IRENA
International Renewable Energy Agency

Operation of Power Systems with High Shares of Variable Renewables

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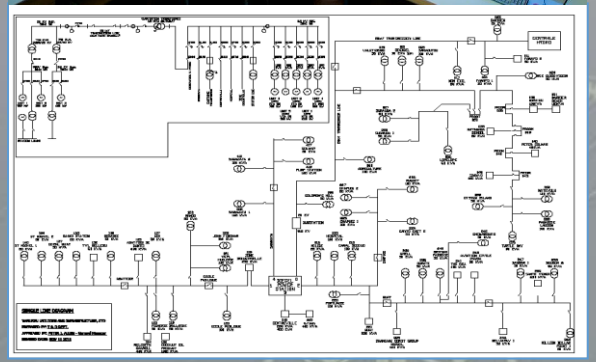
IRENA Innovation and Technology Centre

Similar or Different?

STORK

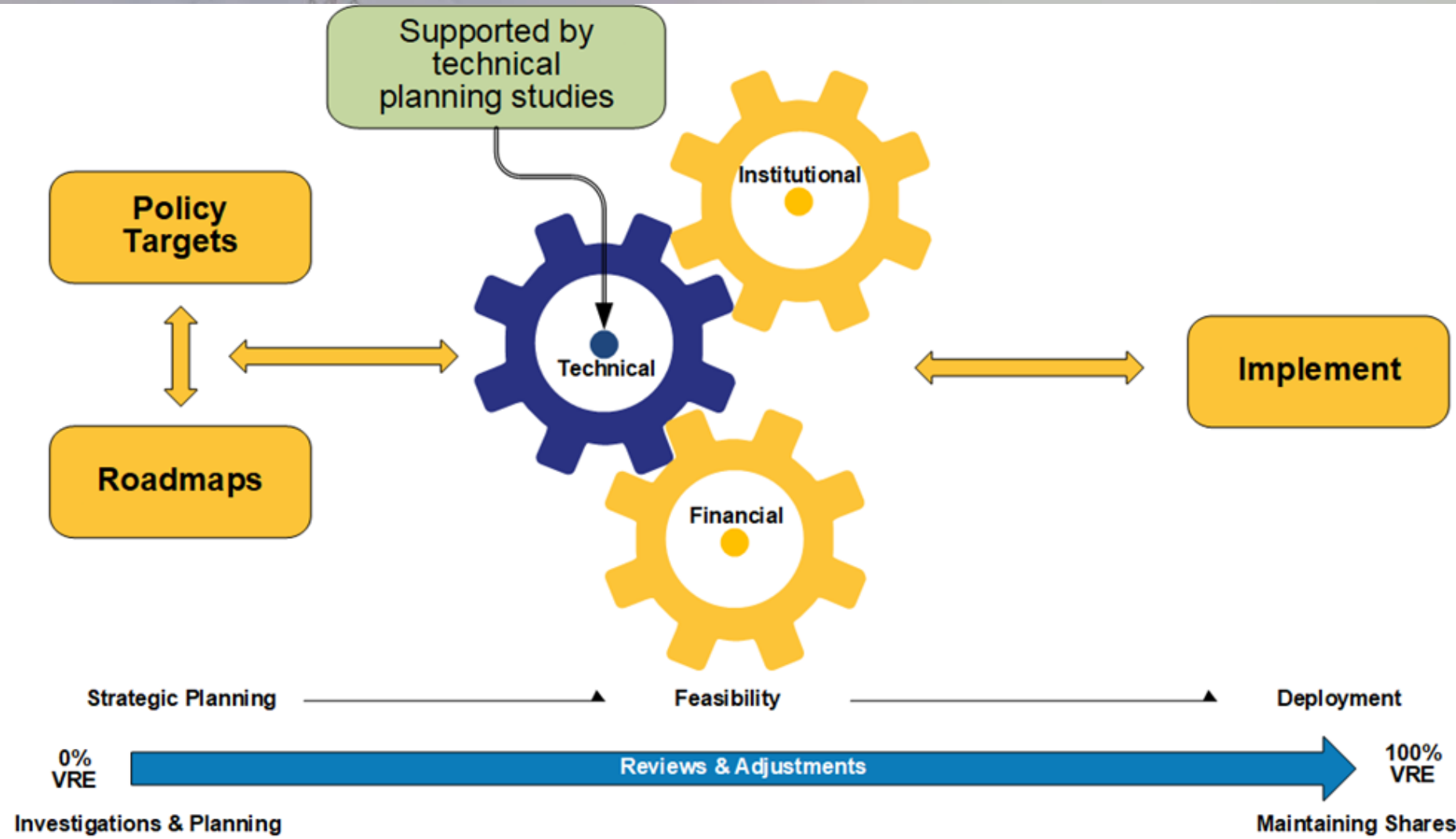
STORM

AGENDA



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

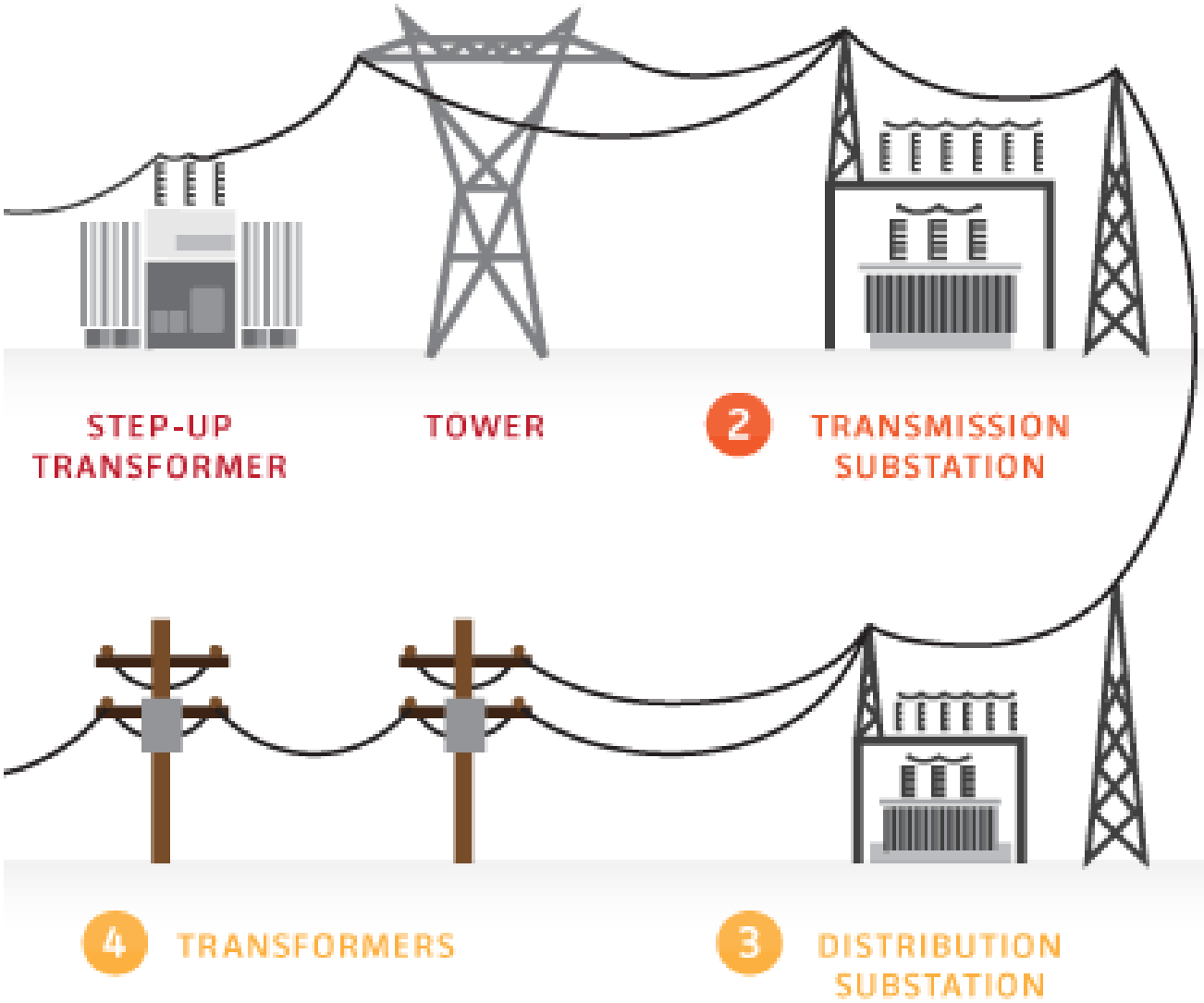
1. Transforming Power Systems



CHALLENGES

2. Challenges to Integration of VRE vs Resilience

GENERATION

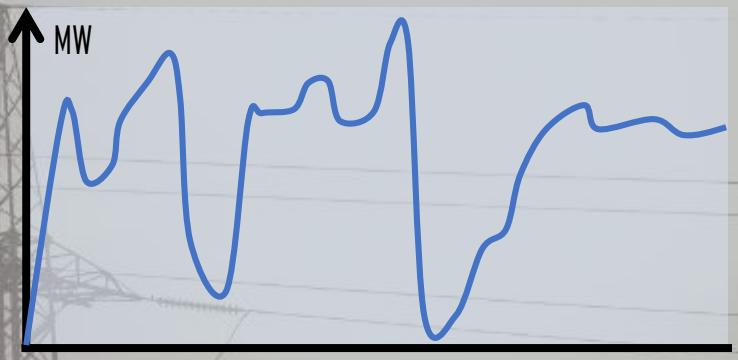


