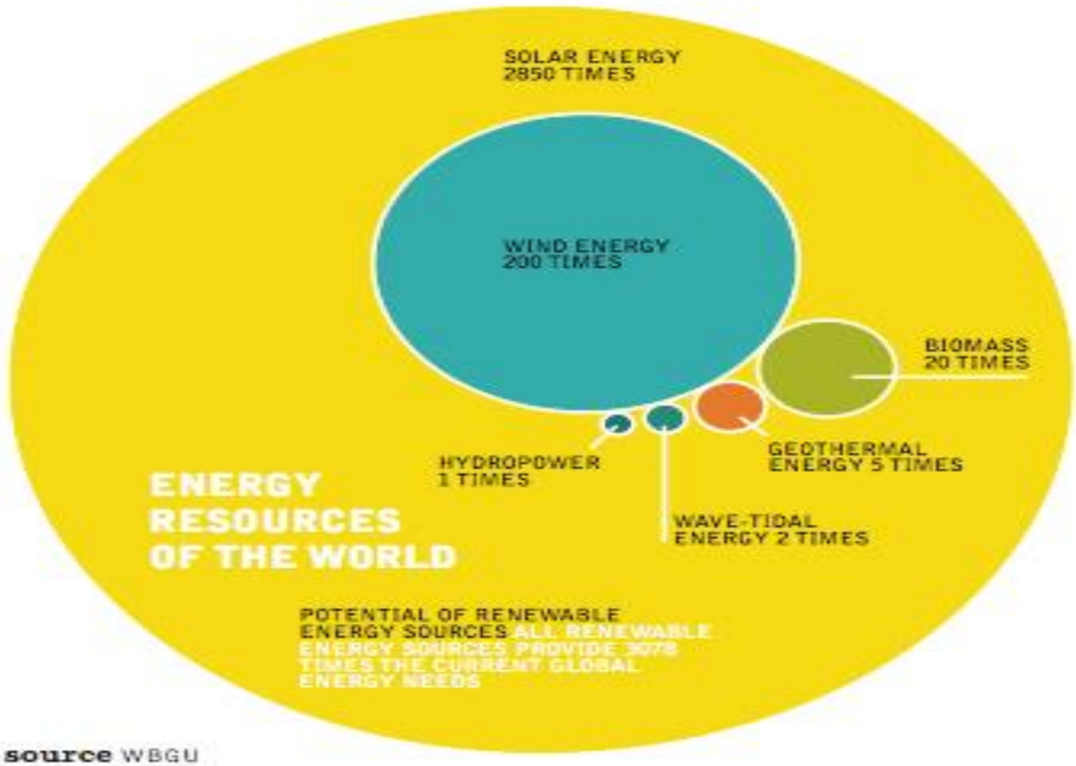
Dr. David Jacobs – IET (International Energy Transition)

The relation between resource mapping and target setting

- Mapping results into availability of information on amount of available resource and suitable areas
- Policymakers are enabled to set targets based on available resources
- HOWEVER: Resource mapping is only the first step:
  - Limiting factors need to be taken into consideration to elaborate the the economic potential

From technical potential economic potential

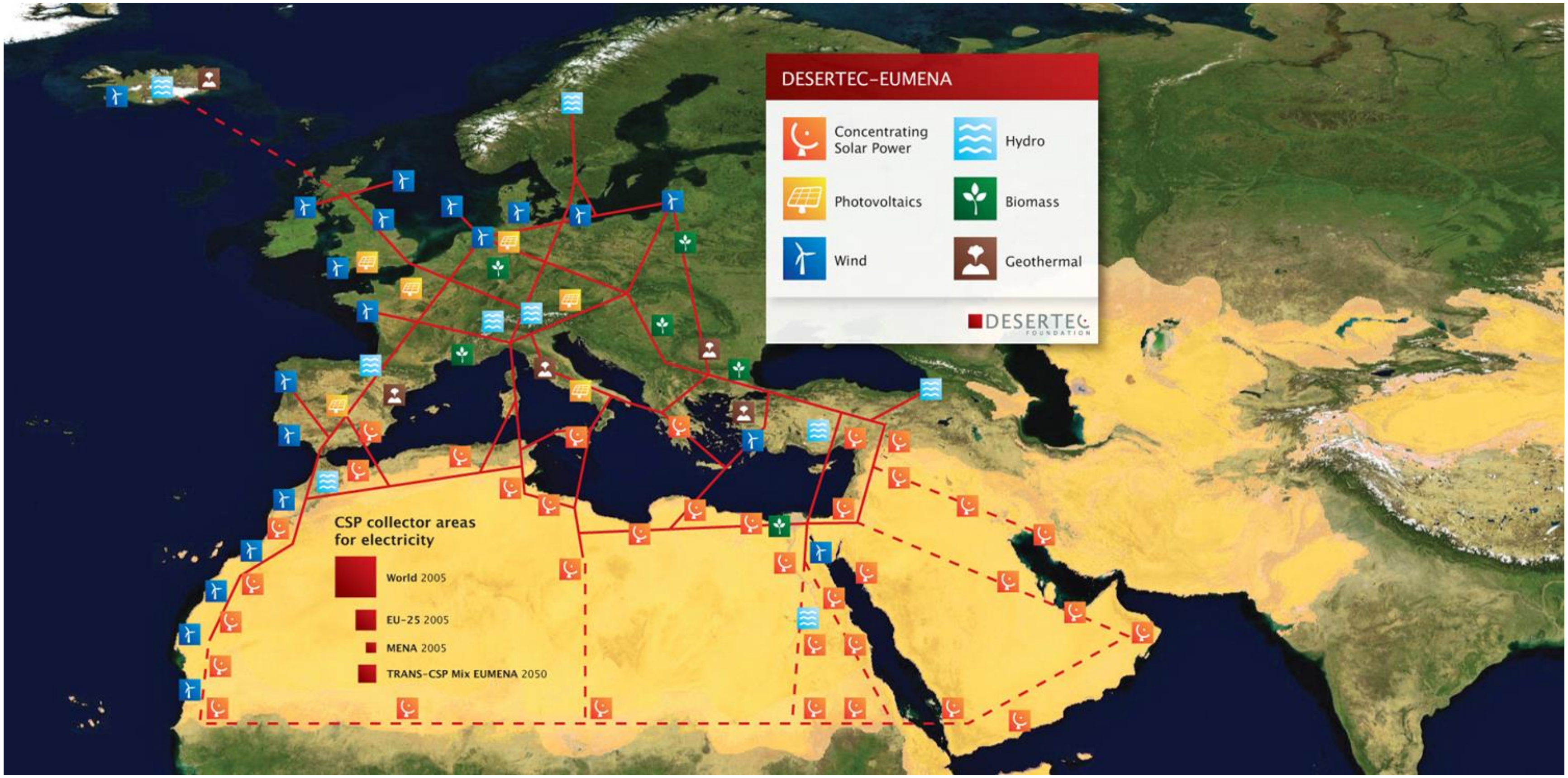
figure 7.1: energy resources of the world



source WBGU

Source: http://www.wbgu.de/fileadmin/templates/dateien/veroeffentlichungen/hauptgutachten/jg2003/wbgu_jg2003_engl.pdf

From technical potential economic potential



Source: Desertec Foundation 2009, http://www.desertec.org/fileadmin/downloads/DESERTEC-WhiteBook_en_small.pdf

Questions

How did you set targets for renewables in your country? Did you analyse the available resources first?

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How did you set targets for renewables in your country? Did you analyse the available resources first?

What were the reasons objectives/reasons for setting renewable energy targets in your country?

Objectives for setting renewable energy targets

- Make use of existing, national resources (Increasing **energy security)**
- **Diversifying** the fuel mix
- **Reducing fossil fuel** consumption (for both importers and exporters)
- Improving **energy access**
- Mitigating **climate change** and other environmental risks (fuel spills)
- **Macro-economic** benefits (i.e., job creation)
- Increasing **private sector** investment

Source: E3 Analytics, Toby Couture

How to integrate target setting for renewables into integrated resource planning?

- What is the target function in your country for determining the optimal electricity mix?
  - least cost planning?
  - Industry policy?
  - Security of supply?
  - Energy access?
  - Climate policy?

Renewable energy targets

- More countries are setting policy targets for renewable energy:
  - 144 countries with targets as of 2013

- Countries are also enacting support policies to ensure fulfillment of the target:
  - 138 countries as of 2013

Source: REN21 Global Status Report (GSR) 2014 renac renewables academy | IET International Energy Transition | IRENA International Renewable Energy Agency

Target characteristics

- Decision parameters for setting RE targets:

  Option 1: Technology Neutral (generic RE target) vs. Technology Differentiated (wind, solar, biomass, etc.)

  Option 2: Short-term targets versus long-term target (harvest the low hangging fruits first?)

  Option 3: National targets versus regional planning (locational signals for harvesting renewables in different “hot spots”?)

How to Set Targets after Resource Assessment

Establishing targets requires a few essential components:

1. Identify resources – theoretical/technical potential
2. Identifying constraints (e.g. grid capacity, available land, financial resources, etc.) – derive the economic potential
3. Substract areas dedicated to natural protection – ecological potential
4. Model the current and future electricity mix – feasible level of system integration of wind and PV? Cost effects?

Come up with the realizable potential and translate this into targets!

