Integrated Resource Planning Training for Decision Makers

Day 6, Session 16 Namibia case study

17 March 2021
Content

- Rationale for selecting Namibia for the case study discussion
- Namibia Integrated Resource Plan - the essentials and context
  - Key actors in the Electricity Sector Industry (ESI)
  - Governance framework
  - A quick summary of planning procedures
- 2016 NIRP Energy and Peak Demand Forecasts
- Evaluation of supply side options and expansion scenarios
- Other considerations
  - Transmission planning, reliability criteria, environmental and climate change analysis, decision process under uncertainty
- Implementation
- Stakeholder management and capacity building
Rationale for selecting Namibia for the case study discussion
Why is Namibia an interesting case study?

- Namibia is currently in the process of developing the second revision of its Integrated Resource Plan (IRP)
  - Opportunity to build on lessons from 2013 and 2016 NIRP
- The introduction of the MSB framework slightly changes the purpose of the NIRP
  - Plan provides guidance rather than a directive on the sequence of generation investments
  - NamPower, the appointed TSO, will need to use the NIRP as an input to the transmission investment plan and as a guide to its generation investments
  - Does not change anything on the demand side- the plan is developed from a national perspective
Namibia Integrated Resource Plan – the essentials
Key actors of the Electricity Supply Industry in Namibia

Policy maker: Ministry of Mines and Energy
Regulator: Electricity Control Board (ECB)

Licensees (Regulated Entities):
- NamPower
- Energy Trading
- Import & Export
- Transmission
- Distribution
- Consumers
- REDs
- Local and Regional Authorities
- Other Distributors
- Source: 2016 NIRP

The MSB framework enables consumers to contract up to 30% of their demand with IPPs directly.
Governance framework

- The 2016 Electricity Bill empowers the Ministry of Mines and Energy (MME) to undertake electricity sector planning
  - NIRP 2016 was managed by the Electricity Control Board (ECB)
  - The 2020 Update is being managed directly by MME
  - The managing organisation was also responsible for coordination of key institutions involved in the sector
    - For the 2020 NIRP update, a Project Management Unit of key stakeholders was established

2020 NIRP objective

- The Ministry of Mines and Energy (MME) seeks to procure the services of a consultant/consultancy firm (…) to review and update the current National Integrated Resource Plan (NIRP 2016) to account for current realities.
- These current realities include all current and realistic future supply-side and demand-side options to enable the Government of the Republic of Namibia (GRN) (…) to meet future electricity demand in a sustainable, cost-effective and reliable manner
## Namibia Integrated Resource Plan - the essentials

<table>
<thead>
<tr>
<th>Name and last update</th>
<th>National Integrated Resource Plan 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>• A new update is currently under development (2020 NIRP)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Timeframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>The 2016 NIRP covered a 20-year period between 2016 and 2035</td>
</tr>
<tr>
<td>• The update will cover the planning period between 2021 and 2040</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Update frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>At least five years but sooner if required</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Namibia Electricity Supply Industry (ESI)</td>
</tr>
<tr>
<td>• While there were significant changes in the market since the 2016 NIRP, the 2020 update will follow the same approach</td>
</tr>
</tbody>
</table>
Consideration of policies and other relevant documents

The 2016 NIRP considered the following documents:
- Vision 2030

Additional plans and policies that will be considered in the 2020 NIRP include:
- The 2017 National Energy Policy
- The 2017 National Renewable Energy Policy
- IPP Policy
- Harambee Prosperity Plan, April 2016
- Namibia’s 5th National Development Plan (NDP), published in 2017
The forecast is for years **2014 to 2035** and considers **three scenarios (reference, low and high)**

- Linear regression analysis to account for **organic growth**
- Interviews were conducted with NamPower, large industrial customers and distribution companies to identify significant increases in demand. **Step loads** were categorised with regard to economic activity and probability of materialising

- Demand side measures were considered and included LED light bulbs, solar thermal heaters and behind the meter installations of solar PV panels

The 2020 NIRP update will review NamPower’s national demand forecast

- This is to avoid two conflicting forecasts in the sector
Supply side options in the 2016 NIRP

- Kudu gas
- LNG
- Coal
- Internal Combustion Reciprocating Engine
- Hydro
- Concentrated Solar Power Plants
- Biomass
- Wind and solar PV
- Battery Energy Storage Systems
- Small modular nuclear reactors
- Imports

