Integrated Resource Planning Training for Decision Makers

Day 6, Session 16 Namibia case study

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  - Transmission planning, reliability criteria, environmental and climate change analysis, decision process under uncertainty
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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**

GOVERNMENT OF THE REPUBLIC OF NAMIBIA

MINISTRY OF MINES AND ENERGY

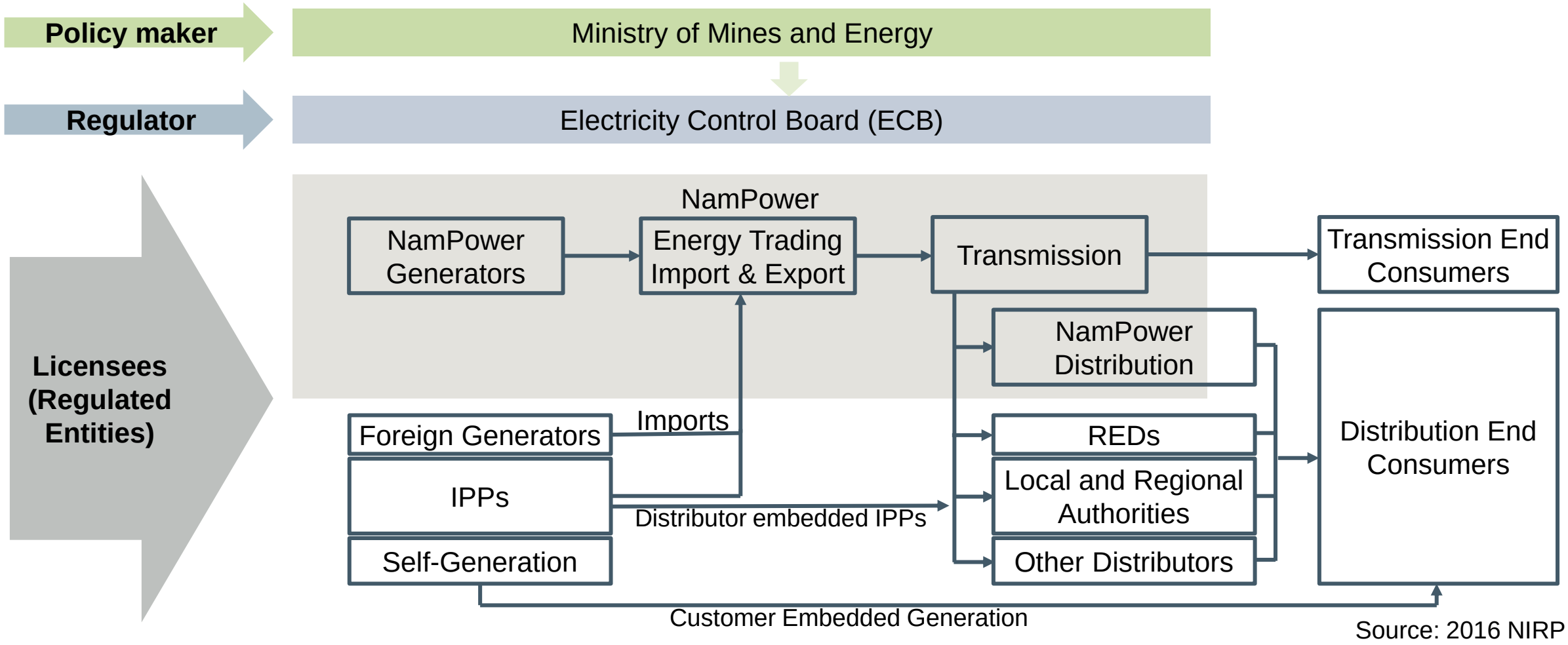
National Integrated Resource Plan – 2016

for the

Electricity Supply Industry in Namibia

Namibia Integrated Resource Plan – the essentials

Key actors of the Electricity Supply Industry in Namibia



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

Name and last update

National Integrated Resource Plan 2016

- A new update is currently under development (2020 NIRP)