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Experience from emerging markets:

The rationale for target setting in Saudi Arabia

Dr. David Jacobs – IET (International Energy Transition)

Renewable energy programs in Saudi Arabia – identifying the best locations

- The Kingdom of Saudi Arabia targets a newly installed renewable energy capacity of 54 GW by 2032
- Rationale:
  - cost savings (oil)
  - technological leadership
  - climate protection
  - energy access

Source: KA-Care, https://www.irena.org/DocumentDownloads/masdar/Abdulrahman%20Al%20Ghabban%20Presentation.pdf

Renewable energy programs in Saudi Arabia – Target setting approach

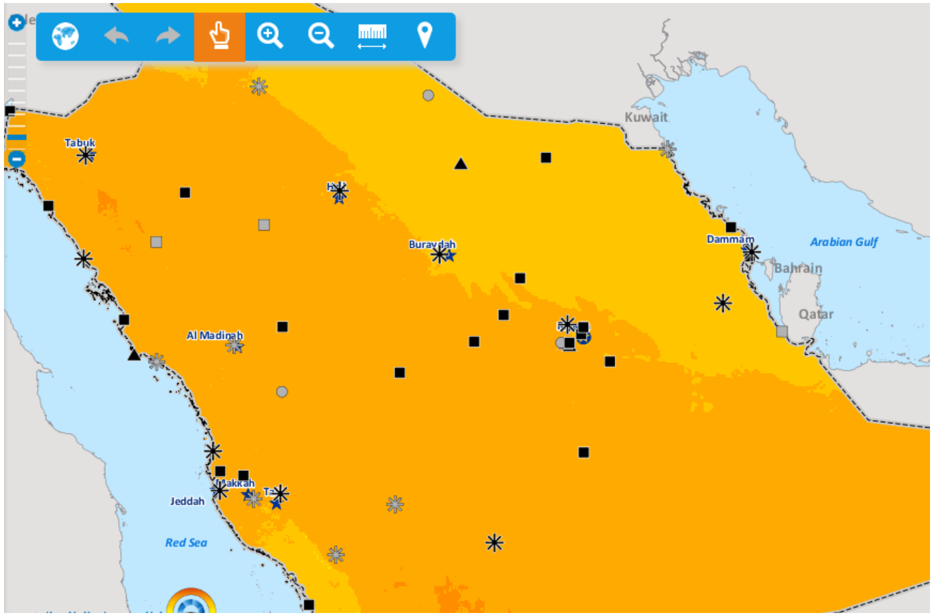
- Technology specific targets (for better system integration and industrial policy)
  - PV: 16 GW
  - CSP: 25 GW
  - Wind: 9 GW
  - Waste-to-Energy: 3 GW
  - Geothermal: 1 GW

Source: KA-Care, https://www.irena.org/DocumentDownloads/masdar/Abdulrahman%20Al%20Ghabban%20Presentation.pdf

Assessing resource availability – KSA solar map

- Renewable energy atlas was launched in Dec 2013:
- Existing resource maps are important elements for Statement of Opportunities (SOO) for project developers
- Onsite measurement required for financing

- Available ONLINE: http://rratlas.kacare.gov.sa/RRMMPublicPortal/



Source: http://rratlas.kacare.gov.sa/RRMMPublicPortal/

Limiting factors for the actually realizable potential:

Available grids,
available space (spatial planning),
system flexibility

The relation between resource mapping limiting factors (grid, space, flexibility)

- To derive the actually realizable potential from the theoretical/technical potential requires an analysis of all limiting factors
  - The availability of grid infrastructure
  - The availability of space (spatial planning and protected areas)
  - The technical potential of the electricity system to absorb fluctuating renewables (wind and solar)

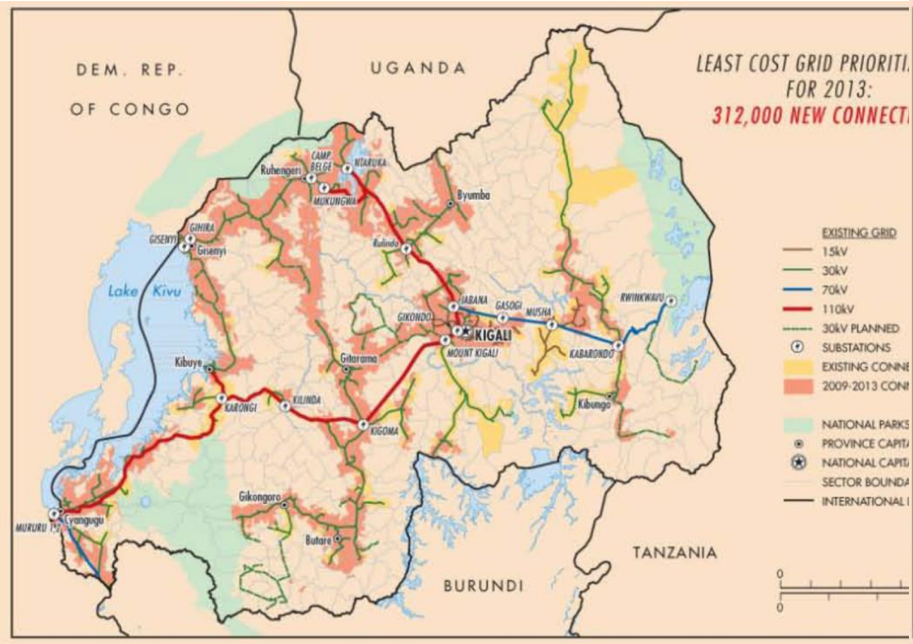
Availability of grid infrastructure?

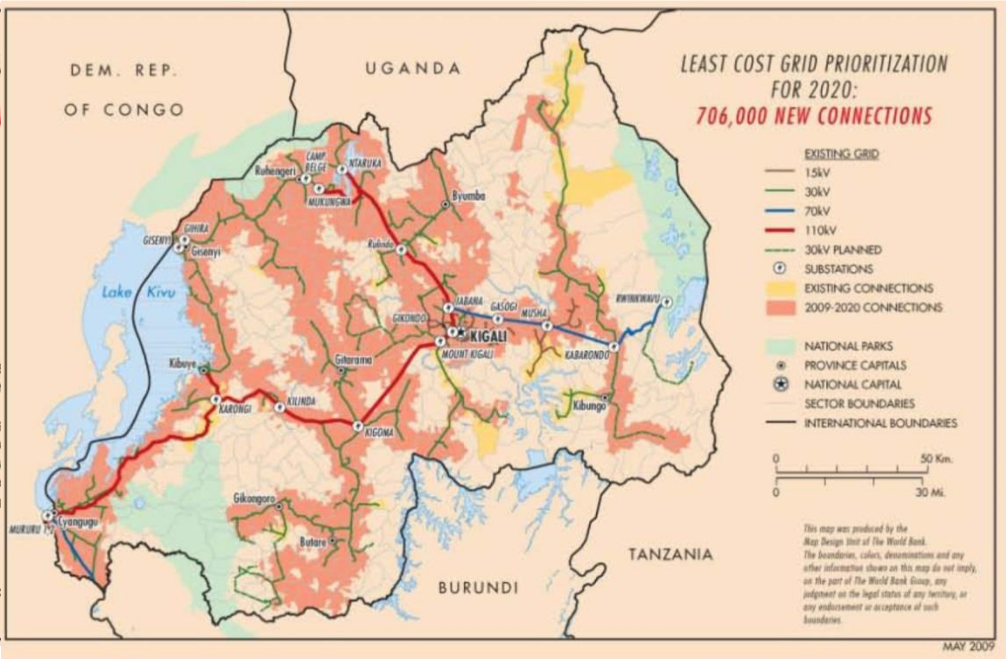
Using the existing grid, expanding the grid or developing renewables off-grid

Dr. David Jacobs – IET (International Energy Transition)

Least cost grid expansion plan in Rwanda

- Grid expansion is a crucial component for rural electrification
- However, costs of transmission, distribution, and oil have gone up; costs of off-grid solutions have come down

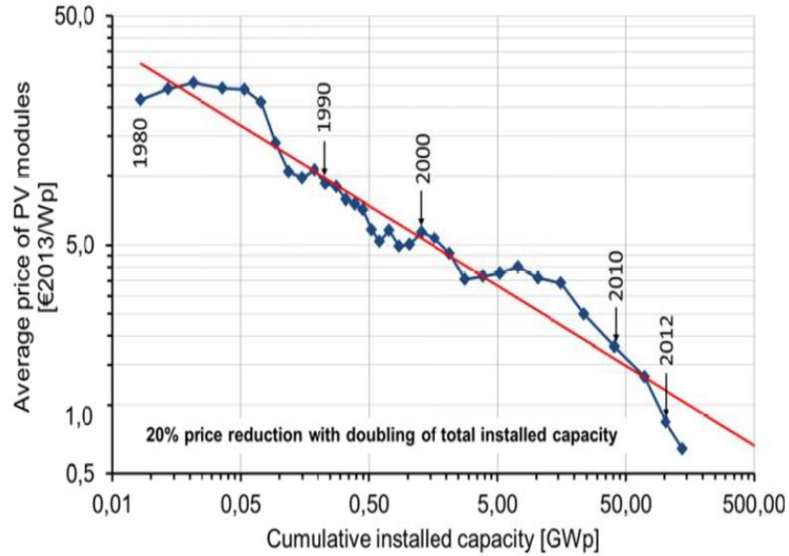




Source: World Bank http://siteresources.worldbank.org/EXTAFRREGTOPENERGY/Resources/717305-1327690230600/8397692-1327691237767/DAKARHVI_AEI_Practitioner_WorkshopNov14-15_2011_Nov7.pdf

Rule of thumb for rural electrification and technology choice

- Due to dramatic reductions in PV costs in the past years, PV mini-grids are a viable alternatives to grid extension anc diesel mini-grids.
- The LCOE will generally be competitive with that of grid extension when the extension would imply less than 10 connections/km.
- Obstacles: the need for upfront financing, ensuring proper maintenance, etc.



Source: Norplan 2012

Rule of thumb for rural electrification and technology choice

- Several factors influence the viability of off-grid solutions, including mini-grids, solar-home-systems and hybrid systems, e.g. the level of market penetration, transport cost for equipment, etc.

- The rules-of-thumb are fairly sensitive to the assumed consumption per household (50kWh /HH/month).
  - If lower, the number of connections would have to be higher to justify grid extension.
  - If higher, grid connection might already make sense with less connections

Source: Norplan 2012

Questions

What decision parameters do you apply in your country for grid expansion of off-grid solutions?

