Operation of Power Systems with High Shares of Variable Renewables

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Similar or Different?

STORK

STORM
AGENDA

1. Transforming Power Systems
2. Challenges to Integration of Variable Renewable Energy vs Power Resilience
3. Measures
4. Case study
5. Conclusions
1. Transforming Power Systems
CHALLENGES
2. Challenges to Integration of VRE vs Resilience
2. Challenges to Integration of VRE vs Resilience

1. Generation adequacy (G-D)

2. Flexibility needs (G, DSR, ESS)
2. Challenges to Integration of VRE vs Resilience

3. Frequency Stability (F)

4. Physical limits (P, V, T)

5. Power Quality and Harmonics

6. Protection systems
2. Challenges to Integration of VRE vs Resilience

7. Structure and topology of transmission and distribution networks
2. Challenges to Integration of VRE vs Resilience

7. Structure and topology of transmission and distribution networks
2. Challenges to Integration of VRE vs Resilience

7. Structure and topology of transmission and distribution networks
2. Challenges to Integration of VRE

8. Governance and Structure of the Sector

Organized Market PPAs

Private, Public, Local

MARKET STRUCTURE

 OWNERSHIP OF UTILITIES

DSO/TSO

REGULATOR

TSO, DSO, ISO, Micro Grids

Independent Government

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MEASURES
3. Measures To Integration of VRE – Frequency & Voltage

- Increase frequency regulation from VRE sources
- Deployment of energy storage
- Generation redispatch and/or
- Improvement of under frequency load shedding settings.

- Reactive power compensation equipment- network reinforcement
- Review transformer’s tap position and/or voltage set-points
- VRE curtailment
- Upgrading to a higher voltage level, splitting/meshing the network, upgrade circuit breakers
3. Measures to Integration of VRE – Flexibility in the System

Wet hydrologic year

Dry hydrologic year

Wind

Hydro

CCGT Coal

Source: REN
3. Measures to Integration of VRE – Flexibility in the System

- Hydro Pump
- Energy Storage System
- Export
- Resistor
- Curtail
- Wind Turbines
- Solar PV
- Integration and Control system
- Integration and Control system
- Diesel Generator
- Battery Energy Storage
- Hydro Power
- Tertiary Reserve
- Load Shedding
- Import
- Secondary Reserve
- Primary Reserve
3. Measures to Integration of VRE – Infrastructure

**Infrastructure Investments**

- Diversification of VRE installations
- VRE enablers and Electricity storage
- Conventional transmission and distribution reinforcements
- Interconnection with neighboring power system
- Smart Grid
- Smart Demand Management
CASE STUDIES - VANUATU
Case Study: Vanuatu

Methodology: Resources (Solar PV Hydro and Wind Power)

- Modelling to generate high frequency solar resource data and power generation profile
- Water Flow (1 Cite)
  - Sarakata River
- Solar PV Sites
  - Countrywide
- Wind Power (1 Cite)
  - Port Olry
Case Study: Vanuatu

Methodology: Integration of Solar PV and Hydro Power

Grid Assets
Grid Planning
Load and Generation Profiles
Solar PV and Wind Time Series
Water Flow Forecast

Economic Dispatch for 2018 and 2030

Stead-State and Dynamic Simulations for 2018 and 2030

Security of the System
VRE Enablers Assessment
Grid Expansion Plan
Flexibility Assessment

Scenarios (16 Scenario):
• Maximum and Minimum Demand for 2018 and 2030
• Existing System
• Lowest Long-Term Cost
• Highest Share of VRE
• No Major Enablers

1M
4
2C
3
2

NORTH

HYDRO

OH

ON

DIESEL

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Case Study: Vanuatu

OUTCOME (ONE HYPOTHESIS FOR 2030)

Highest Renewable Energy Case without Biofuel
With and Without extension of Port Olry
RECOMMENDATIONS

• Upgrade the transmission line between the hydro power plant to the main substation;
• Upgrade the line between the main substation to the diesel power plant;
• Install Battery Storage System at the diesel power plant;
• Install Battery Storage System at the PV plant;
• Install SCADA system and automatic control of hydro and diesel generation units;
• Train the grid operators.
CONCLUSION
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THANK YOU FOR YOUR ATTENTION

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