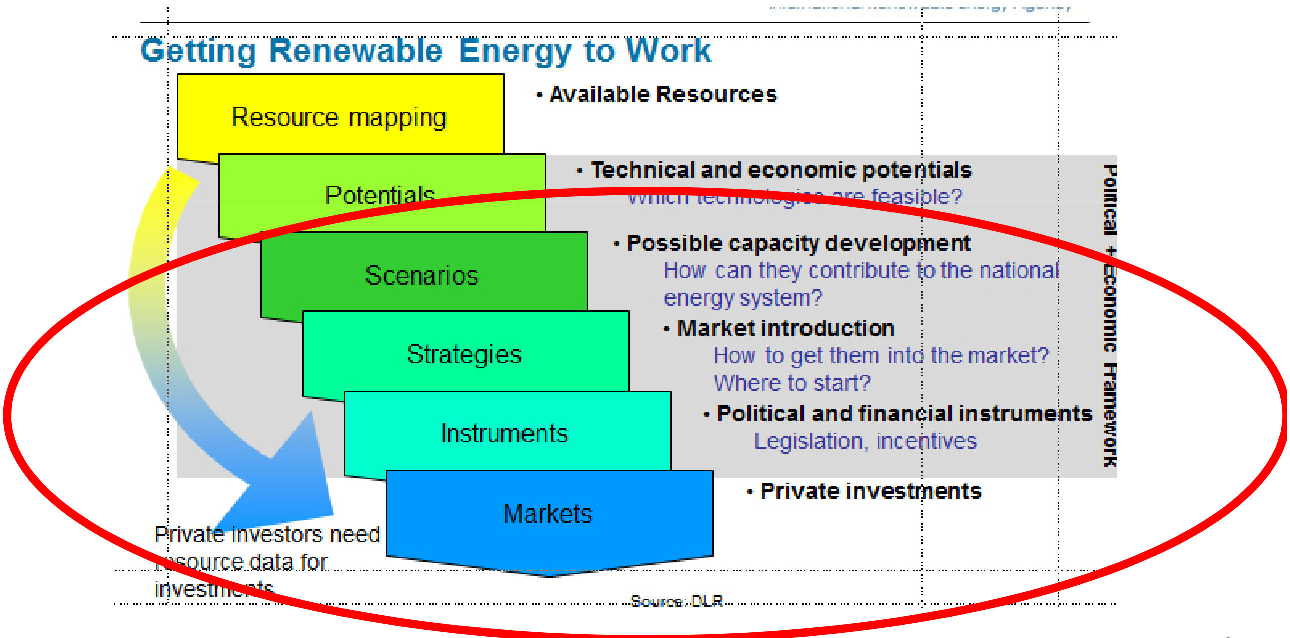
Session 4:
From scenarios to policy and market development

IRENA Global Atlas
Spatial planning techniques
2-day seminar

Dr. David Jacobs – IET (International Energy Transition)

From scenarios to the actual deployment of renewables



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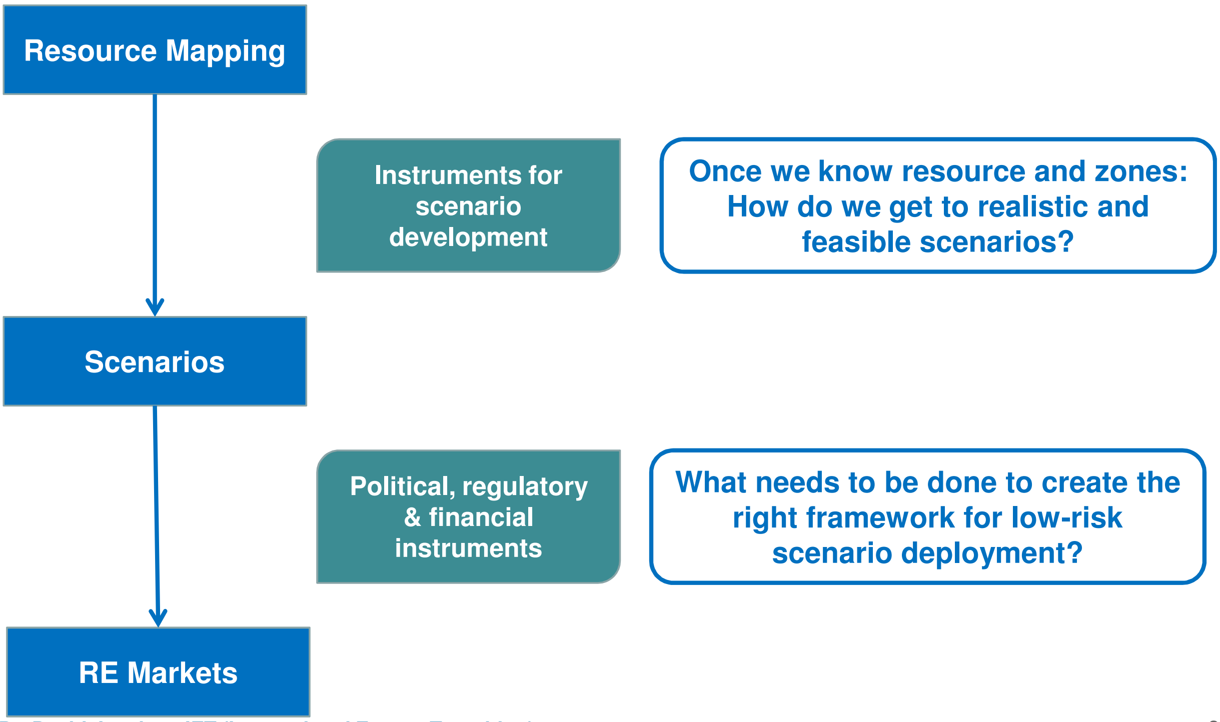

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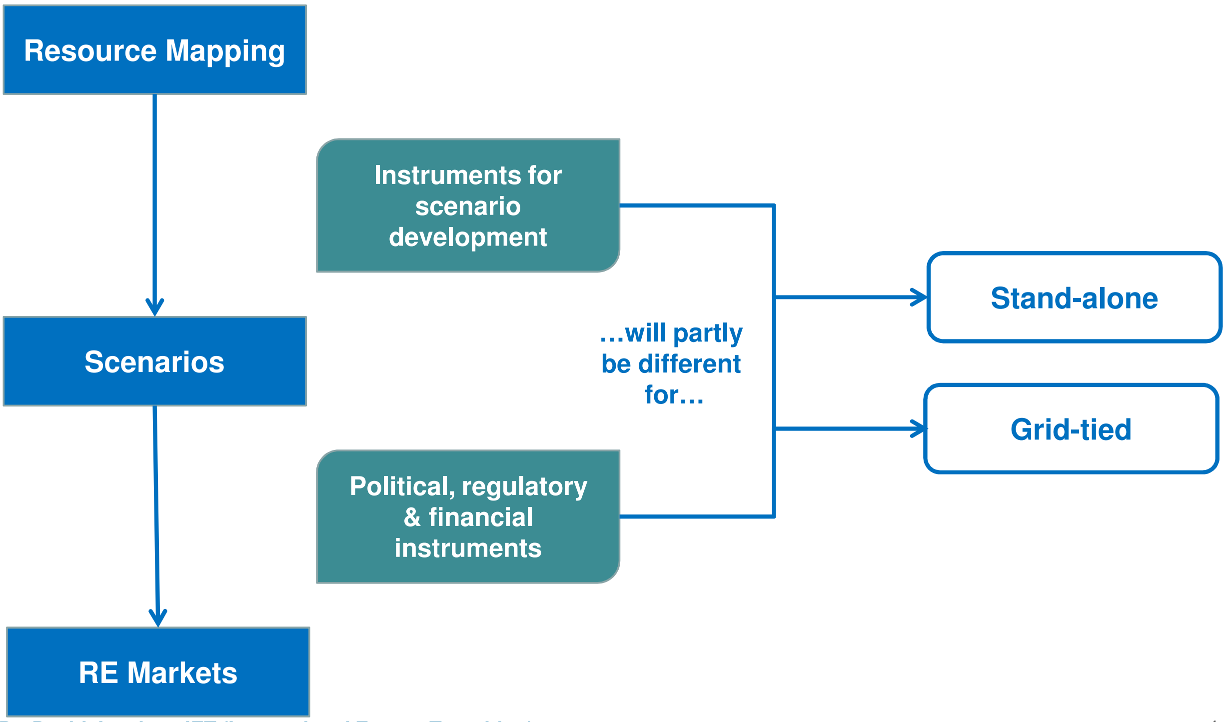