The availability of grid infrastructure

Anticipating required grid expansion to reach ambitious long-term targets (lessons learned from Germany)

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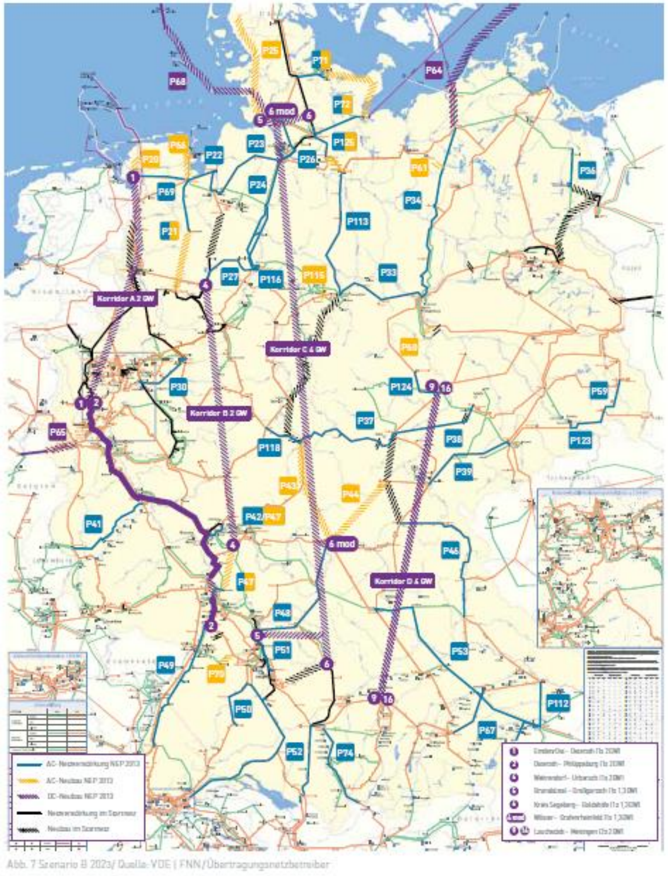
Insufficient grid capacity

- Insufficient grid capacity for new projects due to underdeveloped grid infrastructure?
- Originally designed for conventional, centralized power system – no grid at best locations for renewables?
- National grid extension plans has to be prepared (well in advance!)

Grid extension plans in Germany

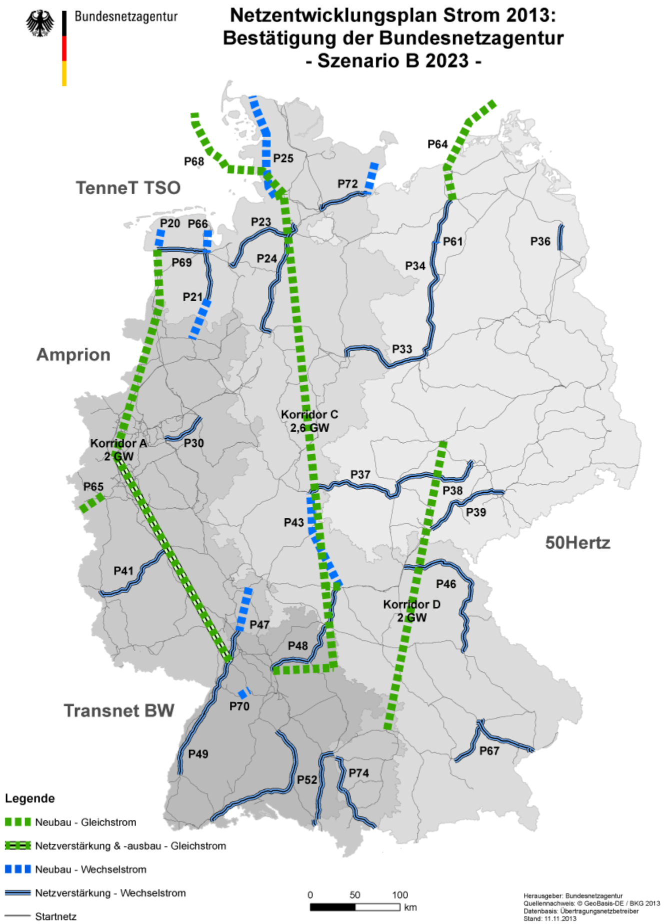
- Transport renewable electricity from the North (onshore and offshore wind) to the load centers in the South
- Distribution grid upgrade:
  - Most renewable energy projects in Germany are connected to the distribution grid
  - High shares of renewables (PV) in Bavarian distribution grids
  - Bi-directional transformer stations



NEP 2013, Stand: Juli 2013
www.netzentwicklungsplan.de

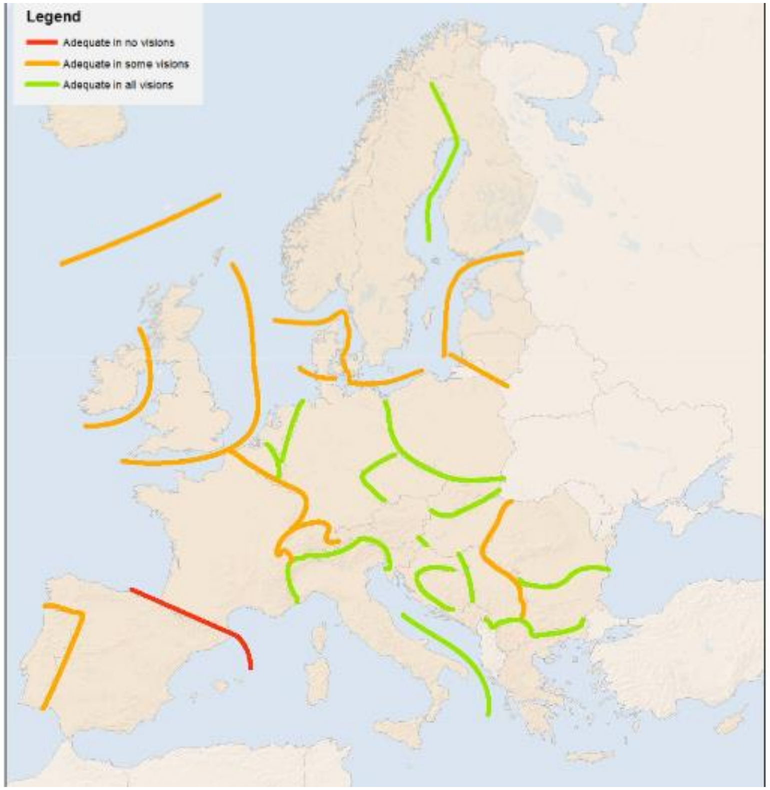
Grid expansion for the German Energiewende

- Part of European grid integration process (TEN-E)
- Grid development plan for new electricity lines from 2013
  - 2,800 km of new transmission lines
  - 2,900 km of grid upgrades



The expansion of the European transmission grid

- 10-year network development plan from ENTSO-e
- The latest report pinpoints about 100 spots on the European grid where bottlenecks exist or may develop in the future
- Transmission adequacy by 2030?
- Full market coupling with European neigbours (e.g. one merit order for Germany and Austria).



Source: ENTSO-e 2014

Stakeholder engagement

In how far are citizens and other concerned actors involved in the planning and siting process for energy infrastructure in your country?

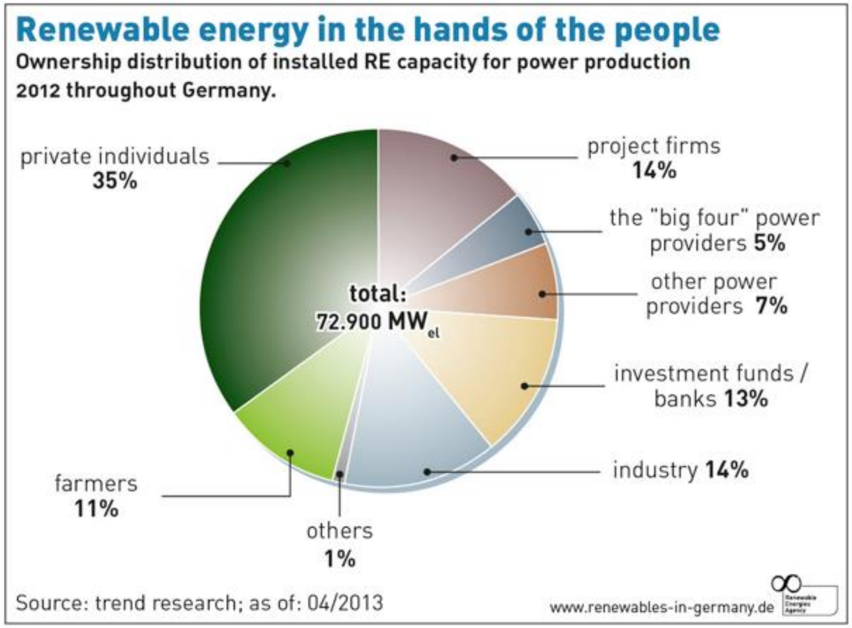
Is there a trade-off between quick planning (and execution) of projects and stakeholder engagement?

Reasons for opposition from citizens and communities

- Visual impact (noise in the case of wind energy)
- Lack of information about the required grid infrastructure for the energy transition ("we want to produce electricity decentrally, no offshore wind!)
- Lack of information about the need for the existing project (why through my village and not the neighbouring village?).
- Lack of direct financial advantages for communities and citizens

Financial compensation for exposure to new electricity grid

- Amendment to German law (NABEG):
  - Effected villages can receive one-off payment of 40.000 € per km of new transmission line in their territory
  - Much critizised!



- German deployment of renewable energy sources large grass-rout driven
- Denmark: Project developers need to involve local citizens in financing renewable energy power plants

New transmission technologies: underground cable

- Underground solutions are being discussed in more densely populated areas

- more expensive than above-ground options (factor 3-10)
  - more costly insulation is used
  - more complex equipment
  - larger cables are needed

The availability of grid infrastructure

Which grid connection charging approach fits with your grid expansion plan?

