Integrated Resource Planning Training for Decision Makers

Day 6, Session 12 – RE resource assessment and implications of RE targets

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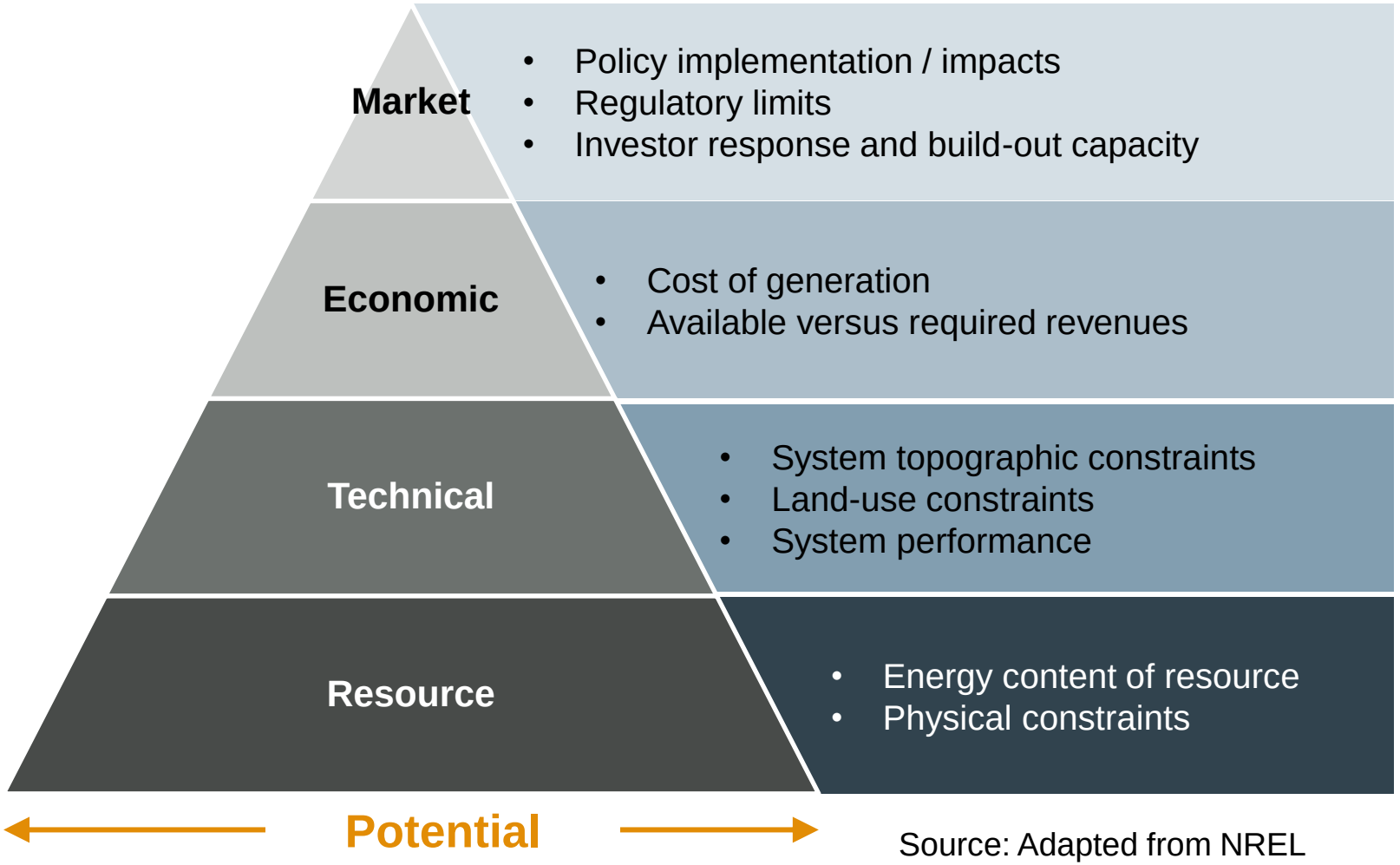
Agenda