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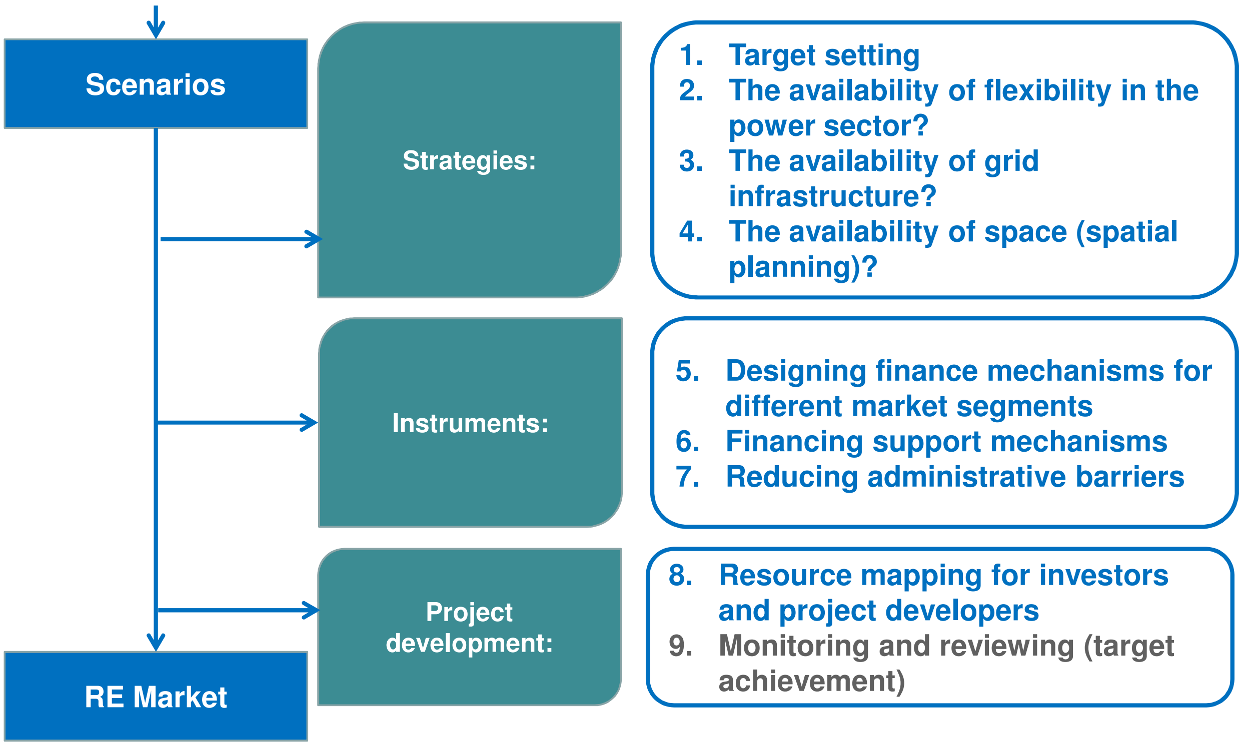

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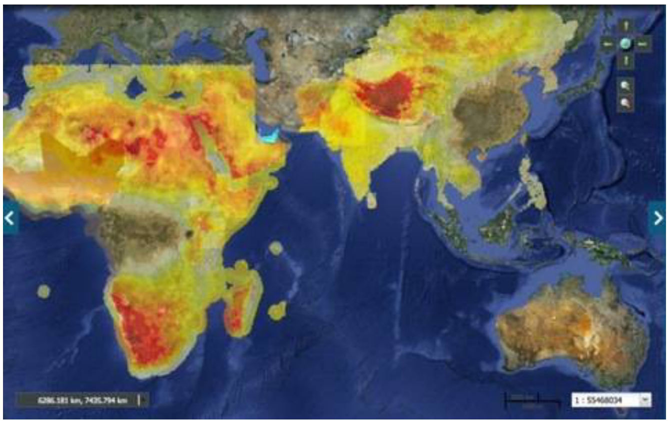
Strategies and target setting –

The availability of resources and setting of deployment targets based on resource assessments

From resource assessment to deployment targets

- Mapping results into availability of information on amount of available resource and suitable areas

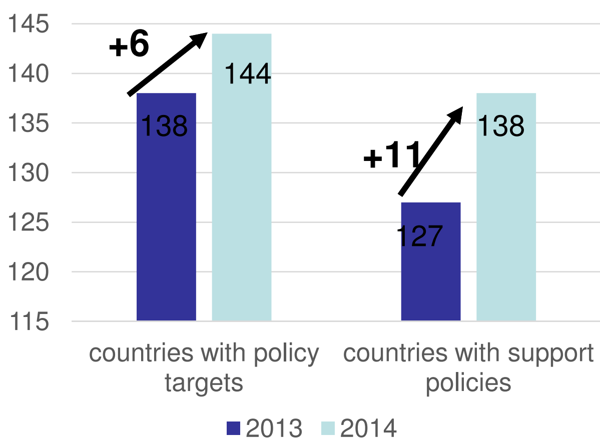
- Policymakers are enabled to set targets based on available resources



Renewable energy targets

- **More countries are setting policy targets for renewable energy**
- **Countries are also enacting support policies to ensure fulfillment of the target**
- **2013: more revisions of policies and targets to:**
  - Improve efficiency and effectiveness of targets and policies
  - Curtail cost of promoting renewables
  - Increase RE support and adopt more ambitious policies (Cape Verde)

Source: E3 Analytics, Toby Couture



Source: REN21 Global Status Report (GSR) 2014

Objectives for setting renewable energy targets

- 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:
  - least cost planning?
  - Industry policy?
  - Security of supply?
  - Energy access?
  - Climate policy?

How to Set Targets after Resource Assessment

Establishing targets requires a few essential components:

1. Identifying constraints (e.g. grid capacity, cost impacts, etc.)
2. Identifying technical and economic potential
3. Analysing the Current Energy and Electricity Mix – system integration
4. Estimating Cost Impacts and Conducting Scenario Analyses

Source: E3 Analytics, Toby Couture

Target characteristics

- Other key distinctions between different RE targets:

  Option 1: Binding (mandatory by law) vs. Non-Binding (Voluntary or 'Aspirational')

  Option 2: Technology Neutral (generic RE target) vs. Technology Differentiated (wind, solar, biomass, etc.)

  Option 3: National targets versus regional planning (locational signals)

Source: E3 Analytics, Toby Couture

Scenarios, targets and system integration:

Availability of flexibility in the power sector?