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General best practise for grid connection

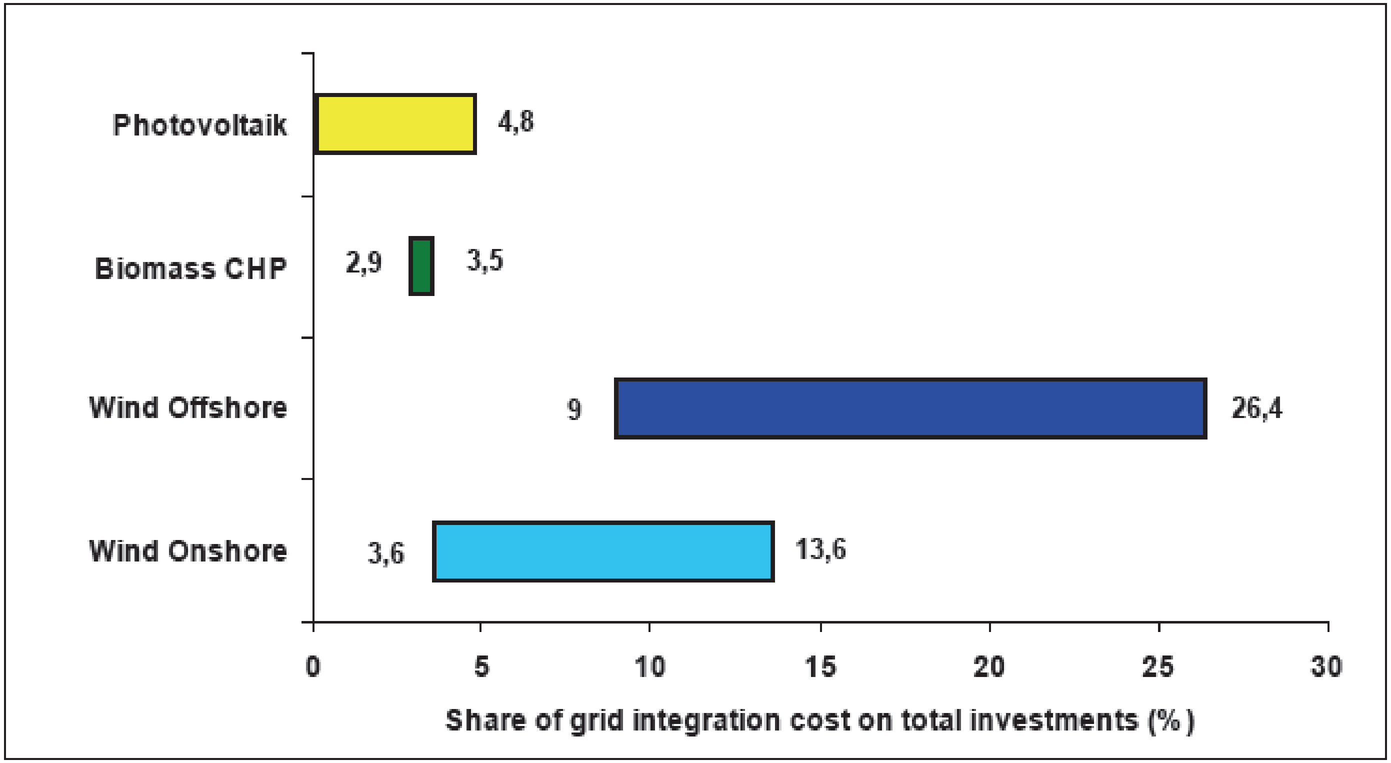
- Fair and transparent grid connection procedures required
- Data (grid availability, costs, technical) need to be verifiable and disclosed by grid operator/utility
- Clear rules about grid connection point and step in grid connection application

Cost sharing methodologies for grid connection

Who pays for grid connection (nearest connection point)?

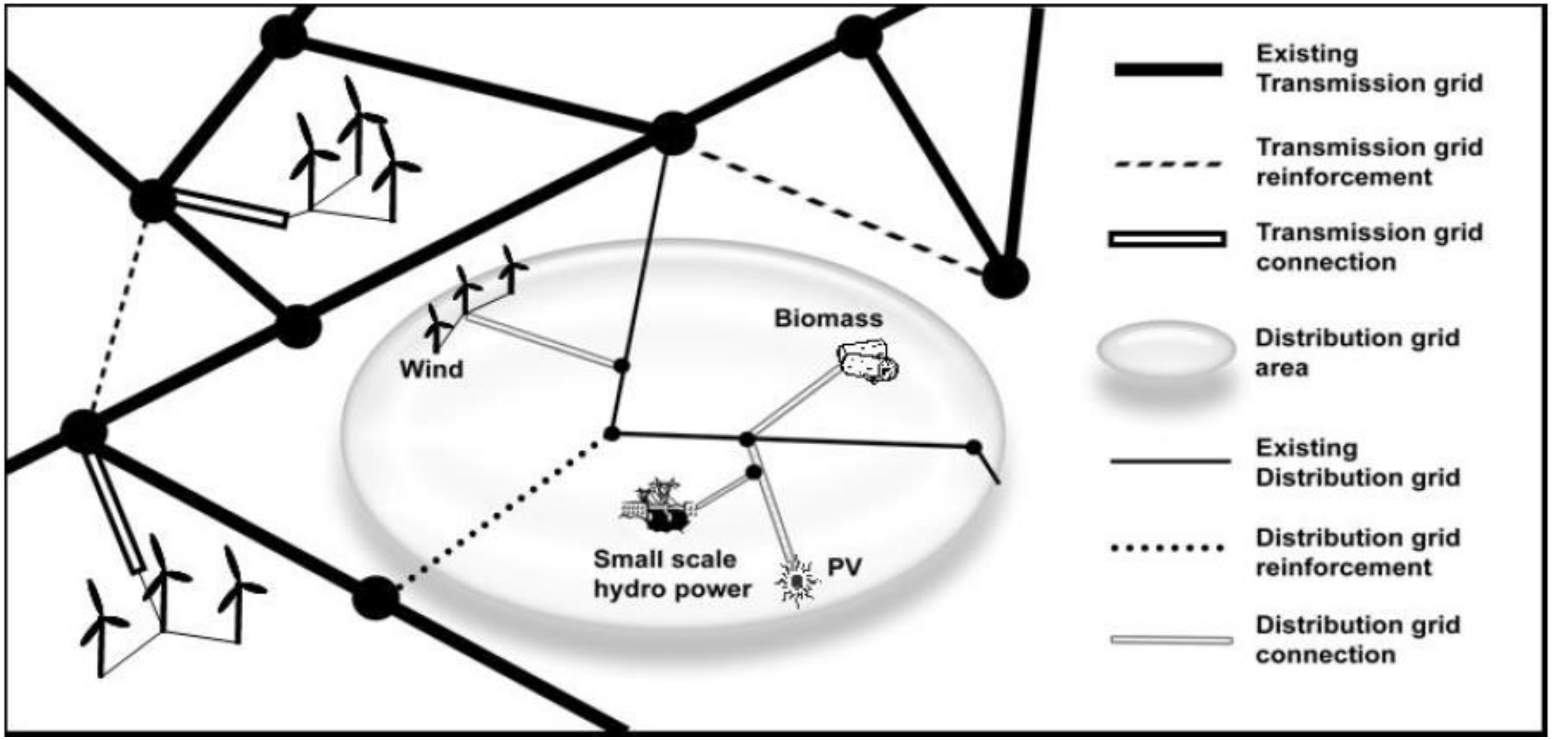
Who pays for grid reinforcement (because of existing grid capacity restrictions)?

Grid connection costs for different renewable energy technologies



Source: Auer et al. 2007, http://greennet.i-generation.at/files/Report%20on%20Synthesis%20of%20Results%20on%20RES-E%20Grid%20Integration%20%28D11%20GreenNet-EU27%29.pdf

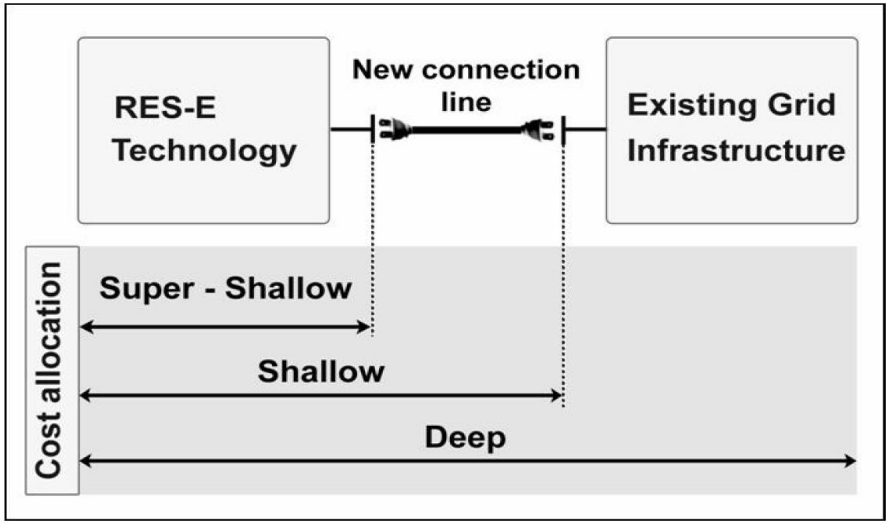
Distribution and transmission grid reinforcement



Source: Auer et al. 2007, http://greennet.i-generation.at/files/Report%20on%20Synthesis%20of%20Results%20on%20RES-E%20Grid%20Integration%20%28D11%20GreenNet-EU27%29.pdf

Shallow vs. deep connection charging

- Who pays for the connection to the nearest connection point?
- Who pays for distribution and transmission network upgrades?
- Who pays for substation, etc.



Source: Auer et al. 2007, http://greennet.i-generation.at/files/Report%20on%20Synthesis%20of%20Results%20on%20RES-E%20Grid%20Integration%20%28D11%20GreenNet-EU27%29.pdf

Super shallow connection charging for solar in India

- ADB financed renewable energy development in Rajasthan, India
- ADB provided $500 m for transmission grid expansion
  - construction of grid substations at project location
  - construction of associated automation and control infrastructure

- Objective:
  - Decrease grid-related costs for project developers;
  - Access locations with high solar radiation

Source: ADB - Rajasthan Renewable Energy Transmission Investment Program

The availability of space

Spatial planning and the deployment of renewables

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Spatial planning: Introductory questions

Who is responsible for spatial planning (national, regional, local)?