Timeframe

The 2016 NIRP covered a 20-year period between 2016 and 2035

- The update will cover the planning period between 2021 and 2040

Update frequency

At least five years but sooner if required

Scope

Namibia Electricity Supply Industry (ESI)

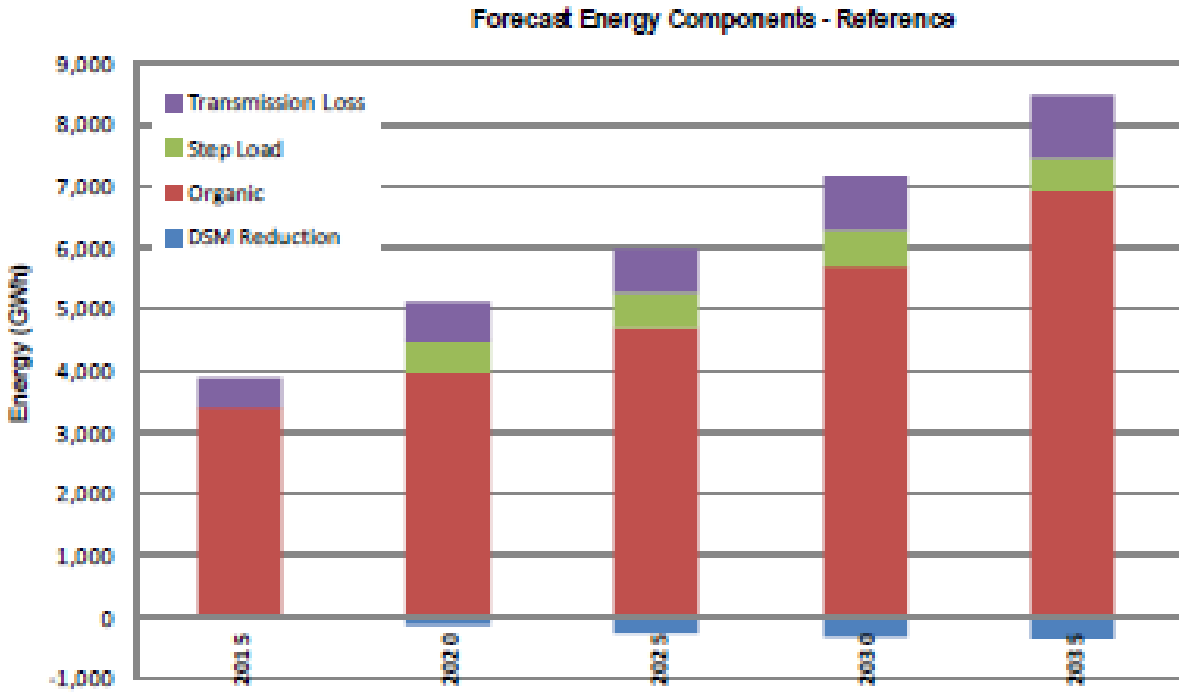
- While there were significant changes in the market since the 2016 NIRP, the 2020 update will follow the same approach

Consideration of policies and other relevant documents

- The 2016 NIRP considered the following documents:
  - The 1998 White Paper on Energy Policy
  - 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