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Integrating increasing shares of renewables

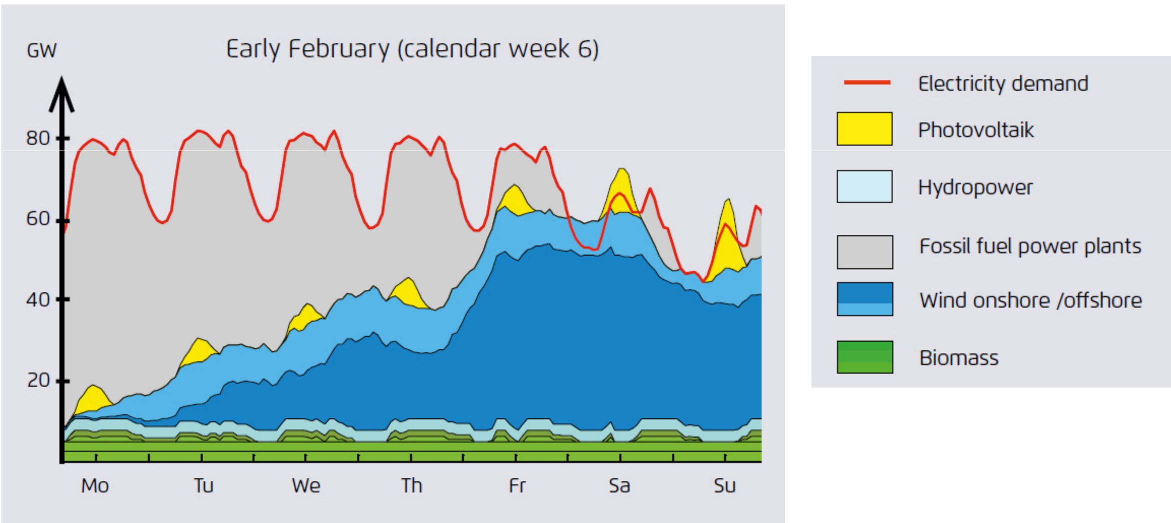
- Options for integrating high shares of wind and solar PV
- What is the design of the power sector in your country?
  - subsidized electricity prices, liberalized market vs. state-owned utilities/grid operators?
- What is the level on knowledge on renewables in the responsible ministry/the grid operator/utilities, regional agencies? Is it necessary to include specific trainings or consultancy services, campaigning?

Creating a flexible power market

- Options for integrating high shares of wind and solar PV
  - Grid expansion/integration; smart grid
  - **Dispatch from 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

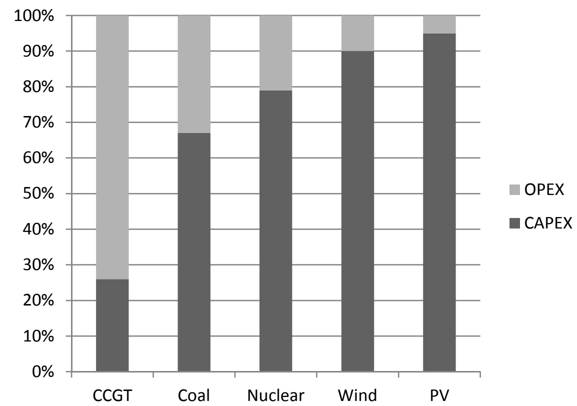


Source: Agora Energiewende 2012

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



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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

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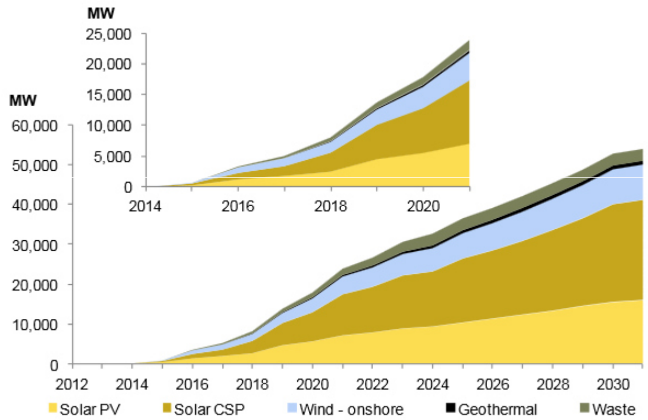
Experience from emerging markets:

Resource assessment and target setting in Saudi Arabia

Renewable energy programs in Saudi Arabia – identifying the best locations

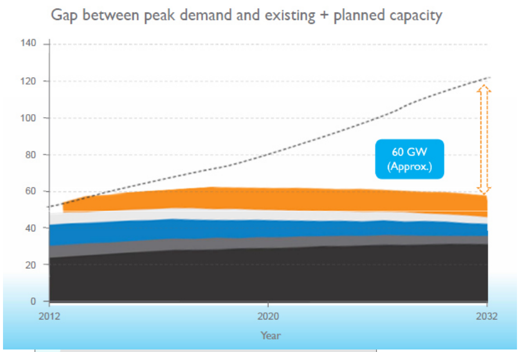
- The Kingdom of Saudi Arabia targets a newly installed renewable energy capacity of 54 GW by 2032
- Rationale: cost savings, climate protection, energy access
- Proposed RE deployment until 2032:

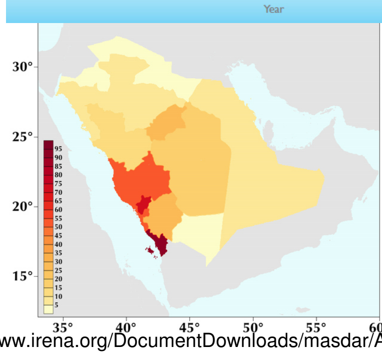


Source: KA-Care 2012 (White Paper)

Assessing electricity demand and load centres

- Electricity demand is expected to increase considerably in the coming decade (60 GW of new capacity required)
- Load centres are very centralized (along the cost and in the greater Riyadh area).
- Off-grid solutions for oil businesses





Source 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)
- Pre-development of sites envisaged (speed up deployment process)

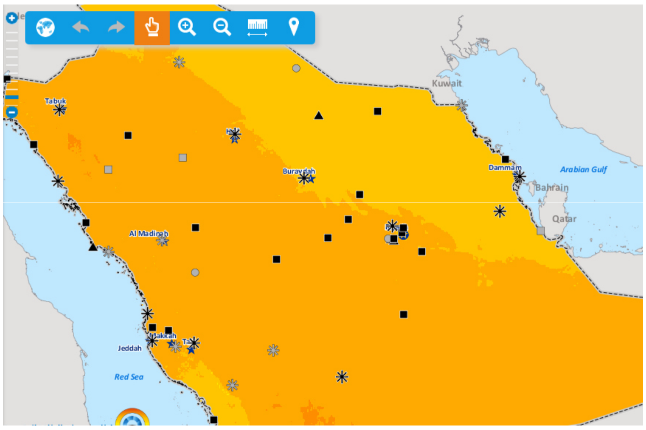
Technologies	Round 1	Round 2
Solar PV	1,100	1,300
Solar Thermal	900	1,200
Wind	650	1,050
Others (including geothermal, waste to energy)	50-350	50-350

Source: KA-Care 2012

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/

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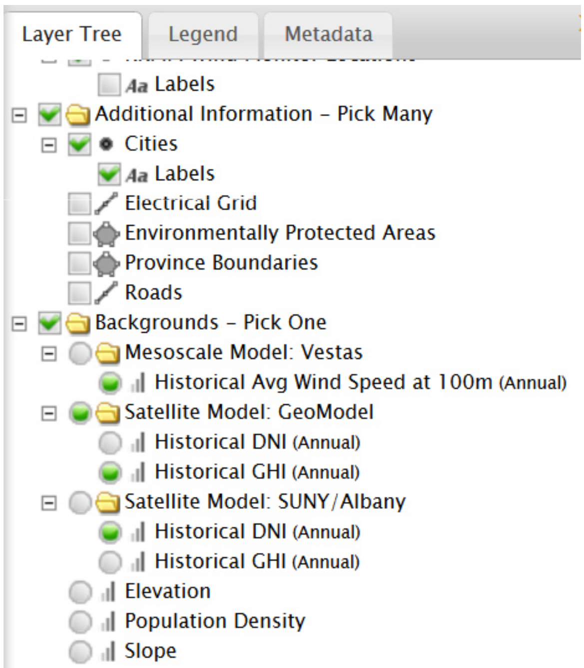
Assessing the grid infrastructure

- Limited grid availability outside of cities/few big load centres
- Few roads, environmentally protected areas
- Early dialogue between policymakers and National Grid Saudi Arabia (NGSA) to ensure grid availability or extension suitability
- Need for pilot projects!