How are (renewable) energy projects integrated into spatial planning legislation?

Is there competition for limited space?

General approach:

- Clarify responsibilities for spatial planning (interplay between regional level and national planning programs)
- Identify areas which are definitely excluded from building renewable energy projects (matrimonial heritage sites, natural parks, etc.).
- Identify areas which might be potentially excluded (environmentally and culturally sensitive areas) or where there is potential competition with other infrastructure development

General approach – densely populated countries

- In densely populated countries:
  - Determine the minimum distance of renewable energy projects from cities, villages, houses, industrial complexes
  - Reserve space for the future development of renewable energy projects (especially in areas with high resource potential).
  - Define the role of renewables in spatial planning (see case study Germany)

Spatial planning in Germany

- Complex interplay of planning legislation at national (Raumordnungsgesetz), regional (Landesplanungsgesetze) and community level (Baugesetzbuch).
- Typical planning process:
  - Spatial development plan from local government
  - First planning draft from local planning authority
  - In parallel: First draft for environmental impact assessment
  - Start of first participation phase (written comments from citizens on planned project)

http://www.kommunal-erneuerbar.de/fileadmin/content/PDF/62_Renews_Spezial_Planungsrecht_online.pdf

Spatial planning in Germany

- Typical planning process (continued):
  - Comments from citizens and other actors are included an first planning draft is presented
  - In parallel: Environmental Impact Assessment from responsible authority
  - Start of second participation phase (at least one month for further comments)
  - Followed by weighting whether stakeholder statements should be incorporated (if yes, another round of stakeholder participation is necessary).
  - Next step: crucial phase of approval process (approval from a higher ranking planning level, e.g. regional or national).

http://www.kommunal-erneuerbar.de/fileadmin/content/PDF/62_Renews_Spezial_Planungsrecht_online.pdf

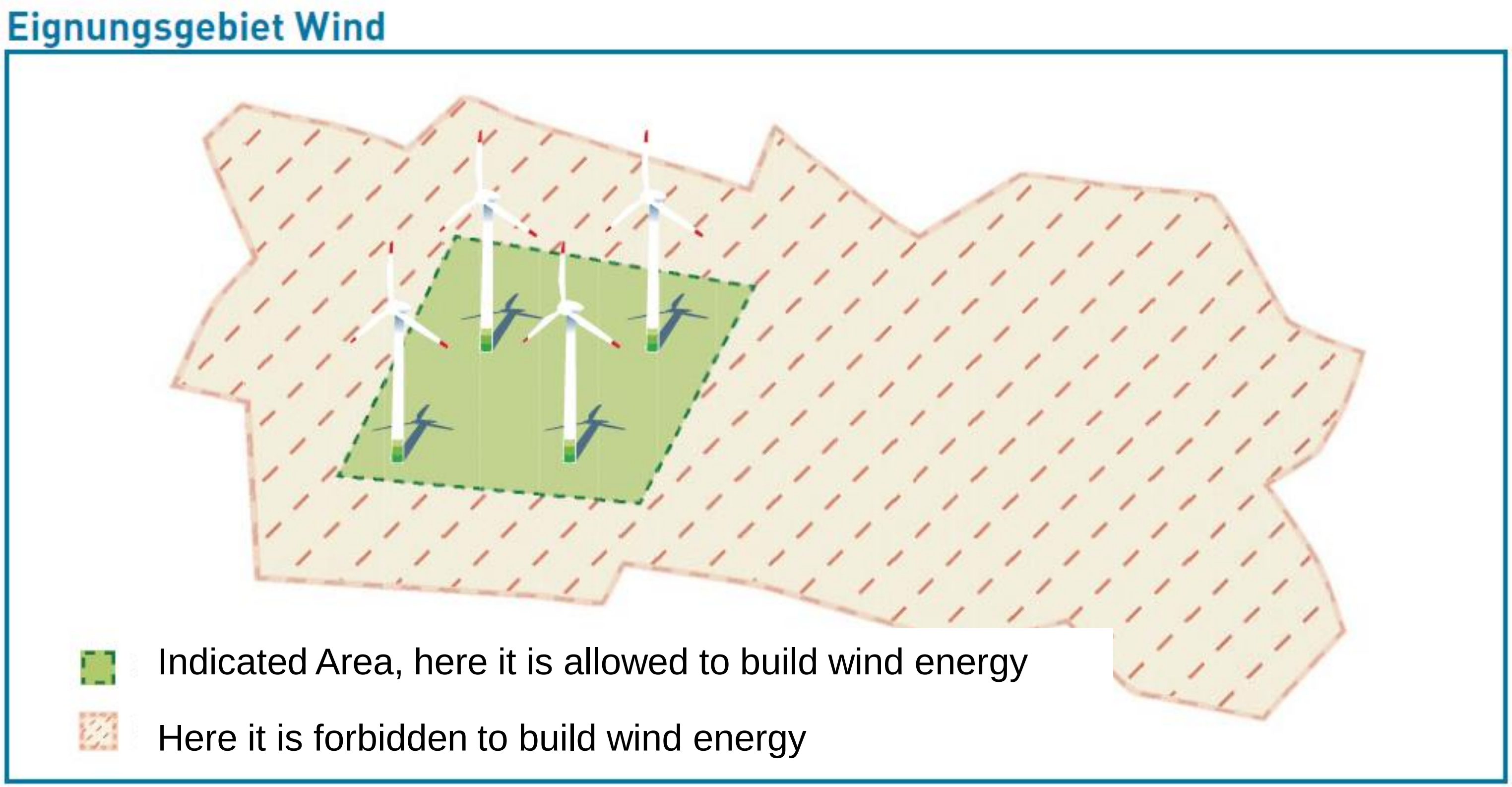
Spatial planning in Germany – Land use plans

- Land use plans include:
  - Determination of general spatial structure (settlements, free zones, infrastructure such as streets, energy, industrial areas).
  - Optional implementation of so-called special area classes (Sondergebietsklassen)

http://www.kommunal-erneuerbar.de/fileadmin/content/PDF/62_Renews_Spezial_Planungsrecht_online.pdf

Spatial planning in Germany – Indicated Areas

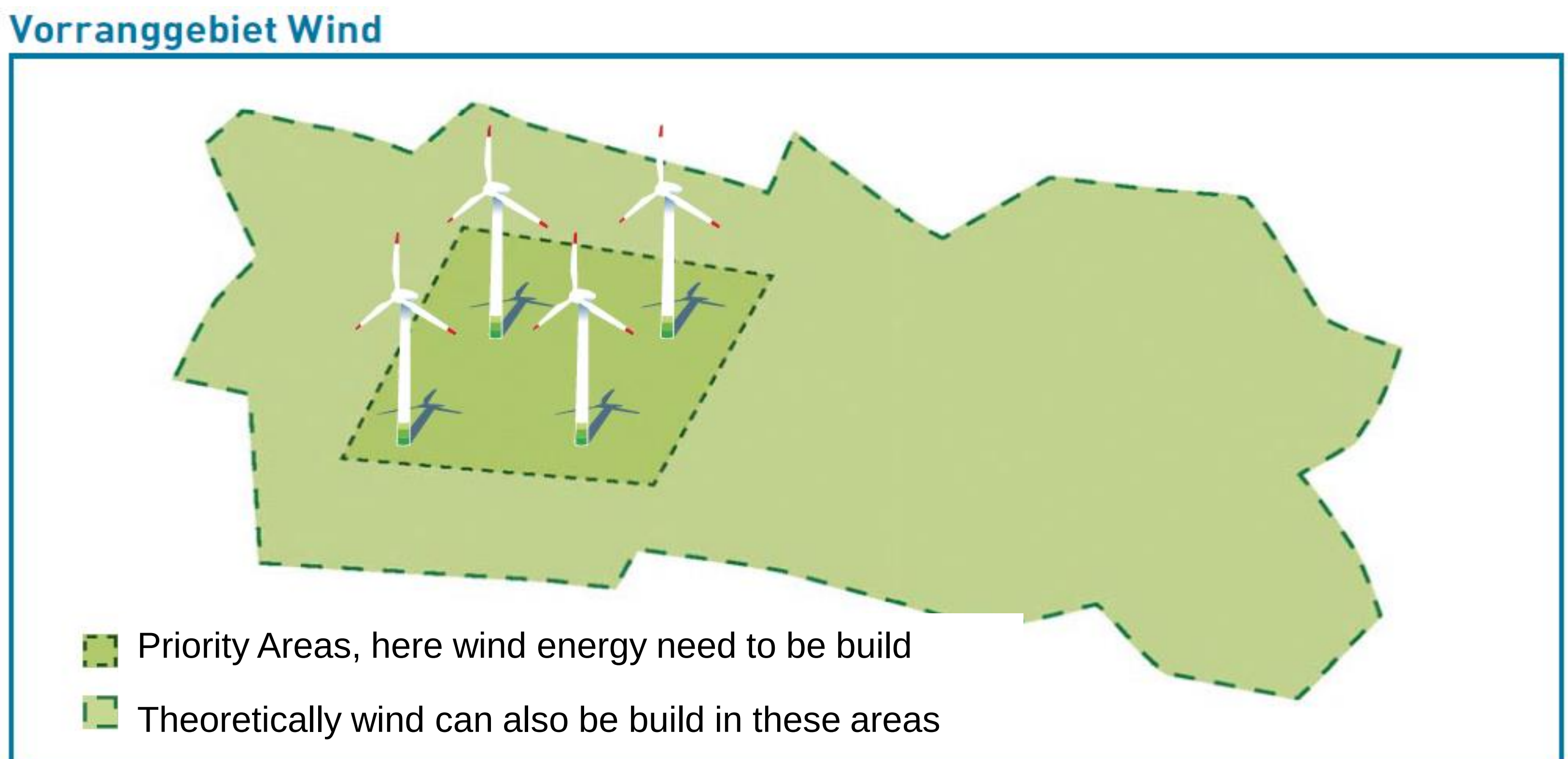
- Implementation of “Indicated Areas” (Sondergebietsklasse) for wind energy in 1995 accelerated market development