- **Technical assessment of RE resource**
  - Measuring and mapping RE resource
  - Constraint mapping and system performance
- **Economic assessment of RE resource**
  - Defining the economic potential
  - Cost structure of RE generation
  - Cost curves of resources and LCOE
  - Integration in least-cost planning
- **Implications for targets and policies**
  - Rationale and guidance for setting of targets
  - Policies and programmes for addressing barriers
  - Incentive mechanisms

Different ways of describing RE potential



Source: Adapted from NREL

- Resource can be limited in differing ways
- Applying technical, economic and market limitations in turn narrows potential
- These can change over time
- Important for entering candidate plants and build-out limitations to least-cost planning

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Technical assessment of RE resource

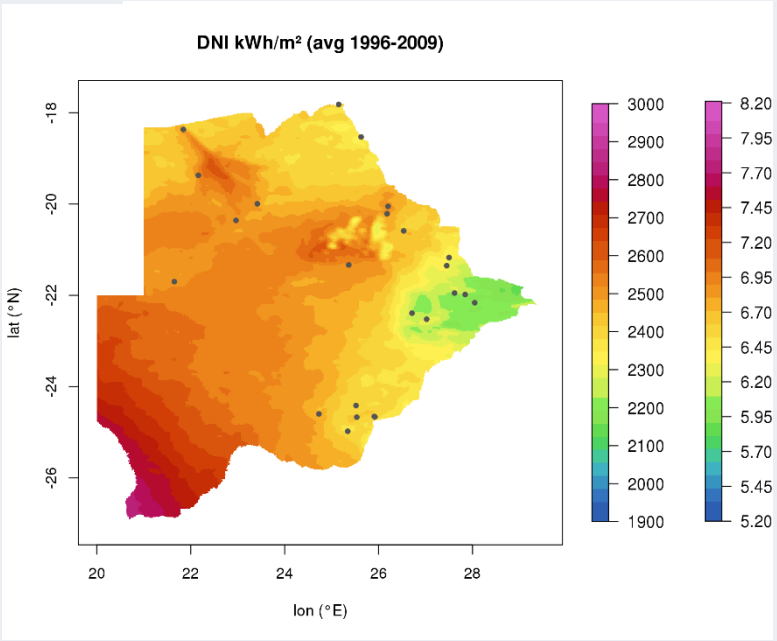
Economic assessment of RE resource

Implications for targets and policies

Resource: Measuring and mapping resource availability

- **Strength of resource is a significant driver of cost of energy from RE**
- **For strategic planning, policy makers want to know:**
  - Realistic technical potential present in country
  - How economic this potential is relative to other candidate plants
- **Resource and constraints mapping is the first step**
- **Wind and solar maps** are a combination of **measurements and computer modelling**
- **Biomass requires spatial assessment of residue availability**

- Typically presented as colour-graded maps
- The World Bank has supported freely available versions: globalwindatlas.info and globalsolaratlas.info



Source: Botswana Renewable Energy Strategy

Technical: Constraint mapping and system performance

- **Build on resource maps to ascertain viable locations for development**
- **Considers various "hard" constraints:**
  - Areas with pre-existing buildings and infrastructure
  - Environmentally-protected areas (including bird migration routes and protected woodland)
  - Areas with security restrictions
  - Complex terrain and other physical limitations

- **May also map "soft" constraints:**
  - Grid network and connection options
  - Transport and access routes
  - Present land-use

  → **These involve economic trade-offs**
- **Moving from resource to yield**
  - Assumed system performance
  - Can use generic technology
  - May see improvements over time

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Technical assessment of RE resource

Economic assessment of RE resource

Implications for targets and policies

Defining economic potential

- **There is no uniform definition on what constitutes “economic potential”**
- **Can be taken as the potential level of RE generation which returns a net economic benefit**
  - Depends on the benefits and costs
  - This is relative to counterfactual case of alternative generation sources available

Costs may include:

- RES generation cost (LCOE) including necessary return
- Grid infrastructure strengthening
- Reserves managing variability

Benefits may include:

- Avoided power purchases
- Carbon emissions reductions
- Avoided health costs from reduced NOx and SOx emissions