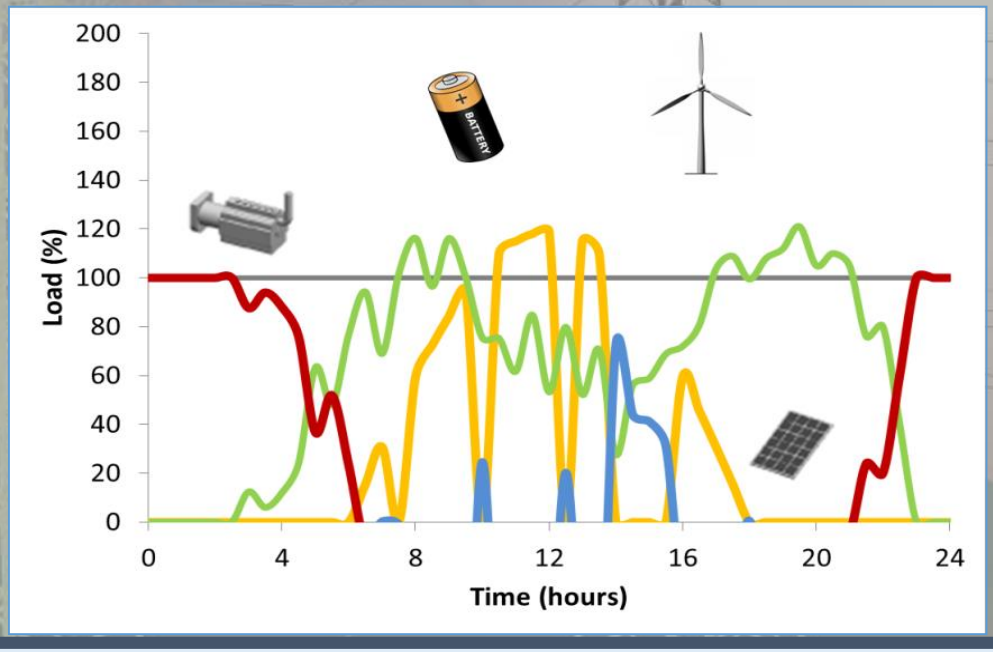
CONSUMPTION

2. Challenges to Integration of VRE vs Resilience

1. Generation adequacy (G-D)

2. Flexibility needs (G, DSR, ESS)

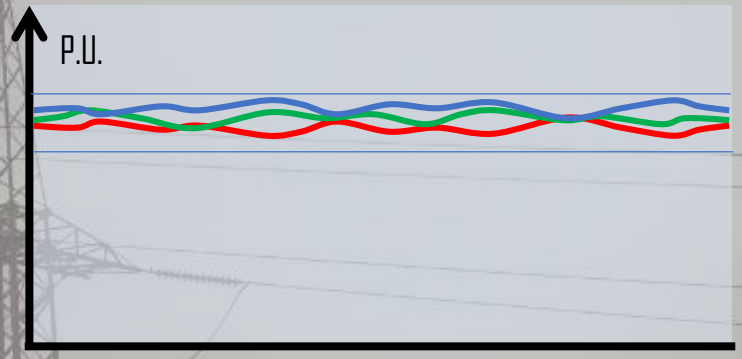




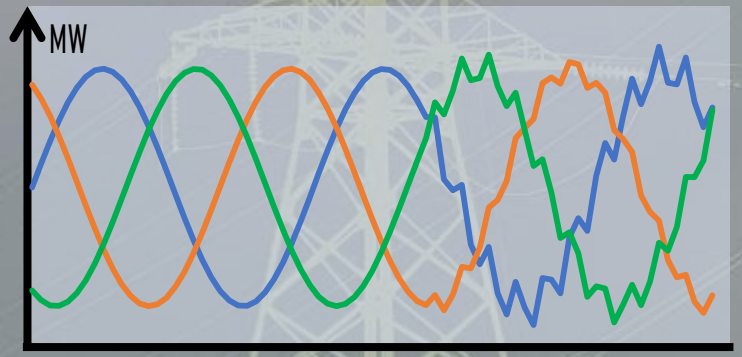
2. Challenges to Integration of VRE vs Resilience