2016 NIRP Energy and Peak Demand Forecasts

- 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



Source:2016 NIRP

- 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

Generation Technology	CFB	PC	Comment
Fuel	Coal		
Plant Gross Capacity (MW)	168	162	
Plant Net Capacity (MW)	150	150	
Number of Units	1	1	
Economic Life (Year)	30	30	
Lead Time (Year)	6-7	6-7	
Earliest On-Line Year	2021/2022	2021/2022	
Equivalent Availability (%)	85	85	Based on NERC database
Equivalent Forced Outage Rate (%)	7.0	7.0	
Planed Outage Rate (%)	8.0	8.0	four weeks per year
Production Profile (Daily)	Dispatched as per system requirements		
Production Profile (Seasonal)	Dispatched as per system requirements		
Net Heat Rate (KJ/kWh, HHV)	11,600	11,000	
Primary Fuel Cost ($/GJ)	40.16	40.16	
Overall Capitalized Cost ($M)	6,302.6	5,670.4	
Plant EPC ($M)	4,080.0	3,600.0	Based on net capacity
Owner's Cost ($M)	408.0	360.0	10% of Plant's EPC cost
Plant CAPEX Disbursement Flow (%)	30%, 40%, 30%		
Plant IDC ($M)	703.9	621.1	Rate of 10% to align the cost to service year
Grid Integration EPC ($M)	734.0	734.0	
Owner's Cost for Grid Integration ($M)	73.4	73.4	10% of integration cost
Grid Integration CAPEX Disbursement Flow (%)	60%, 40%	60%, 40%	
Grid Integration IDC ($M)	90.2	90.2	Rate of 10% to align the cost to service year
Financing Charges Including Commitment ($M)	91.3	82.2	1.5% of sum of all EPC, Owner's cost and IDC
Commissioning Cost ($M)			
Decommissioning Cost ($M)	121.8	109.6	2% of sum of all EPC, Owner's cost and IDC
Overall Plant Capital Unit Capacity Cost ($/kW)	42,018	37,803	Based on the net capacity
Fixed O&M Cost ($/MW-Year)	816.0	720.0	Based on 3% of EPC cost, including insurance
Variable O&M Cost ($/MWh)	320.0	320.0	
CO2 Emission Rate (kg/GJ)	87.970	87.970	Uncontrolled factors calculated as per the parameters from the US EIA and EPA. About 90% of NOx could be reduced by GT. SO2 emission factor was calculated based on 1% sulphur content.
NOx Emission Rate (kg/GJ)	0.089151	0.21396	
SO2 Emission Rate (kg/GJ)	0.067755	0.67755	
Particulate Matter Emission Rate (kg/GJ)	0.025679	0.02568	

Note: All Costs expressed in N$

Source:2016 NIRP

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

Generation options retained in the 2016 NIRP

Generation Technology	Fuel	Unit/Plant Size (MW)	Resources Available (MW)	Capacity Factor (%)	Function	Unit Cost of Energy ($/kWh)
CC	NG	450	450	80	Base Load / Mid Merit	1.79
CC	LNG	150	> 300	80	Base Load	2.29
GT	LNG	50	> 200	80	Base Load	2.72
CFB	Coal	150	> 300	80	Base Load	1.54
ICRE	HFO	20	No Limit	80	Base Load	1.98
ICRE	HFO	20	No Limit	25	Peaking	3.18
Hydro	Water	300	300	30	Peaking	3.49
CSP-4 Hour	Solar	50	No Limit	30	Peaking	3.31
CSP-8 Hour	Solar	50	No Limit	50	Mid Merit	2.85
CSP-12 Hour	Solar	50	No Limit	70	Base Load	2.65
BFB	Biomass	10	<=600	80	Base Load	2.07
Wind	Wind	50	<= 300	40	Intermittent	1.54
Solar PV	Solar	10	No Limit	30	Intermittent	1.61
Import	Zambia	50	50	50	Mid Merit	2.22
Import	Lunsemfwa	50	50	80	Mid Merit	1.78
Import	Botswana	200	200	96	Base Load	2.27