Cost structure of RE generation

- **RE generation have different cost structures to traditional thermal plants**
  - Often no fuel input leading to lower opex
- **Cost structure depends on type of RE**

Variable resource RES

Solar PV and **wind**

- Capital expenditure intensive
- Low operating costs (zero fuel costs)
- Modular although economy-of-scale effects greater for wind (solar can be “off-the-shelf” at small-scale)
- Offshore wind higher cost than onshore but has seen rapid price reductions
- Non-dispatchable and thus will need flexible balancing capacity or storage to accommodate

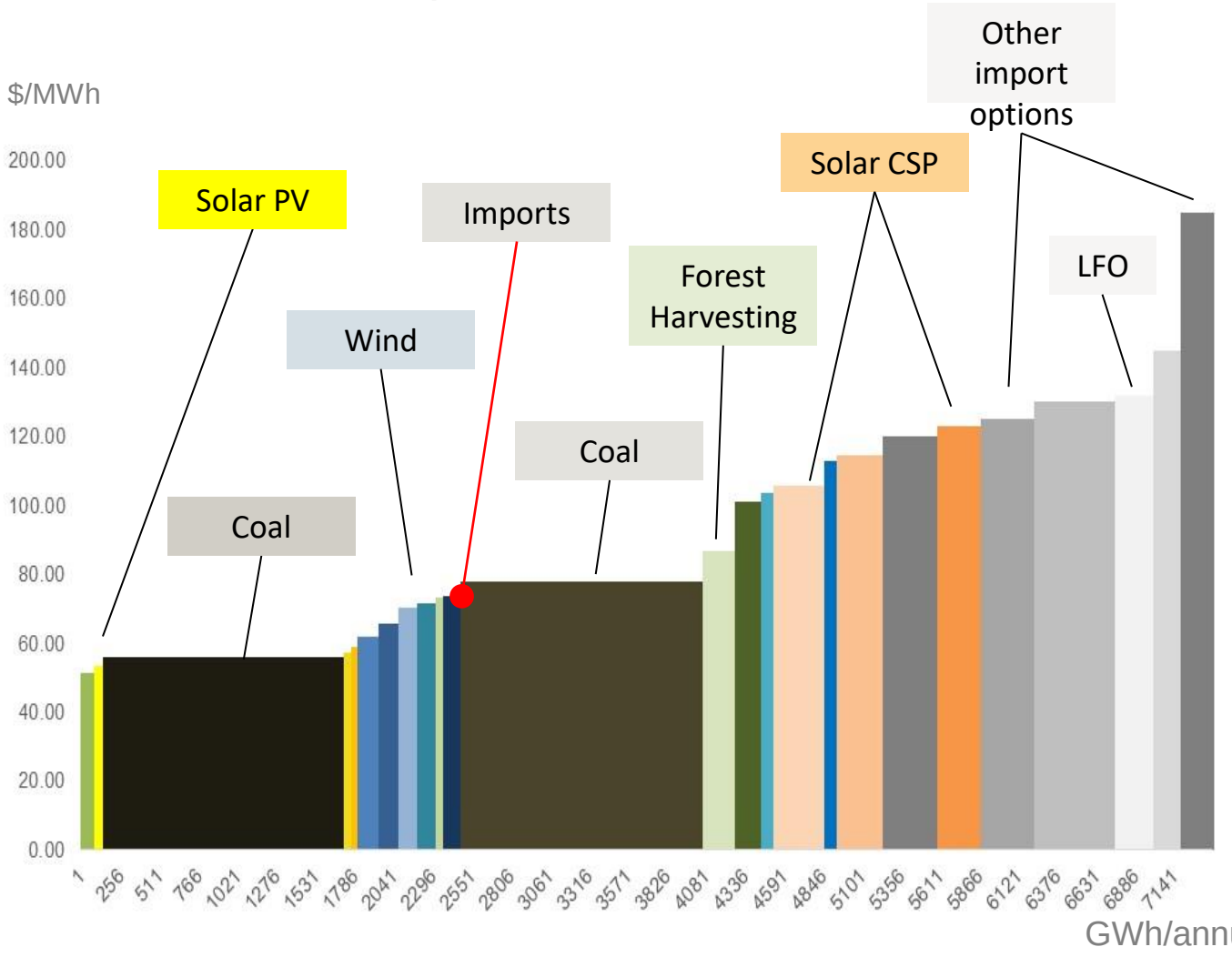
Dispatchable RES

- **Hydro** has large development costs and low operating costs
- **Hydro** is dispatchable and flexible, able to provide as base load or peaking
- **Solar CSP** has similar cost profile but storage is limited and LCOE remains high (but reducing)
- **Biomass** has moderate development costs but fuel is not free – cost depends on resource abundance and form

Cost curves of resources and LCOE

- **RE sources can be shown on a cost curve along with conventional sources**
  - Shows the LCOE and generation potential of different technologies
  - Considers upfront costs and ongoing operational costs (capex and opex)
- **Cost curves do not match generation to load**
- **Not all capacity is wanted all the time** – RES plant vary in availability