Source: http://rratlas.kacare.gov.sa/RRMMDataPortal/en/MapTool

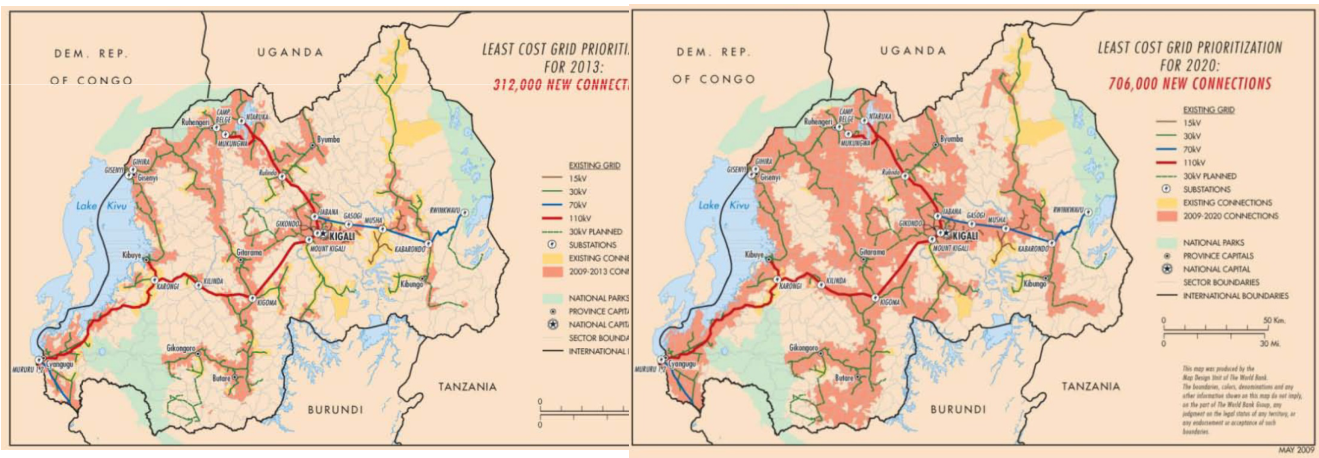
From scenarios to strategies:

Availability of grid infrastructure?

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

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

Figure 2: Rates of Electrification in Tanzania (%)

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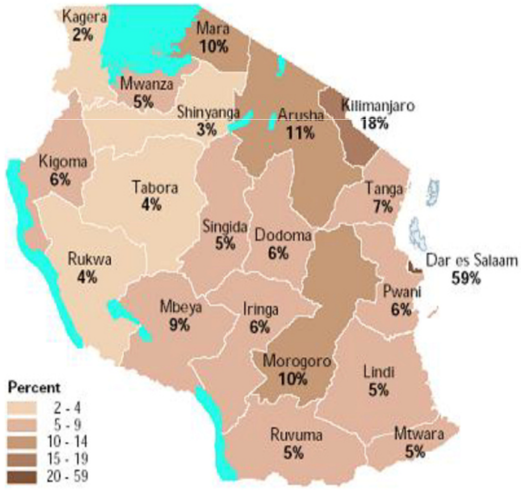
Grid coverage and rural electrification in Tanzania

Option 1: Extend existing transmission and distribution infrastructure

Option 2: Install off-grid systems, most often using liquid fuels such as diesel



Source: Rural Energy Agency 2010

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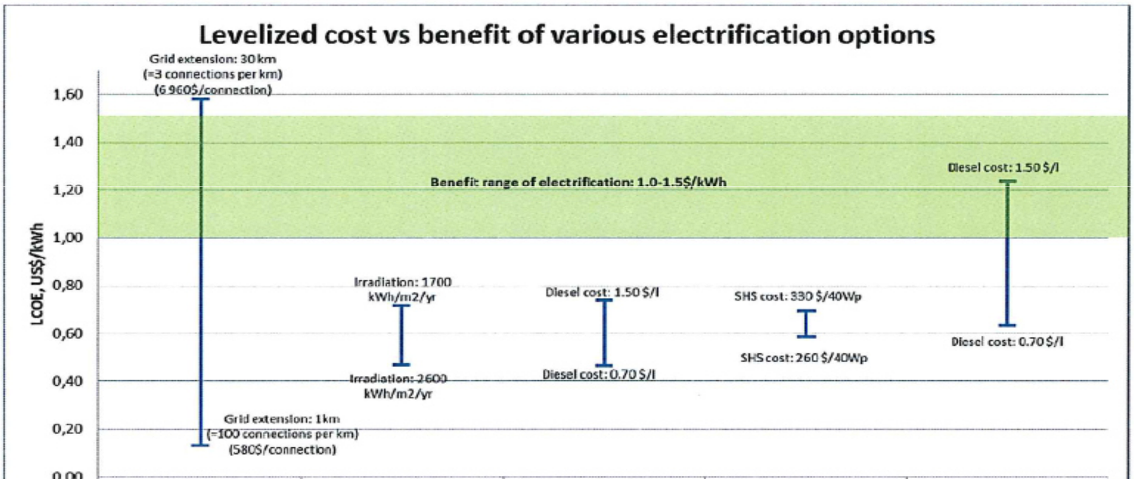
Incentives for grid expansion in Tanzania

- Performance grants
- Credit lines
- Loan refinancing facility
- Lower interest rates

Comparing costs for off-grid technologies and grid expansion



	Grid extension	Solar PV mini-grid	Solar PV-diesel hybrid mini-grid	Solar Home System	Diesel mini-grid
– High	1,579	0,714	0,738	0,695	1,237
– Low	0,132	0,467	0,463	0,585	0,633

Source: http://www.multiconsult.no/Frontpage/Aktuelt/News/NORPLAN-Study-Cost-Competitiveness-of-Rural-Electrification-Solutions-/

Rule of thumb for rural electrification and technology choice

- **Grid extension**
  - 5-100 connections/km ($580-4500 per connection). The social economic benefits will almost always be greater than the costs in a life cycle analysis.
  - 3-5 connections/km ($4500-6500 per connection). The social economic benefits will generally be marginally greater than the costs.
  - <3 connections/km (>$6500 per connection). The social economic benefits will generally be less than the costs.
  - Irrespective of the economic attractiveness, the degree to which the grid extension will prove financially viable will be dependent upon a tariff which reflects the WTP.