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

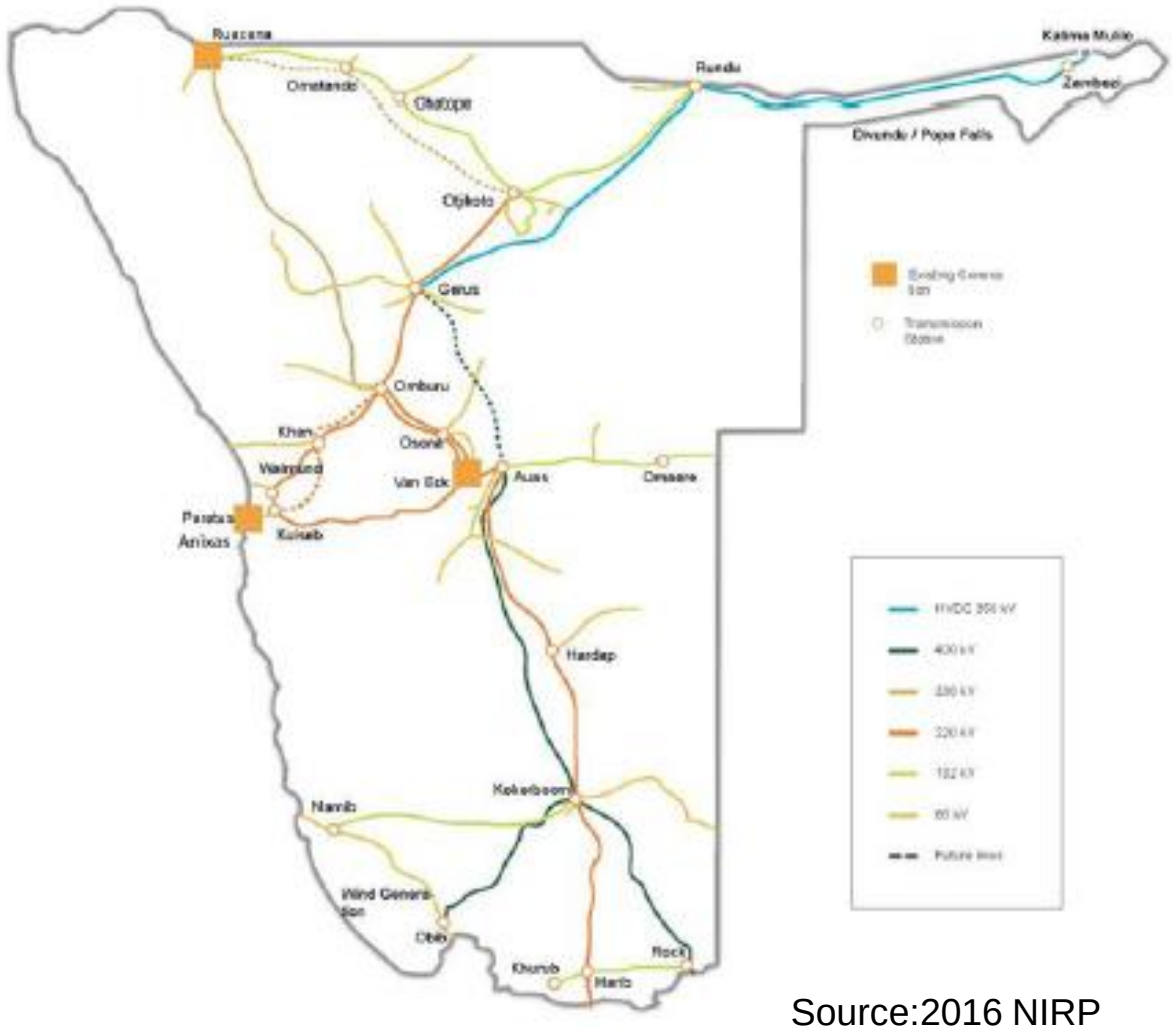
Attributes of Generation Options in the 2016 NIRP

Generation Technology	Energy Source	Located in Namibia	Use of Indigenous Resources	Renewable Energy	Foreign Exchange Requirement	Need for Government Investment	Development/ Operating Complexity
Combined Cycle	Kudu NG	yes	yes	no	inv + ops	high	high
Combined Cycle	LNG	yes	no	no	inv + ops	moderate	medium
Gas Turbine	LNG	yes	no	no	inv + ops	moderate	medium
Steam Turbine	Coal	yes	no	no	inv + ops	moderate	low
ICRE	HFO	yes	no	no	inv + ops	limited	low
Hydro	Baynes water	yes	yes	yes	inv only	high	high
CSP	sunlight	yes	yes	yes	inv only	moderate	medium
Steam Turbine	Biomass	yes	yes	yes	inv only	limited	medium
Wind	wind	yes	yes	yes	inv only	no	low
Solar PV	sunlight	yes	yes	yes	inv only	no	low
Import	coal/NG	no	no	no	ops	no	low
Import	water	no	no	yes	ops	no	low

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%. CO_2 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”.

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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