3. Frequency Stability (F)

4. Physical limits (P, V, T)



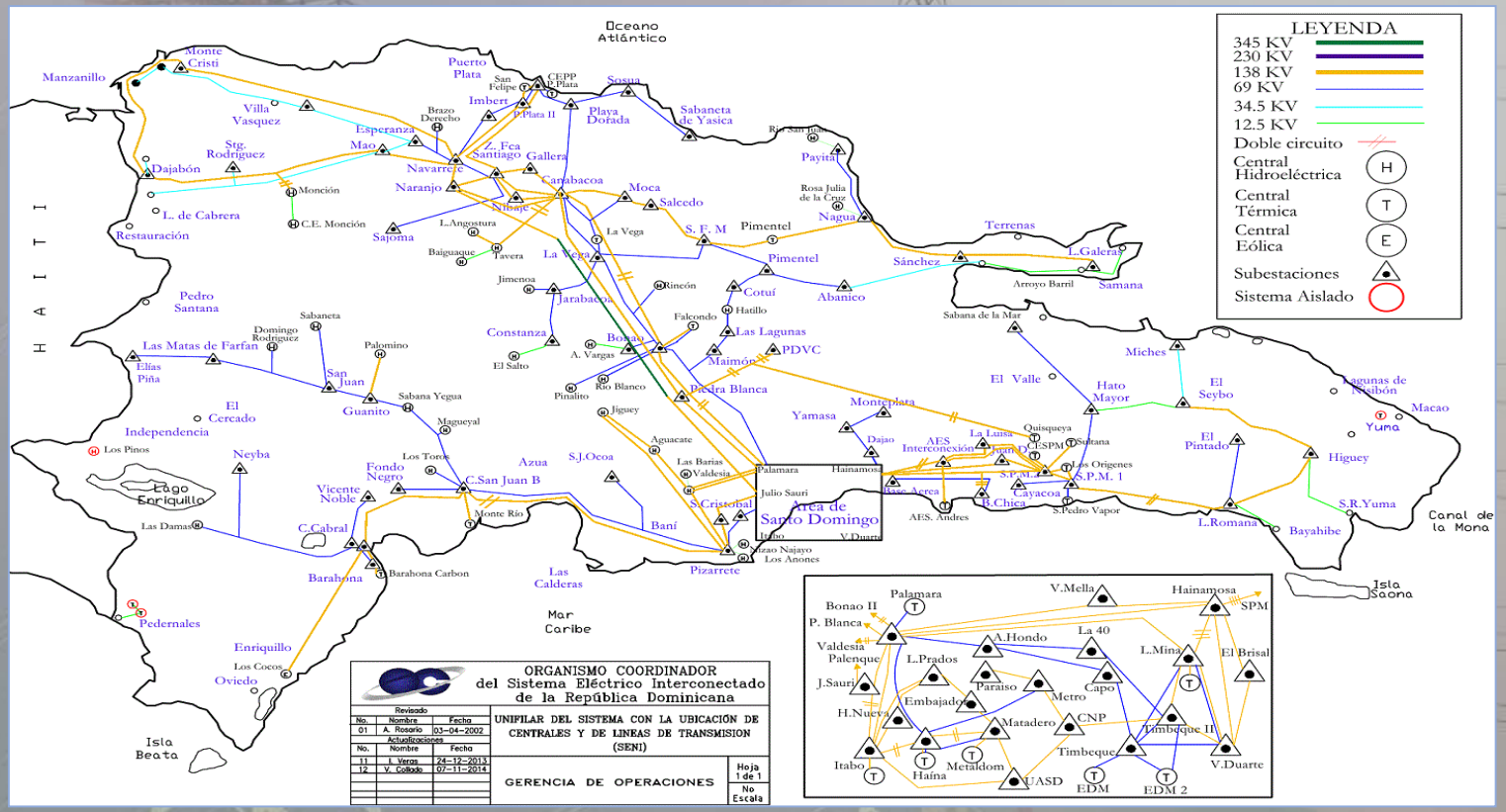
5. Power Quality and Harmonics



6. Protection systems

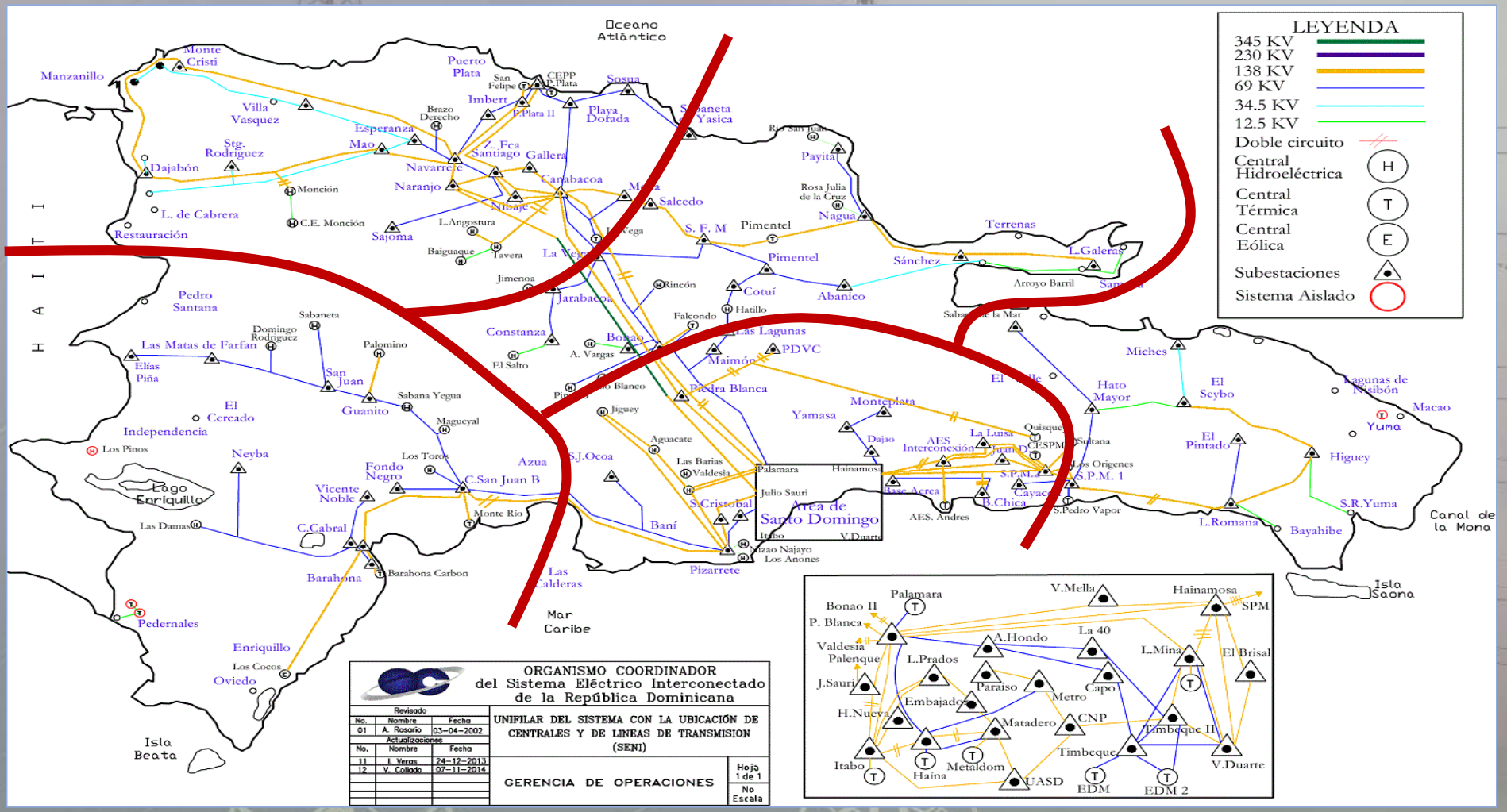
2. Challenges to Integration of VRE vs Resilience