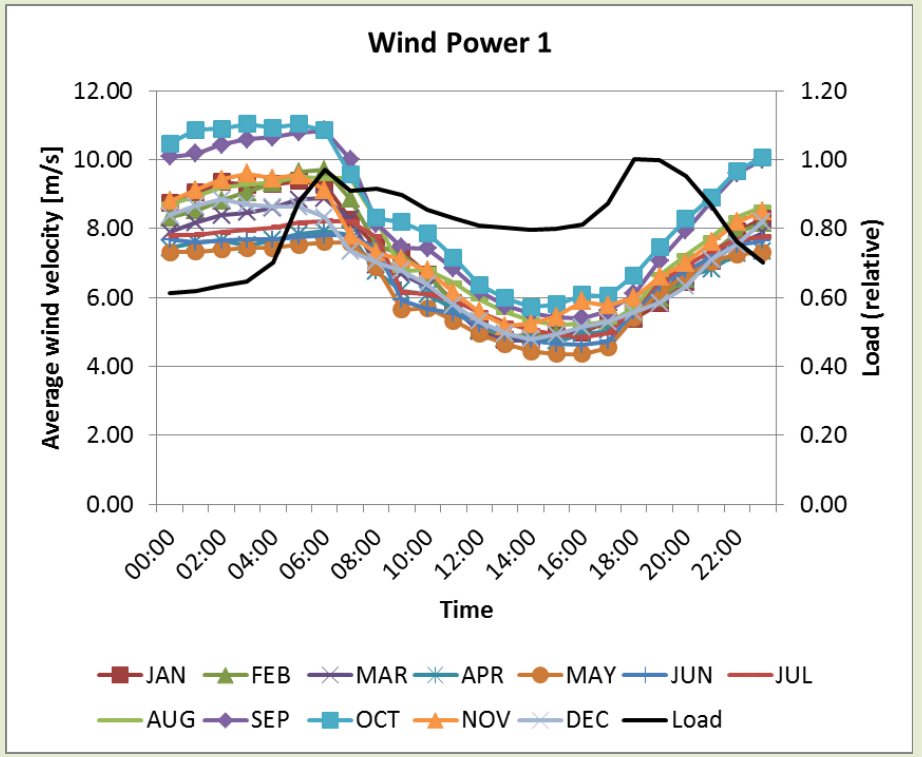
Example RES cost curve



Limitations of LCOE in assessing RE generation

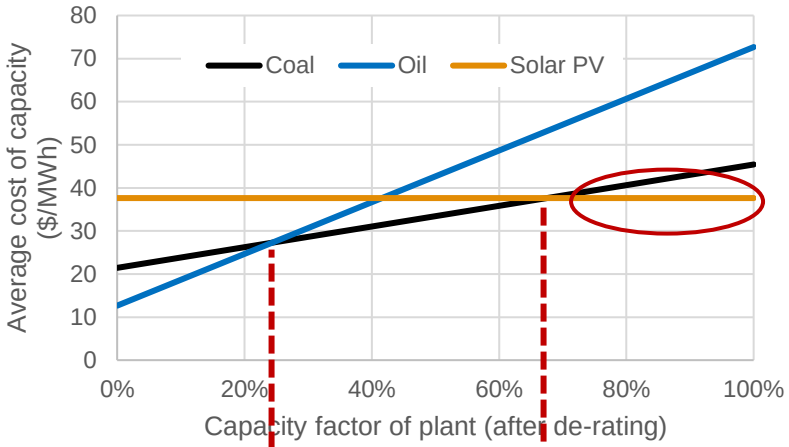
- **LCOE is focused on generation not load**
  - Capacity is needed according to demand, and not according to RE plant availability
  - These intraday variations in load and dispatch are vital, especially in high RE environments
- **Other limitations of LCOE**
  - Cost data for new technologies based on international data
  - Future cost trends are uncertain
  - No benefit given to diversification
  - Other system costs imposed by variable RES (e.g. higher balancing costs, storage costs) are ignored
  - Environmental externalities are not considered

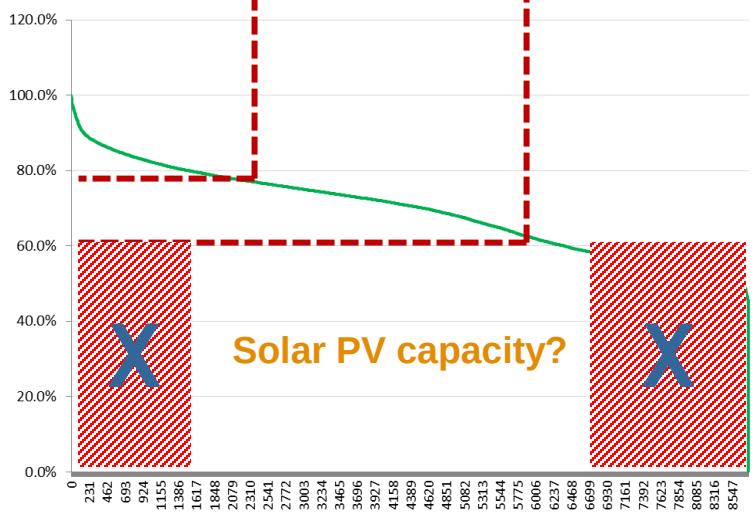
- **RE is characterized by variability in supply**
  - A GWh delivered at night is not as valuable as one delivered at peak load



Limitations of screening curves for RES

- But Solar PV and wind are **not dispatchable** → adding to a screening curve is problematic
- Using average capacity factor as de-rated "availability" may indicate relative economic competitiveness at far right of curve (see PV example, right)
- But this ignores need to sell all generation when operating at full capacity and **any correlation between load and output**
- **Cannot be used to assess competitiveness**
- Instead may use a **chronological load time-series** and resource pattern (for RE output) computational model in least-cost planning





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Technical assessment of RE resource
Economic assessment of RE resource
Implications for targets and policies

Rationale and guidance for setting of targets

- **IRP scenarios often include targets for RE penetration**
  - Reflect constraints set by national RE resource assessment (technical and economic)
  - Decarbonization commitments from a country's Nationally Determined Contributions (NDCs)
  - Wider economic and political incentives (eg. development of RE industry)
- **Targets should be achievable**
  - IRP scenarios need to consider targets which are realistic as they will inform generation planning
- Targets demonstrate **political will** and act as **public commitment** to RES development

RE targets considered selected SADC country planning documents

Country	Target	Note
Angola	7.5% 'new' RE by 2025	RE strategy
Botswana	20% by 2030 and 35% by 2040	Clean energy scenario in IRP Diversification considered as a strategic supply-side objective
Mozambique	Solar and wind to provide 10% of peak demand	20% sensitivity case
Namibia	70% by 2030	RE Policy
Seychelles	15% by 2030	
South Africa	Build limit on REs: 1,000MW for PV and 1,600MW for wind	Aim to ensure constant pipeline of new projects