Source: Norplan 2012

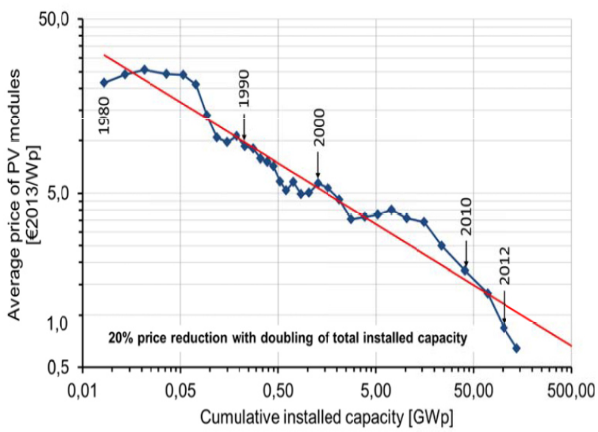
Rule of thumb for rural electrification and technology choice

- **Solar PV mini-grid**
  - Due to dramatic reductions in PV costs in recent years, PV mini-grids are proving to be viable alternatives to grid extension and diesel mini-grids.
  - The LCOE will generally be competitive with that of grid extension when the extension would imply <10 connections/km7.
  - Obstacles: the need for upfront financing, ensuring proper maintenance, etc.

Source: Norplan 2012

Rule of thumb for rural electrification and technology choice

- **Solar PV-diesel hybrid**
  - Due to dramatic reductions in PV costs and high fossil fuel prices, there is currently limited economic justification for a hybrid over a pure solar PV.
  - The LCOE is in the same range as solar PV, but maybe somewhat more attractive in relatively low radiation areas (e.g. <1800/m2).



Source: Norplan 2012

Rule of thumb for rural electrification and technology choice

- **Solar home systems**
  - Market penetration, business climate, transportation costs, etc all have an influence on competition and local prices of solar home systems.
  - Solar home systems will not offer all of the same benefits as electrification and would likely offer benefits somewhere between WTP for lighting and TV ($0.1-0.4/kWh) and that of full electrification ($1-1.5/kWh).
  - In this case, the social economic benefits of solar home systems will likely only outweigh the costs for high income households where no alternative is provided.

Source: Norplan 2012

Rule of thumb for rural electrification and technology choice

- Note:
  - 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).

Source: Norplan 2012

From scenarios to strategies:

Availability of sufficient grid infrastructure?

Grid expansion planning and stakeholder involvement (lessons learned from Germany)

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Insufficient grid capacity

- Insufficient grid capacity 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!)

Stakeholder engagement: Introductory questions

- In how far are citizens and other concerned actors involved in the planning and siting process for energy infrastructure in your country?
- Which actors should be better integrated in the existing planning processes?
- Is there a trade-off between quick planning (and execution) of projects and stakeholder engagement?

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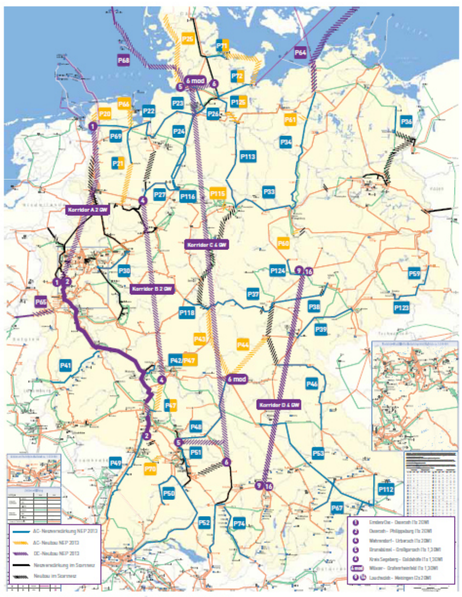
Grid extension plans in Germany

- 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

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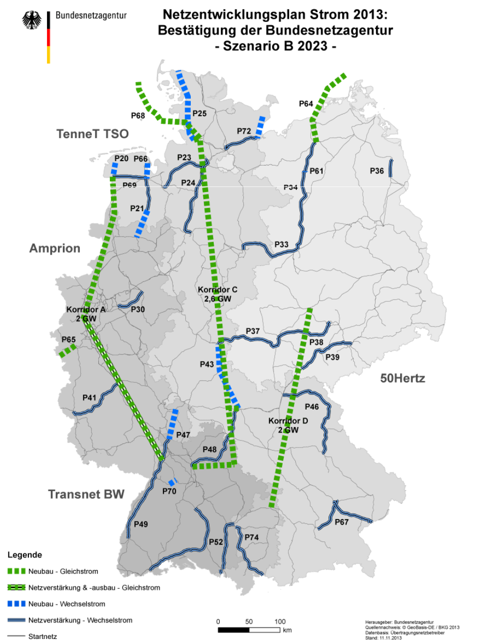
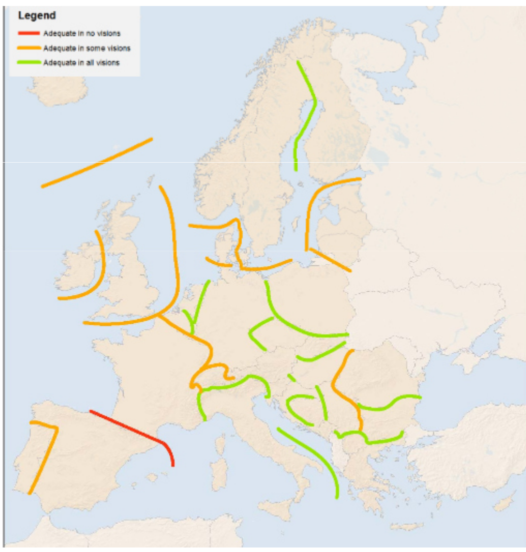
Grid expansion for the German Energiewende

- 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

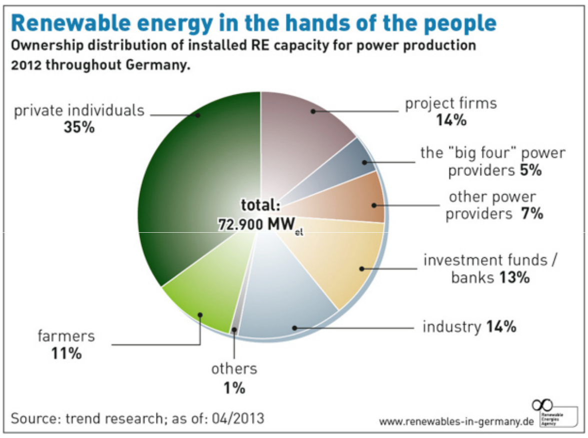
Reasons for opposition from citizens and communities

- 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

Source: Schwäbische Zeitung, 13.10.2013

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

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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

Source: http://www.bg-high-voltage.ca/images/capabilities/distribution/underground/underground-1.jpg

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From scenarios to strategies:

Availability of sufficient grid infrastructure and best practise regulation?

System integration and grid codes

System reliability and grid codes

- Grid codes need to be adjusted to renewable energy technologies (medium voltage and low voltage)
- **The loading capacity of network equipment**
  (Is the grid able to absorb the electrical power of the PV plant at all times?),
- **Voltage changes in the undisturbed grid**
  (Is the voltage change due to the PV plant within defined limits, how can it be limited?),
- **Potential network disturbances caused by the PV plant**
  (What kind of disturbances could be caused by a PV system, what are acceptable limits?), and,
- **The behaviour of PV plants in case of grid disturbances**
  (If there is a grid disturbance, which automatic and active control features does the PV system have to have to be able to support the grid or to avoid further adverse effects?).

From scenarios to strategies:

Availability of sufficient grid infrastructure and best practise regulation?