Table 4-1: Coal Fired Power Generation

<table>
<thead>
<tr>
<th>Generation Technology</th>
<th>CHB</th>
<th>PC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant Gross Capacity (MW)</td>
<td>158</td>
<td>162</td>
</tr>
<tr>
<td>Plant Net Capacity (MW)</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td>Number of Units</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Economic Life Years</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Lead Time (hr)</td>
<td>0:7</td>
<td>0:7</td>
</tr>
<tr>
<td>Earliest On Line Year (222/222)</td>
<td>2022/2022</td>
<td>2022/2022</td>
</tr>
<tr>
<td>Equivalent Availability (%)</td>
<td>85</td>
<td>85</td>
</tr>
<tr>
<td>Equivalent Forced Outage Rate (%)</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Power Outage Rate (%)</td>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>

Production Profile (Daily): Dispatched as per system requirements
Production Profile (Seasonal): Dispatched as per system requirements
Net Heat Rate (kW/kWh, H/Hv): 11,600
Primary Fuel Cost ($/GJ): 42.16
Overall Capitalized Cost ($M): 6,302.6

Table 4-1: Coal Fired Power Generation

<table>
<thead>
<tr>
<th>Description</th>
<th>CHB</th>
<th>PC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant EPC Cost ($M)</td>
<td>4,080</td>
<td>3,800</td>
</tr>
<tr>
<td>Owner’s Cost ($M)</td>
<td>408.0</td>
<td>360.0</td>
</tr>
<tr>
<td>Owners’ Cost (% of Plant’s EPC Cost)</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>Plant Capitalized Cost ($M)</td>
<td>4,488.6</td>
<td>4,160.4</td>
</tr>
<tr>
<td>Grid Integration EPC Cost ($M)</td>
<td>724.9</td>
<td>621.2</td>
</tr>
<tr>
<td>Grid Integration Owner’s Cost ($M)</td>
<td>73.4</td>
<td>73.4</td>
</tr>
<tr>
<td>Grid Integration Owner’s Cost (% of Plant’s EPC Cost)</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>Grid Integration CapEx Disbursement (%)</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>Grid Integration I&amp;C (M)</td>
<td>50.2</td>
<td>50.2</td>
</tr>
<tr>
<td>Financing Charges Inc. Commitment (M)</td>
<td>91.5</td>
<td>82.1</td>
</tr>
<tr>
<td>Commissioning Cost ($M)</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Decommissioning Cost ($M)</td>
<td>121.8</td>
<td>100.9</td>
</tr>
<tr>
<td>Overall Plant Capital Unit Capacity Cost ($M/kW)</td>
<td>42.018</td>
<td>37.872</td>
</tr>
<tr>
<td>Fixed O&amp;M Cost ($M/kW-year)</td>
<td>81.0</td>
<td>72.0</td>
</tr>
<tr>
<td>Variable O&amp;M Cost ($M/kW)</td>
<td>320.0</td>
<td>320.0</td>
</tr>
<tr>
<td>CO2 Emission Rate (kg/GJ)</td>
<td>0.08970</td>
<td>0.08370</td>
</tr>
<tr>
<td>NOx Emission Rate (ppm)</td>
<td>0.1194</td>
<td>0.1194</td>
</tr>
<tr>
<td>SO2 Emission Rate (kg/GJ)</td>
<td>0.082755</td>
<td>0.082755</td>
</tr>
</tbody>
</table>

Note: All Costs expressed in N$
Evaluation of supplied side options in the 2016 NIRP

Based on resource availability and cost data, some generation options were excluded from further analysis:

- These included conventional nuclear, water power projects on the Okavango and Orange river systems, small modular nuclear reactors, municipal solid waste and geothermal.

Retained generation options were subject to screening analysis, resulting in the calculation of a unit cost of energy for each of the generation options.
Expansion scenarios

The 2016 NIRP defined 11 main expansion scenarios for generation investments

- One option was selected as the recommended plan

Ranking of expansion scenarios was based on six attributes together with the present value costs of each of the expansion scenarios

- These were based on principal decision factors:
  - The White Paper on Energy Policy
  - Reliability criteria
  - Load forecast
  - System cost
  - Environmental and social factors

Attributes used to rank scenarios:

- Self-sufficiency: achievement of 100% annual kWh generation in Namibia by 2030 (this requirement is no longer included in the 2017 Energy Policy)
- Indigenous energy resources
- A 70% renewable energy target
- Implications on foreign exchange
- Implications on government investment
- Development and operating complexity
## Attributes of Generation Options in the 2016 NIRP