Policies and programmes for tackling barriers to RE generation

- **Barriers to expanding RE generation**
  - High upfront costs and offtake payment risk
  - Barriers in route to market for developers
  - Availability of financing and local expertise
  - System operator concerns over grid integration
- **Political and institutional solutions:**
  - Set clear, long-term targets
    - Can also increase investor confidence
  - Adopt laws, decrees and regulations to facilitate RE generation
- **Financial solutions:**
  - Capital grants to cover investments
  - RE generation auctions/tenders
  - Feed-in-tariffs

Case Study: Scaling Solar in Zambia

- World Bank 'Scaling Solar' programme provides a one-stop-shop (TA, debt, guarantees) for 100MW of solar
- Pre-selection of sites by government (Multi-Facility Economic Zone)
- First tender achieved record prices (6$c/kWh)
- Shows that reducing barriers can achieve rapid deployment of RE

Incentive mechanisms - components

- The two primary components of a financial support mechanism are the **cost / revenue support model** and the **allocation mechanism**

- **Cost / revenue support model**
  - Capital grants and low interest loans
  - Tax incentives
  - Feed-in tariffs
  - Quota obligation

- **Allocation mechanism**
  - Open-door (may include caps on volume or funding)
  - Tendering

Incentive mechanisms – pros and cons

Incentive options

Administrative FiTs

- Clear and simple
- Stable return
- Low access to market risk

- Difficult to judge accurately
- Administrators may be playing “catch up”
- Do not incentivise cost reduction

Tendered FiT/PPA

- Incentivises lowest cost deployment
- Can align with capacity expansion

- Tender structures may be complex and require substantial administrative capacity
- At-risk development expense

Bilaterally negotiated PPAs

- Low administrative burden
- Quick to initiate in current framework

- Information asymmetry often leads to over-payment
- Lack of transparency

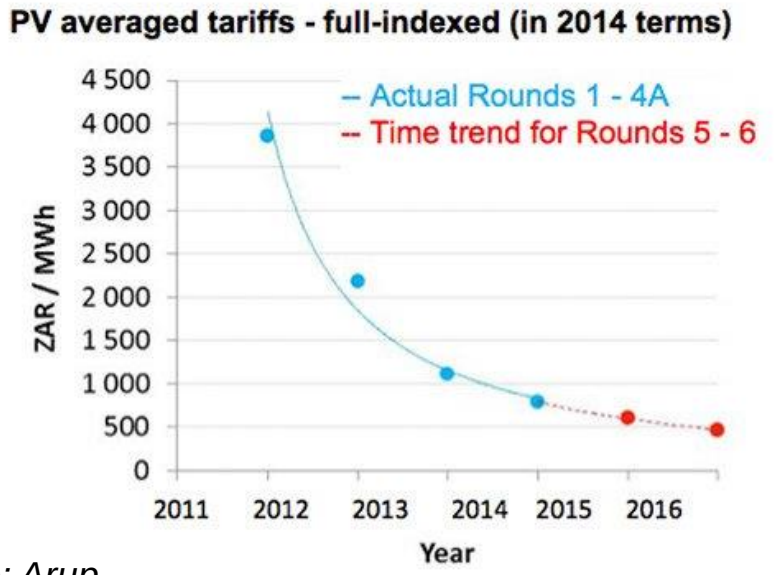
State-developed

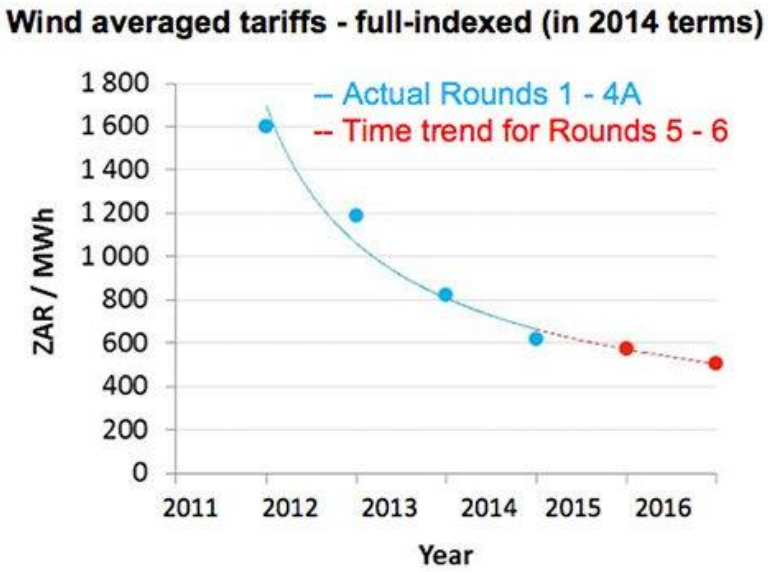
- Builds capacity locally
- Administratively easy in current structure