7. Structure and topology of transmission and distribution networks



2. Challenges to Integration of VRE vs Resilience

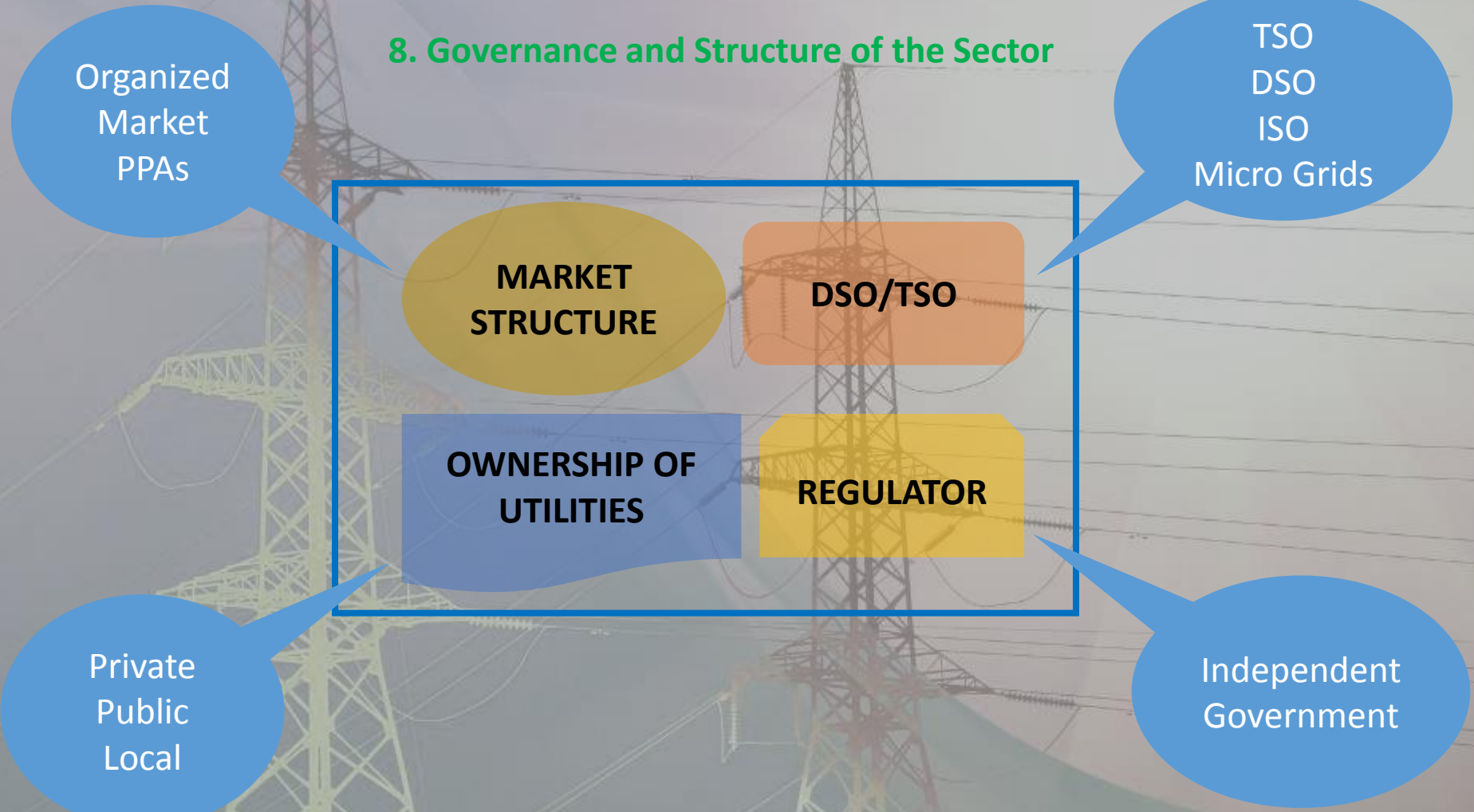
7. Structure and topology of transmission and distribution networks