Source: http://www.unendlich-viel-energie.de/mediathek/hintergrundpapiere/planungsrecht-und-erneuerbare-energien

Spatial planning in Germany – Priority Areas

- Priority areas lead to exclusion from other spatial planning focuses. In this areas, only wind energy projects can be realized

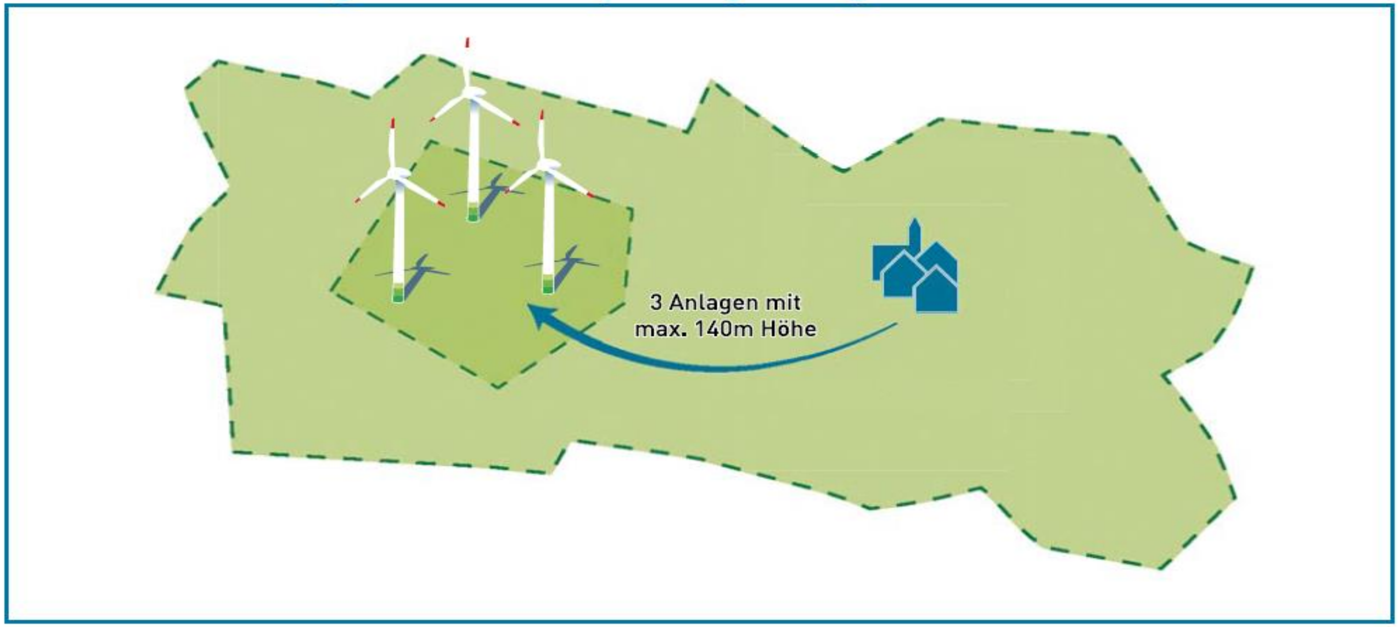


Source: http://www.unendlich-viel-energie.de/mediathek/hintergrundpapiere/planungsrecht-und-erneuerbare-energien

Spatial planning in Germany – The role of communities

- Communities have to comply with planning processes at the next higher political level (regional). However, communities can determine details such as the maximum hight of wind power plants and the distance to the next settlement

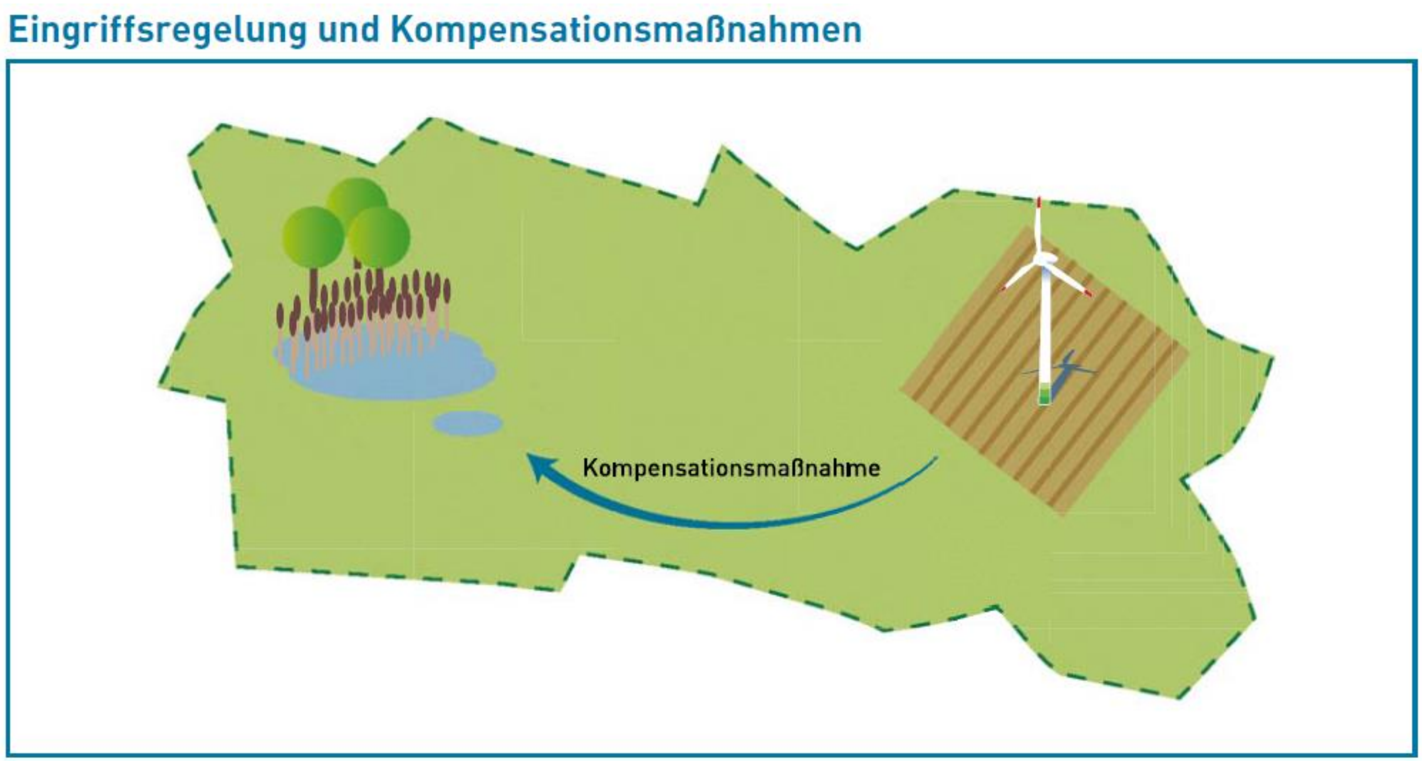
Kommunale Planungshoheit und Anpassungszwang



Source: http://www.unendlich-viel-energie.de/mediathek/hintergrundpapiere/planungsrecht-und-erneuerbare-energien

Spatial planning in Germany – Compensation measures

- Re-create and ecological equilibrium via compensation measures



Source: http://www.unendlich-viel-energie.de/mediathek/hintergrundpapiere/planungsrecht-und-erneuerbare-energien

The availability of system flexibility

Measures to integrate increasing shares of fluctuating renewables

Dr. David Jacobs – IET (International Energy Transition)

The relation between resource mapping and system flexibility

- The technical potential for renewable energy sources in a give country is not only limited by the availability of grid infrastructure and space

- The integration of fluctuating renewables might also be limited due to technical issues (volatility, ramping capability, etc.)

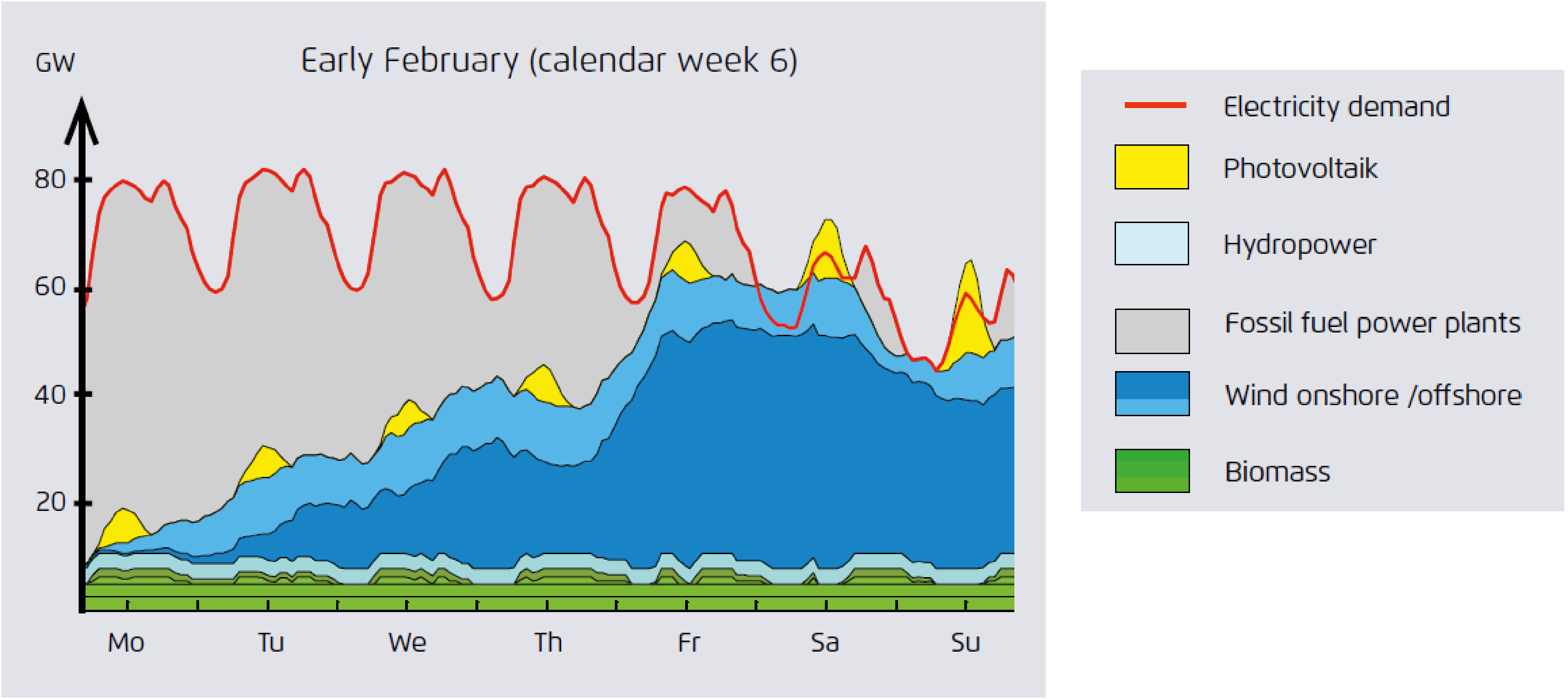
- Therefore, an assessment of various flexibility options in the electricity system is essential in order to assess the actually realizable potential