Grid connection charging

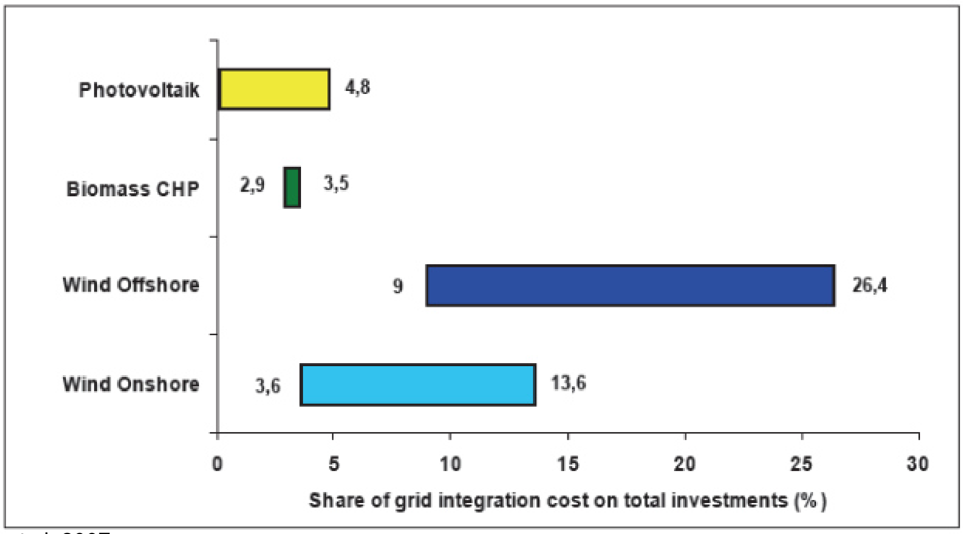
Transparent grid connection

- 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)?
- Deep vs. shallow connection approach (super shallow approach)
- Conventional vs. renewable energy system

Grid connection costs for different renewable energy technologies



Auer et al. 2007

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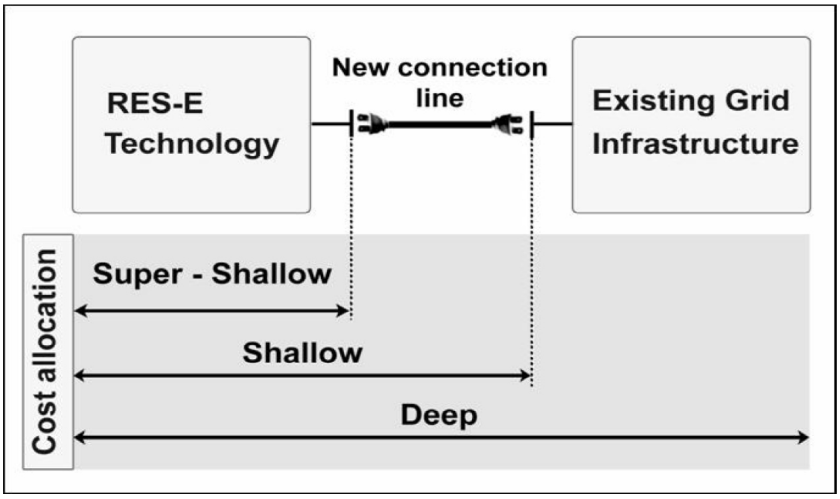
Shallow vs. deep connection charging



Auer et al. 2007

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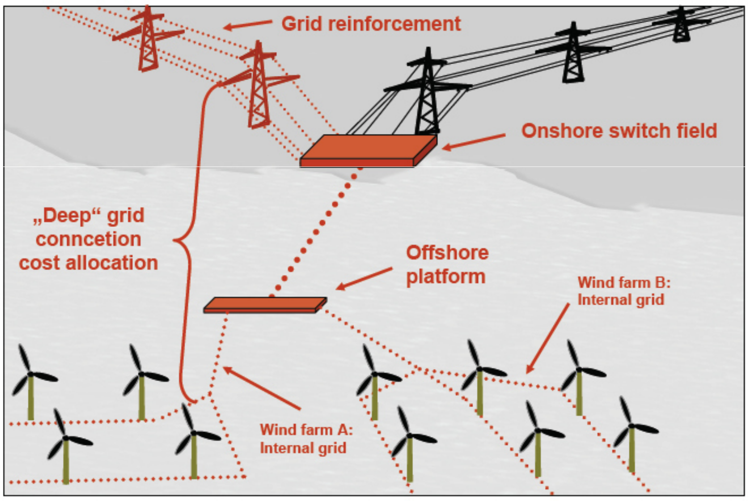
Deep connection charging approach



Auer et al. 2007

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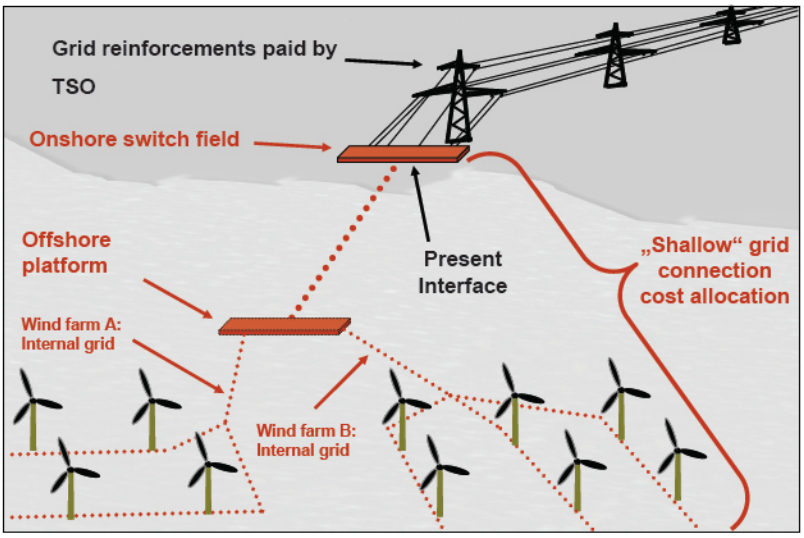
Shallow approach



Auer et al. 2007

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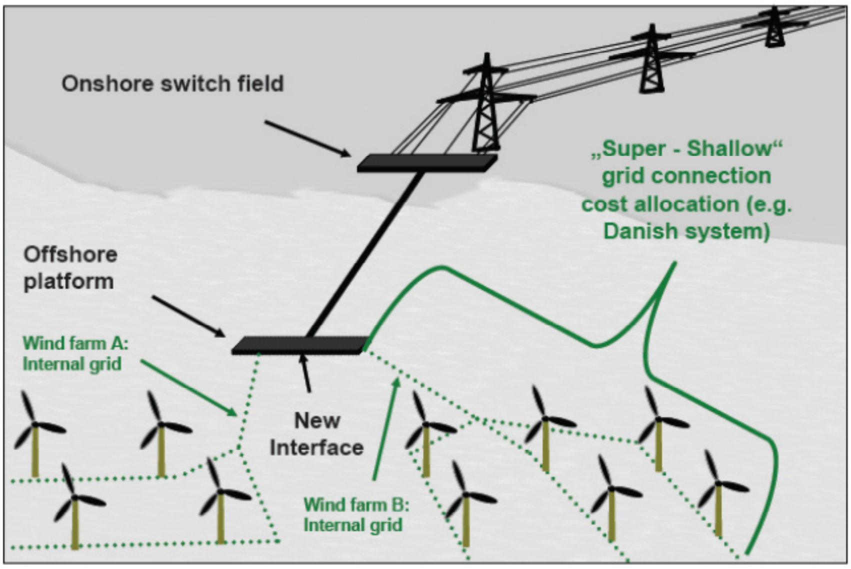
Super shallow approach



Auer et al. 2007

From scenarios to strategies:

The availability of space for project development?