2. Challenges to Integration of VRE vs Resilience

7. Structure and topology of transmission and distribution networks

2. Challenges to Integration of VRE



MEASURES

3. Measures To Integration of VRE – Frequency & Voltage

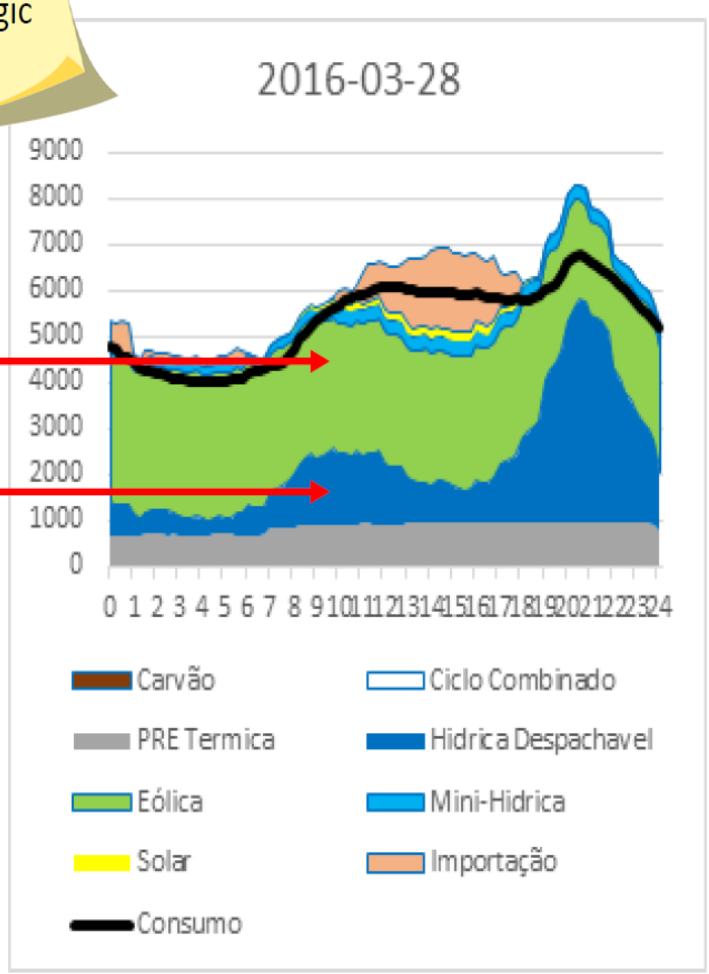
- Increase frequency regulation from VRE sources
- Deployment of energy storage
- Generation redispatch and/or
- Improvement of under frequency load shedding settings.