Creating a flexible power market

- Options for integrating high shares of wind and solar PV
  - Grid expansion/integration; smart grid
  - **Dispatch of conventional power plants**
  - Dispatch and curtailment from renewable energy sources
  - Demand response
  - Storage

The electricity market is determined by wind and solar PV

Electricity demand and renewable power generation in Germany in 2022

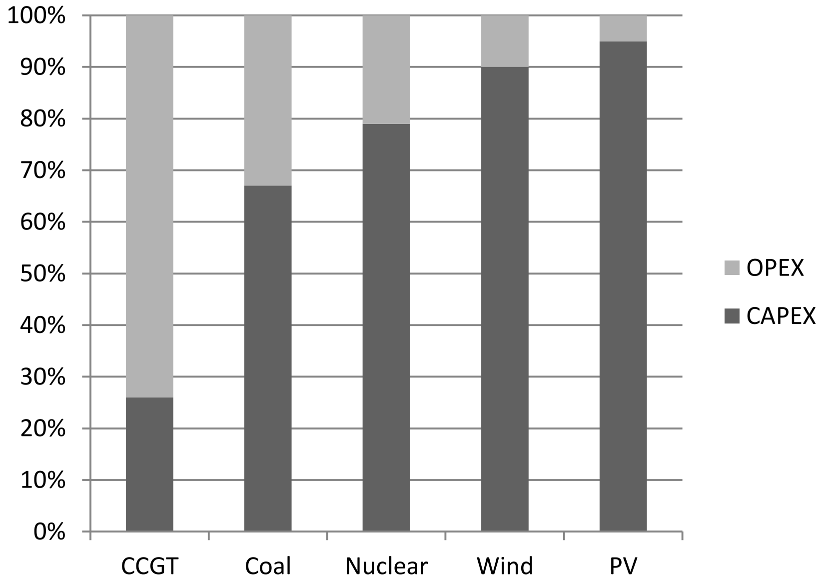


Source: Agora Energiewende 2012

Important features of wind and solar

- High upfront investment (capital costs)
- Almost zero marginal costs
- Fluctuating supply (depending on the weather)

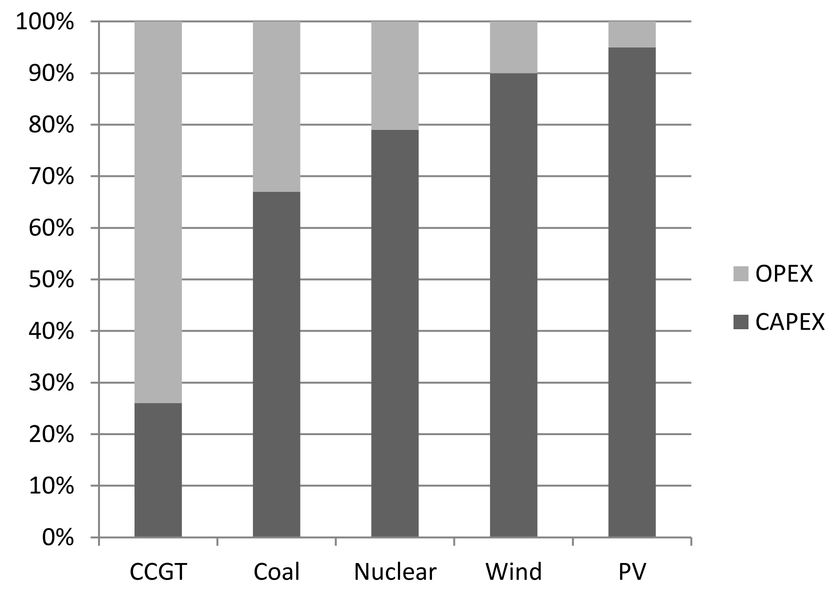
Share of fixed versus variable costs of selected power generation technologies



Important features of wind and solar

- High upfront investment (capital costs) – INVESTMENT SECURITY is crucial!
- Almost zero marginal costs – they come FIRST in the MERIT ORDER!
- Fluctuating supply (depending on the weather) – backup needs to be provided by other flexibility options

Share of fixed versus variable costs of selected power generation technologies



Conventional power plants need to become more flexible

- Base load power plants disappear (fossil fuel power plants need to become more flexible)
- Reduce must-run requirements of conventional power plants
- Reduced full-load hours for coal and gas-fired power plants
  - changing economics and additional revenue requirements via capacity markets?
- Upgrade existing power plant in order to allow for better ramping capabilities

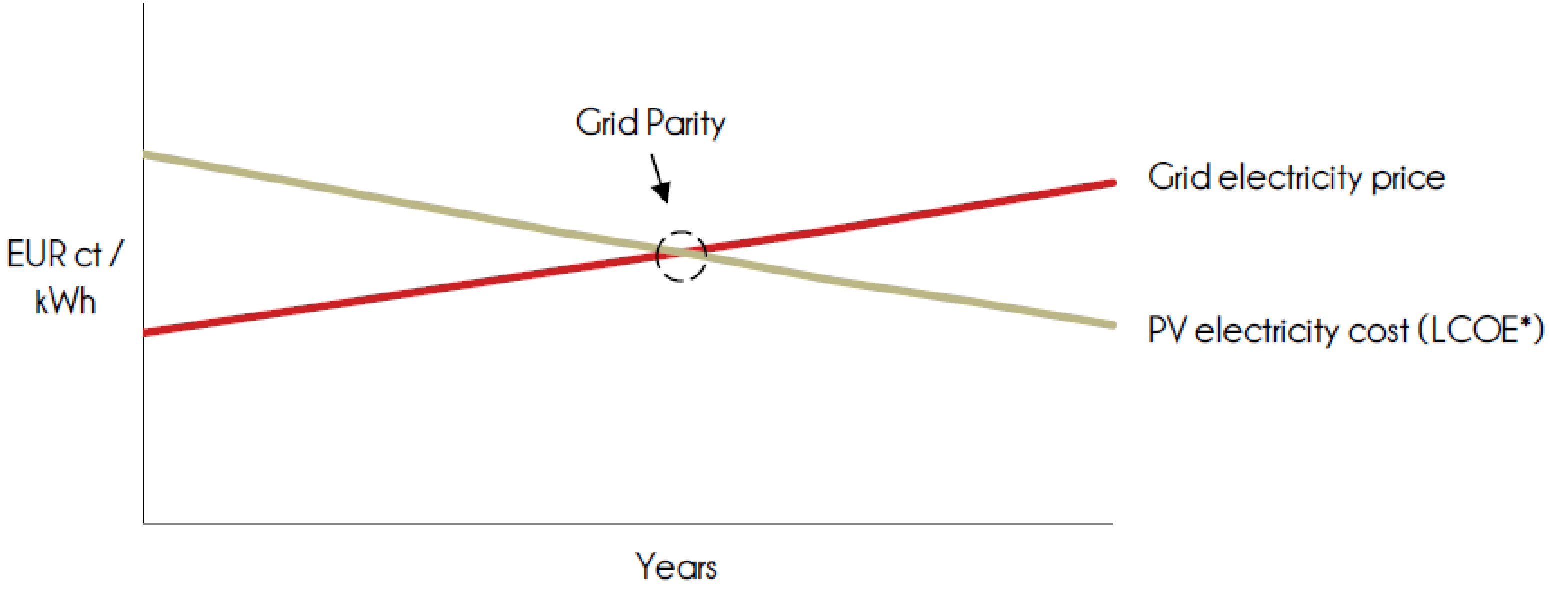
Making best use of the existing grid infrastructure:

Net Metering Policy Design

Dr. David Jacobs – IET (International Energy Transition)

Simplistic grid parity and "self-consumption"