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Combined Cycle</td>
<td>Kudu NG</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
<td>inv + ops</td>
<td>high</td>
<td>high</td>
</tr>
<tr>
<td>Combined Cycle</td>
<td>LNG</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>inv + ops</td>
<td>moderate</td>
<td>medium</td>
</tr>
<tr>
<td>Gas Turbine</td>
<td>LNG</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>inv + ops</td>
<td>moderate</td>
<td>medium</td>
</tr>
<tr>
<td>Steam Turbine</td>
<td>Coal</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>inv + ops</td>
<td>moderate</td>
<td>low</td>
</tr>
<tr>
<td>ICE</td>
<td>HFO</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>inv + ops</td>
<td>limited</td>
<td>low</td>
</tr>
<tr>
<td>Hydro</td>
<td>Baynes water</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>inv only</td>
<td>high</td>
<td>high</td>
</tr>
<tr>
<td>CSP</td>
<td>sunlight</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>inv only</td>
<td>moderate</td>
<td>medium</td>
</tr>
<tr>
<td>Steam Turbine</td>
<td>Biomass</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>inv only</td>
<td>limited</td>
<td>medium</td>
</tr>
<tr>
<td>Wind</td>
<td>wind</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>inv only</td>
<td>no</td>
<td>low</td>
</tr>
<tr>
<td>Solar PV</td>
<td>sunlight</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>inv only</td>
<td>no</td>
<td>low</td>
</tr>
<tr>
<td>Import</td>
<td>coal/NG</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>ops</td>
<td>no</td>
<td>low</td>
</tr>
<tr>
<td>Import</td>
<td>water</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td>ops</td>
<td>no</td>
<td>low</td>
</tr>
</tbody>
</table>

*indicates a relatively desirable rating*
Transmission planning

- NamPower is the Transmission System Operator (TSO). Transmission planning was not specifically undertaken. Transmission connection costs were incorporated in the generation costs.

- The Transmission Master Plan Update was prepared by NamPower in 2019 and will be an input to the 2020 NIRP.

Source: 2016 NIRP
Cost of unserved energy and reliability criteria in the 2016 NIRP

Cost of unserved energy
- Based on customer surveys in South Africa, suggesting a value between 20,000 N$/MWh and 75,000 N$/MWh
- The 2016 NIRP used a value of 30,000 N$/MWh (roughly 2 US$/kWh)
  - Estimated by dividing Namibia’s GDP by electricity generation plus imports
- To put this number into perspective, the national end-user tariff for the period 2019/2020 was 2.42 N$/kWh (~16 USc/KWh)

Reliability criteria
- The loss of load probability (LOLP) of 5 days per year was adopted for the first four years of the planning horizon
  - 2 days per year throughout the rest of the planning period
- The expected unsupplied energy (EUE) was used as an additional criterion and should not exceed the value of 1%
- Additionally, the SAPP reliability criterion was also considered
  - A weighted average of reserve capacity obligations applied to thermal (10.6%) and hydro (7.6%) generating options
  - Checks were carried out to see whether it was satisfied
Other considerations

- Environmental and climate change considerations
  - Not explicitly modelled. A penalty of 60 N$ per tonne of emissions was applied to account for the negative externalities related to greenhouse gas emissions.
  - In the 2020 NIRP Update, new investments are expected to comply with environmental and social standards.
  - Intended Nationally Determined contributions to be satisfied through RES target of 70%. CO₂ emissions to be estimated and the cost of achieving alternative emission reduction levels analysed.

- Risk management
  - Sensitivity studies were carried out with respect to the following factors:
    - Capital costs
    - Fuel price
    - Discount rate
    - Load forecasts
    - Greenhouse gas emissions
  - A similar approach will be followed in the 2020 NIRP Update.
Implementation

Implementation Plan for the NIRP – summary of key activities:

- Secure access to short-term rental generation by 2018 or, if available at better terms, guaranteed access to power markets for electricity imports
- Install fossil-fuel base load generation by 2021
- Continue programs to install solar PV and wind generation and further investigate the use of other renewable power technologies

Source: 2016 NIRP

- An implementation plan formed part of the 2016 NIRP
  - A similar approach is being followed in the 2020 NIRP Update
- An implementation plan should clearly assign responsibilities, e.g.:
  - “Require that MME commissions and completes a feasibility study on concentrated power plants. The implementation plan includes installation of CSP beginning in 2026”.

Source: 2016 NIRP
Stakeholder management and capacity building

In the process of updating the 2016 NIRP, **two stakeholder workshops** were conducted to collect feedback from electricity users

- As the 2020 NIRP is being updated, **draft reports are circulated amongst key stakeholders** who are given a chance to comment on key findings.
  - These include representatives of the ESI (NamPower, Regional Electricity Distributors (REDs), the ECB, government officials and stakeholders from the energy sector
- **Two national stakeholder workshops** will be organized to disseminate the findings of the updated IRP

**Two one-week training workshops** were held as part of the 2016 NIRP study

- Training on the 2020 NIRP will be delivered to selected MME, NamPower, ECB and REDs staff
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