- 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

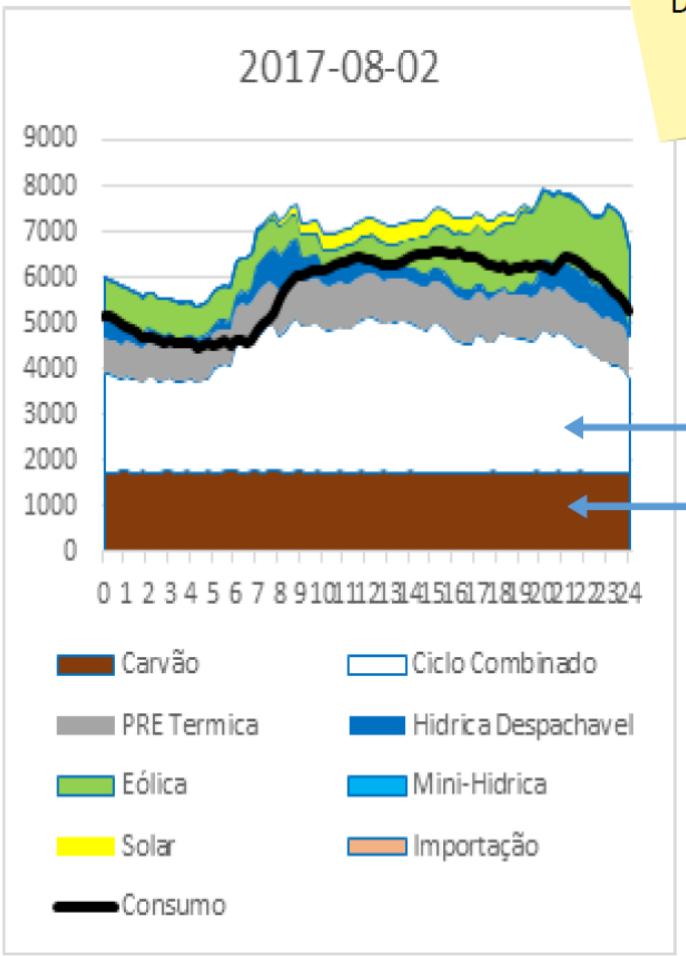
Wet hydrologic year

Dry hydrologic year



Wind

Hydro



CCGT

Coal

Source: REN

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

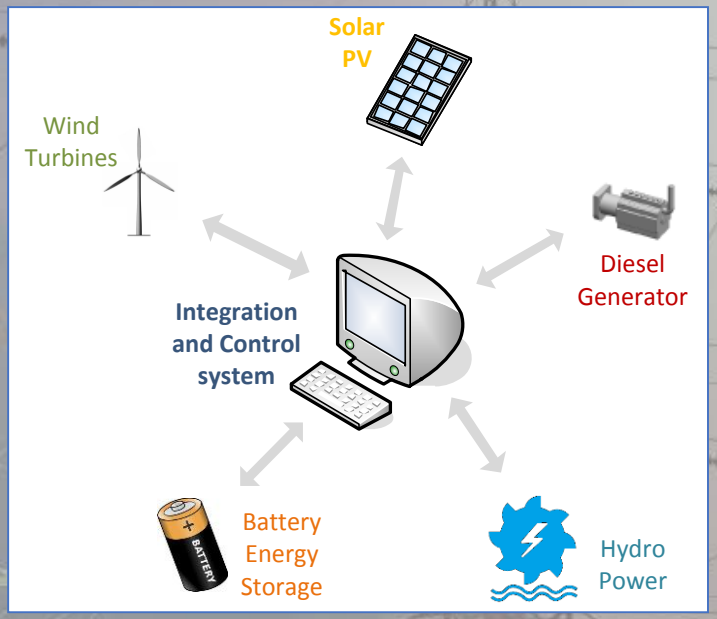
Hydro Pump

Energy Storage System

Export

Resistor

Curtail



Tertiary Reserve

Load Shedding

Import

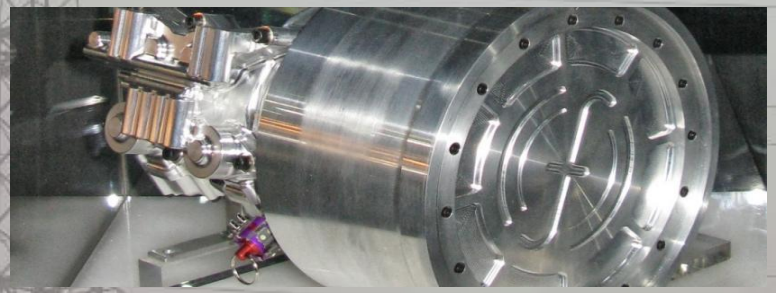
Secondary Reserve

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

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

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