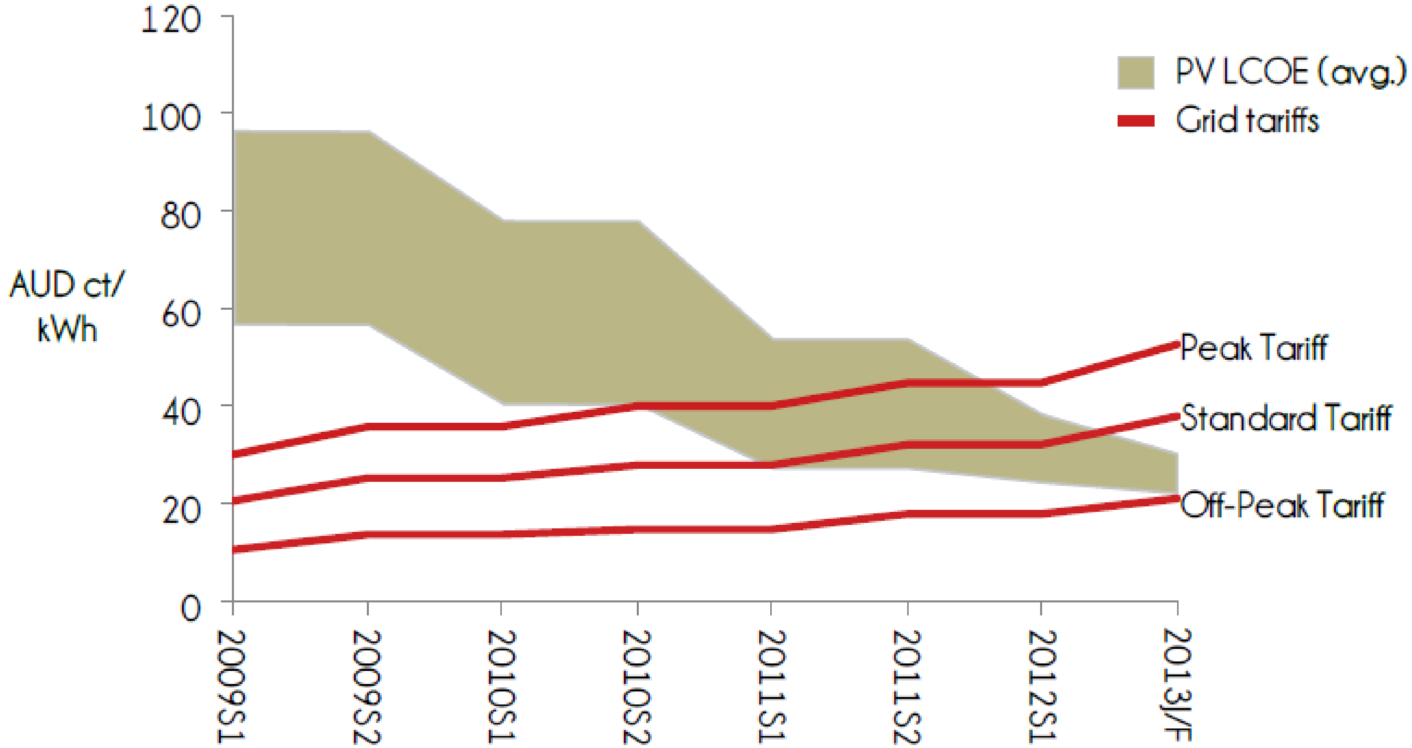
Figure 4: Simplistic Illustration of PV Grid Parity



Note: * Levelized Cost Of Electricity
Source: Eclareon Analysis

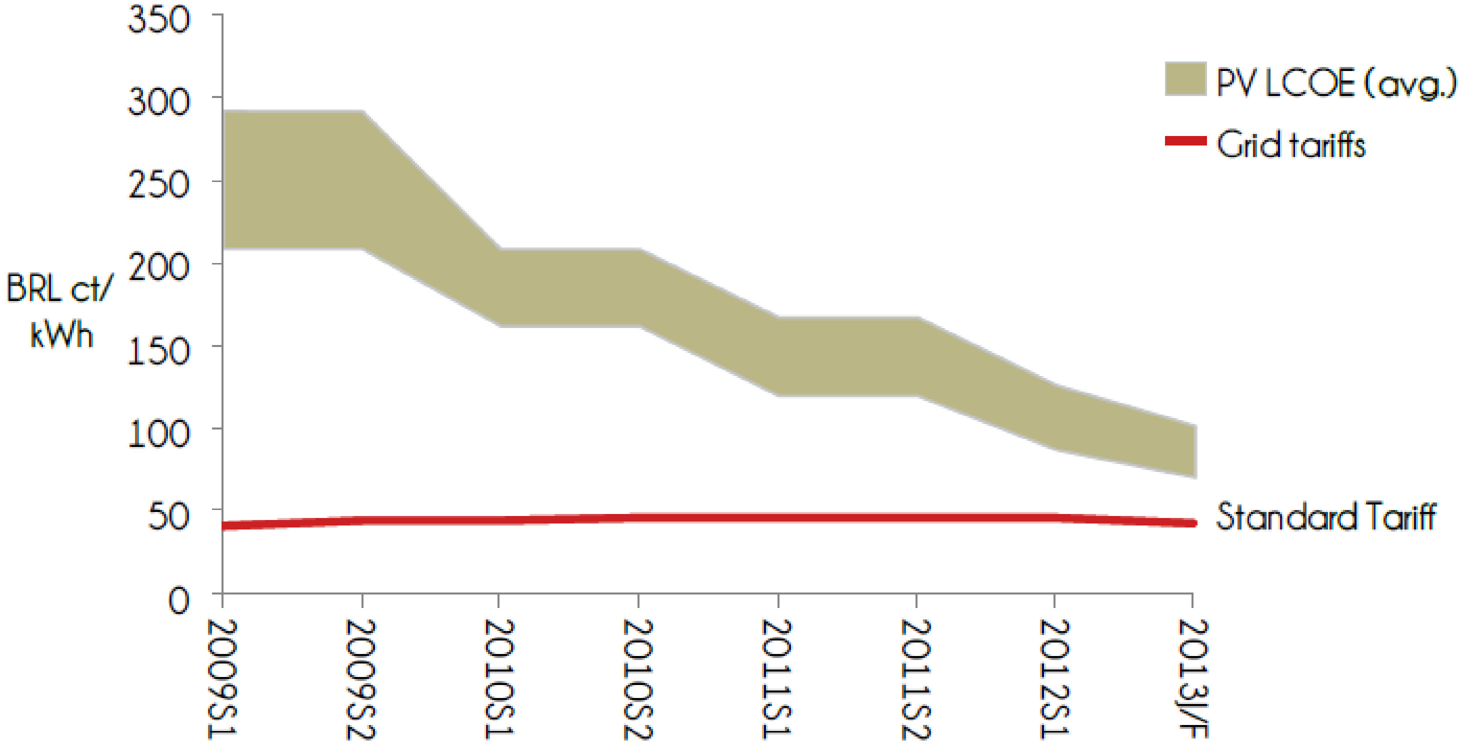
Source: Eclareon 2013

Grid parity in Sydney, Australia (residential)



Source: Eclareon 2013

“Grid parity” in Sao Paulo, Brazil (residential)



Source: Eclareon 2013

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Electricity tariff structure and incentives for self-consumption

- Contrary to European countries and the US, electricity prices in developing countries/African countries are generally low for domestic consumers and high for commercial consumers/industry
- Example: Kenya

Tariff	Type of Customer	Supply Voltage (V)	Consumption (kWh/month)	Fixed Charge (KES/month)	Energy Charge (KES/kWh)	Demand Charge (KES/ kVA/ month)
DC	Domestic Consumers	240 or 415	0 – 50	120.00	2.00	-
			51 – 1,500		8.10	
			Over 1,500		18.57	
SC	Small Commercial	240 or 415	Up to 15,000	120.00	8.96	-
CI1	Commercial/ Industrial	415, 3 phase	Over 15,000	800	5.75	600
CI2		11,000		2,500	4.73	400
CI3		33,000 / 40,000		2,900	4.49	200
CI4		66,000		4,200	4.25	170
CI5		132,000		11,000	4.10	170
IT	Interruptible off-peak supplies	240 or 415	Up to 15,000	240	4.85	-
SL	Street Lighting	240	-	120.00	7.50	-

Source: Hille et al. 2011

Net metering programs world-wide

Europe	Americas	Asia	Middle East	Africa
Belgium	Guatemala	Japan	Jordan	Tunesien
Czech Republic	Canada (regional)	Philippines	Palestine	Cap Verde
Denmark	Mexico	Singapore	Uruguay	
Greece	USA (43 States)	South Korea		
Italy	Peru			
Malta	Dominican Republic			
Switzerland	Panama			
Portugal				
Spain				

Source: REN21 2013

Net Metering Design Features: Eligible technologies and sectors

Features	Design Options
Eligible Renewable/ Other Technologies:	**Photovoltaics** (but also Solar Thermal Electric, Landfill Gas, Wind, Biomass, Hydroelectric, Geothermal Electric, Municipal Solid Waste, Hydrokinetic, Anaerobic Digestion, Small Hydroelectric, Tidal Energy, Wave Energy, Ocean Thermal)
Applicable Sectors:	**Residential (limitation to certain system size?)** Commercial, Industrial, Schools, Local Government, State Government, Federal Government, Agricultural, Institutional

Net Metering Design Options

Features	Design Options
Program size	• Defined as a percentage of total peak demand • Defined as a capacity limit • Unlimited
System size:	• Limit on installed capacity per unit (e.g. 10 kW) • Limitation in relation to the average, annual electricity demand in a region/country (e.g. average electricity demand of 300 kWh/a; 1% of 300 kWh = maximum size of 3 kw) • Local electricity generation may not exceed local electricity demand (household with 300 kWh consumption may not produce/net meter more than 300 kWh of generation).

Roll-over provisions for excess electricity

Features	Design Options
Program size	• Indefinate • Yearly • Monthly • Hourly
The value of the role over:	• retail price • wholesale price • combinations

Auto consumptions and the "solidarity"-based electricity system

- Are there major exemptions/privileges for electricity auto-consumption in your country?
  - Grid usage fees?
  - Other taxes or levies?

- If industry subsidizes household electricity prices in Africa countries, do you want them to auto-produce/consume electricity (and no longer pay the higher industrial/commercial rate?

Investment (in)security in the case of net metering

- Changes in Net Metering regulations will effect new power plants AND existing power plants

- Changes in electricity pricing (moving from monopolised markets to liberalized markets in the coming 20 years?)

- Changes in electricity rate structure (costumer classes)

Thank you very much for your attention!

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