Spatial planning and RES deployment – the German framework

Spatial planning: Introductory questions

- Who is responsible for spatial planning (national, regional, local)?
- Competition for limited space in your country?

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

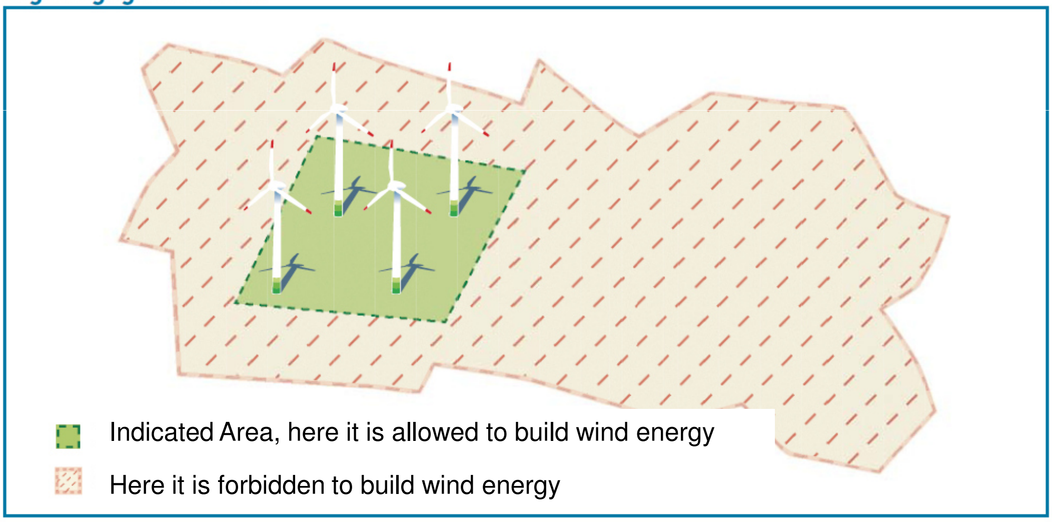
- Land use plans include:
  - Determination of general spatial structure (settlements, free zones, infrastructure such as streets, energy, industrial areas).
  - Optional implementation of so-called special area classes (Sondergebietsklassen)

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

Eignungsgebiet Wind

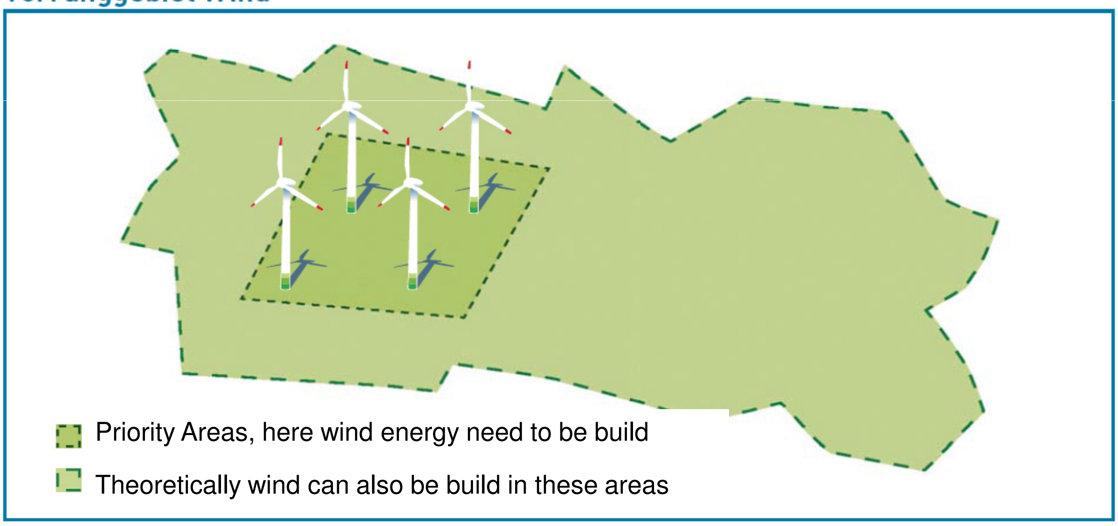


Source: http://www.unendlich-viel-energie.de/mediathek/hintergrundpapiere/planungsrecht-und-erneuerbare-energien

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

Vorranggebiet Wind

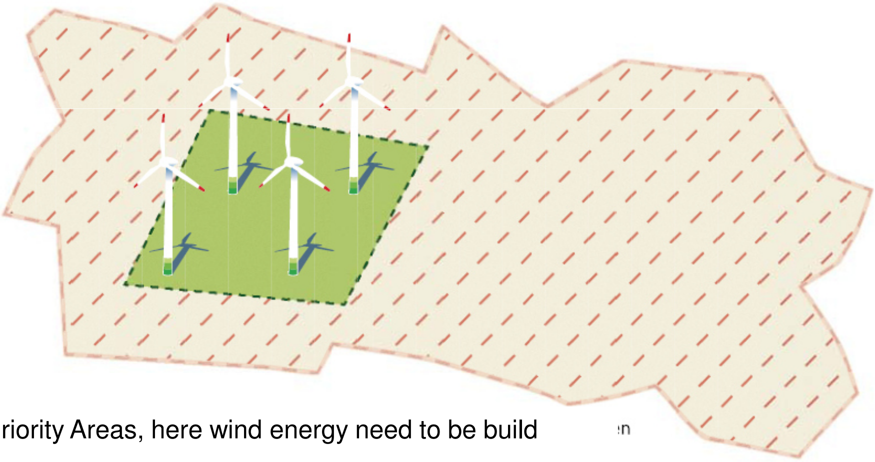


Source: http://www.unendlich-viel-energie.de/mediathek/hintergrundpapiere/planungsrecht-und-erneuerbare-energien

Spatial planning in Germany – Priority Areas with foreclosure

- Combination from indicated area and priority area

Vorranggebiet mit Ausschlusswirkung



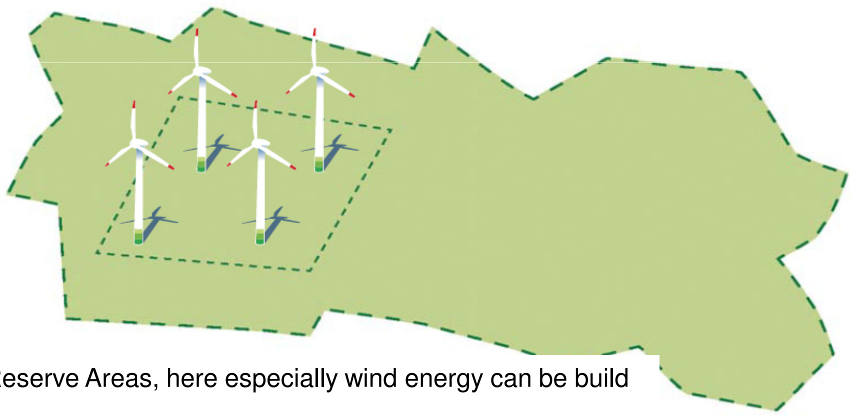
Priority Areas, here wind energy need to be build

Here it is forbidden to build wind energy

Spatial planning in Germany – Reserve Areas

- In case of conflicting planning objectives (roads, housing, etc.) renewable energy projects are being prioritized