- Lack of experience raises cost and risk
- Financial capacity to build uncertain

Tender results – cost reduction or competition?

- South Africa's REI PPP is one of the most successful leverages of private investment in infrastructure in Africa
- Over 6 GW procured – more than 2 GW operational with low attrition
- Technology improvements and lowering cost of capital over time





Source: Arup

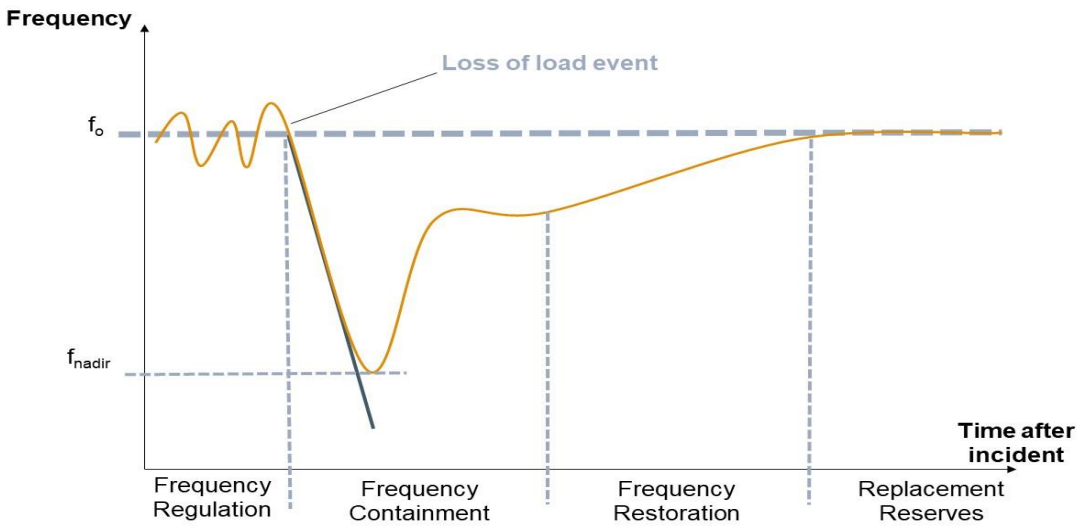
PPA tariff structure

- **For non-dispatchable RES (wind, solar PV)**
  - Unable to respond to time-of-day signals
  - Single-rate fixed tariffs on per kWh basis most appropriate
  - Incentivises maximum availability for when resource is available

- **For dispatchable RES (solar CSP, co-located batteries)**
  - Can respond to demand
  - Aim to incentivize units to be available when most needed
  - Peak, shoulder and base load periods
  - Take-and-pay principle leaves off-taker with volume risk
    - Solar variation for CSP and battery storage capacity limit capability to manage
    - Must ensure adequate reserves
  - Structuring instead with capacity (availability-linked) payment plus energy price passes volume risk to RES operator:
    - Would need to side contract with balancing generation forms (eg oil)

What about costs of intermittency?

- **Misforecasting causing system imbalance**
- **Frequency disturbances in the immediate time-frame (when solar penetration is very high)**
- **Requires back-up supply**
- **For reserves:**
  - Selection of products to procure
  - Define volumes
  - Mandatory or voluntary provision?
  - Payment structure (availability payments; profiling)
- **How are costs allocated? Socialised or "causer pays"?**
- **Do batteries and other clean energy sources of provision have a route to market?**



Renewable energy targets and policies

What factors do you think should be considered in setting national RES targets?

What are the key barriers to accelerating RES deployment in your country and what policies may tackle these?

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