Vorbehaltsgebiet Wind



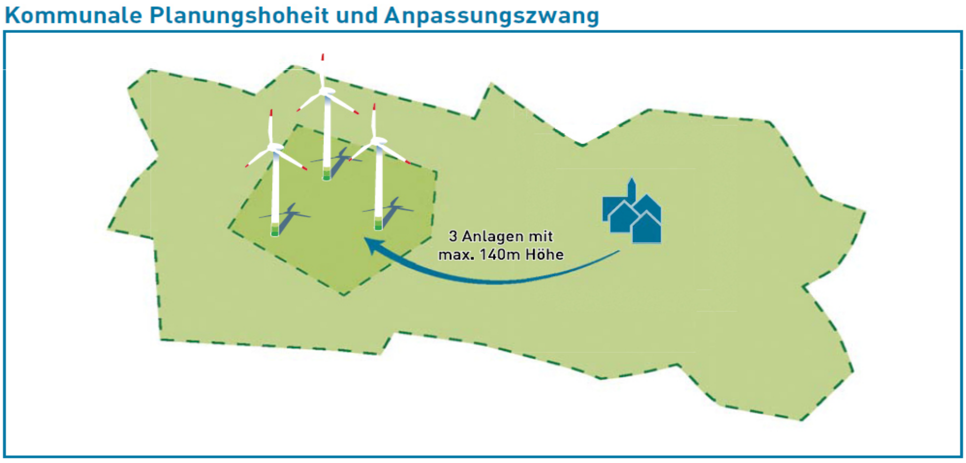
Reserve Areas, here especially wind energy can be build

Theoretically wind can also be build in these areas

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

Spatial planning in Germany – The role of communities

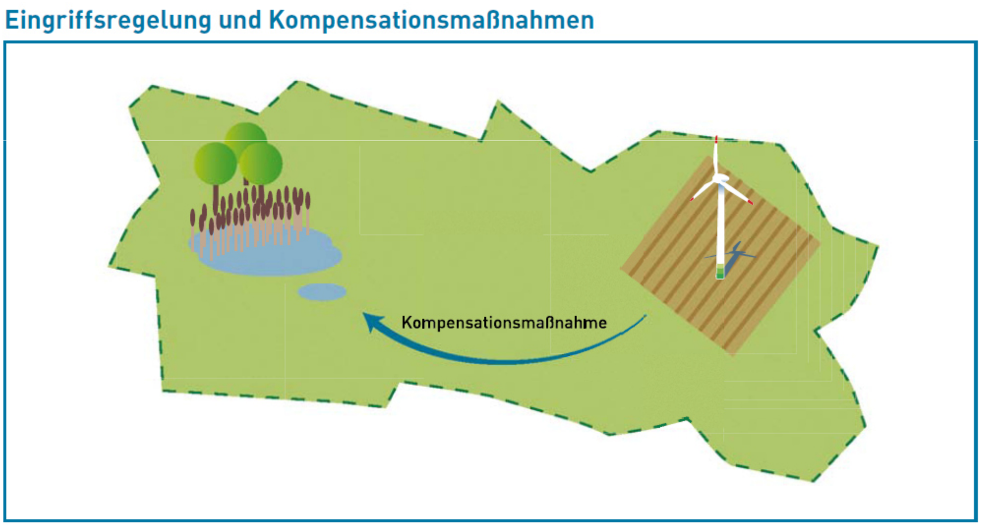
- Communities have to comply with planning processes at the next higher political level (regional). However, communities can determine details such as the maximum hight of wind power plants and the distance to the next settlement



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

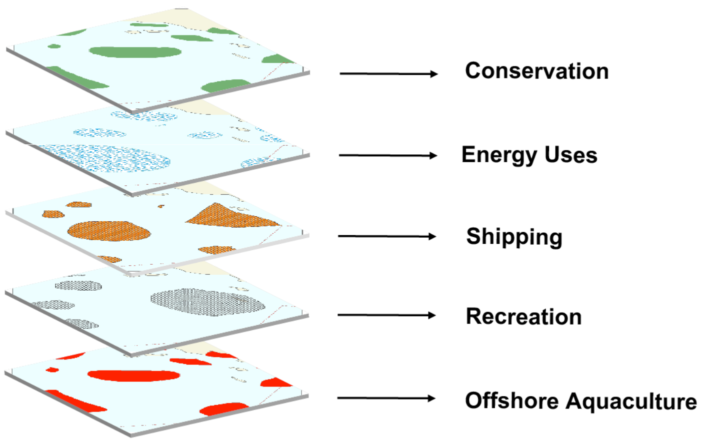
The availability of space for project development?

Spatial planning and RES deployment –Maritime spatial planning in Massachusetts (USA)

Dr. David Jacobs – IET (International Energy Transition)

Maritime spatial planning - Massachusetts Oceans Act and the definition of development areas

- Prohibited Area (Ocean Sanctuaries Act)
- Renewable Energy Areas (tidal and two assigned offshore wind areas)
- Multi-use areas (Aquaculture, Cables and pipelines, Extraction of sand and gravel; community wind).



http://tocdev.pub30.convio.net/our-work/marine-spatial-planning/

Source: http://www.env.state.ma.us/eea/mop/final-v1/v1-complete.pdf

Thank you very much for your attention!

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Additional slides: Stakeholder engagement grid expansion

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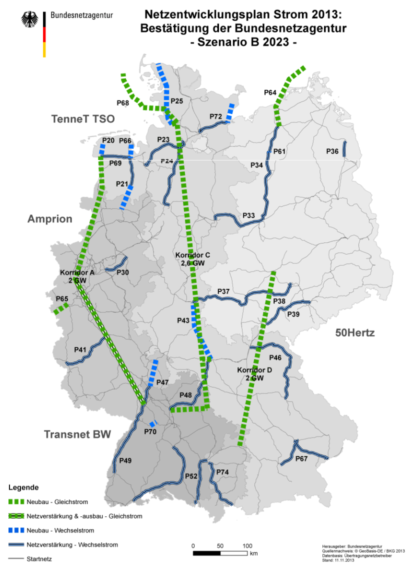
Grid expansion for the German Energiewende

- TSOs are obliged to develop a grid extension plan and submit it to the BNetzA (Federal Network Agency)
- First, the four TSOs develop three scenario frameworks for a market simulation. Once the TSOs have agreed on a set of scenario frameworks, the BNetzA organizes a public consultation **where all stakeholders are invited to discuss assumptions**
- Second, the TSOs transfer the results of the market simulations in the three scenarios to a grid extension plan
- Third, the TSOs develop proposals on how to optimize, maintain and extend the grid in order to guarantee system security



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Consultation in the planning process: Generation plants

- 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

Consultation in the planning process: Generation plants

- 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

Additional slides: Grid connection charging methodology

Connection charging approach

- Super shallow approach – strict separation of costs for generation facilities (power plant) and infrastructure (grid) = no incentives to optimally use the existing grid; "go to where the resources are"

- Deep connection approach – inventive to produce electricity where the grid is best developed

Connection charging approach

France methodology

- Tariffs paid by generators to the national transmission company and system operator for using the grid are independent from the distance between the production and consumption site
- Tariff is identical throughout the French territory
  - Only interconnection facilities costs remain the responsibility of the newly connected generator

German methodology for offshore wind

- German EEG of 2009 (Chapter 3, Section 13 and 14)
  - "The costs associated with connecting installations generating electricity from renewable energy sources or from mine gas to the grid connection point … shall be borne by the installation operator. The grid system operator shall bear the costs of optimizing, boosting and expanding the grid system."

US methodology

- FERC has found that it is just and reasonable to charge interconnection customers for "interconnection facilities but not for network upgrades" as the latter benefits all transmission customers
  - While network upgrades will initially be funded by the interconnection customer, the interconnection customer would then be entitled to a cash equivalent refund
  - Transmission providers are allowed to require several interconnection customer to share the costs of network upgrades