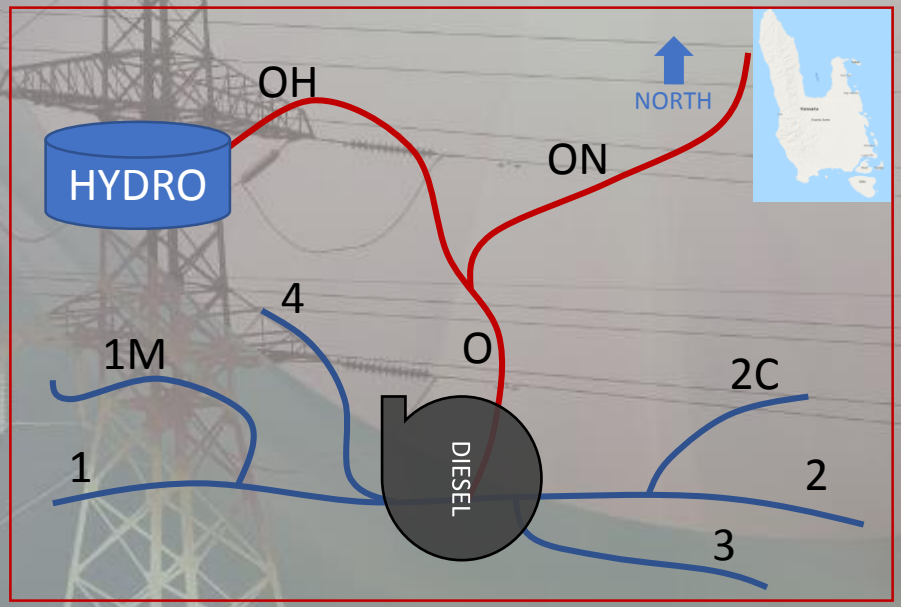
Economic Dispatch for 2018 and 2030

Stead-State and Dynamic Simulations for 2018 and 2030

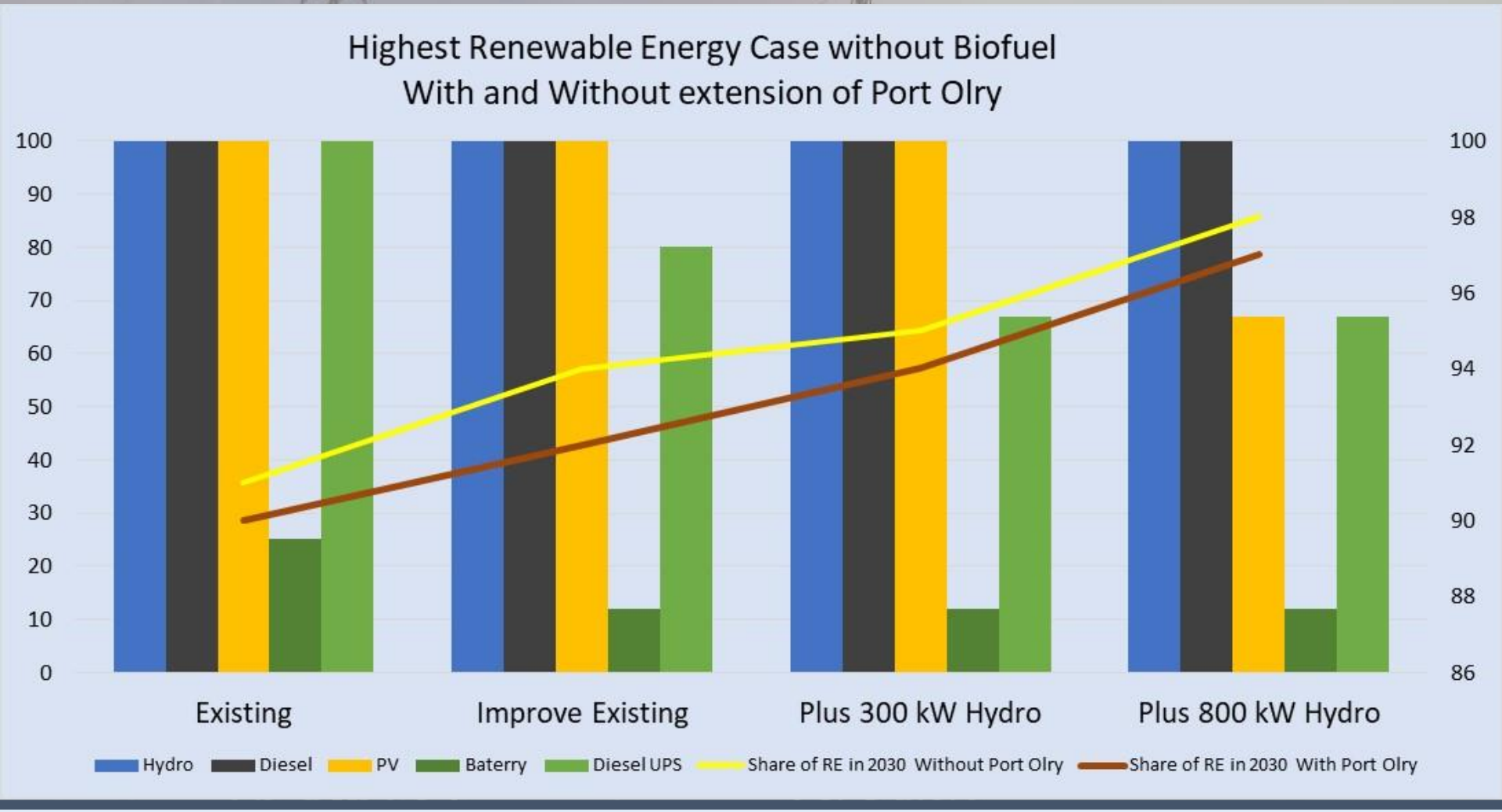
Security of the System
VRE Enablers Assessment
Grid Expansion Plan
Flexibility Assessment

Scenarios (16 Scenario):

- Maximum and Minimum Demand for 2018 and 2030
  - Existing System
  - Lowest Long-Term Cost
  - Highest Share of VRE
  - No Major Enablers



OUTCOME (ONE HYPOTHESIS FOR 2030)



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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International Renewable Energy Agency

THANK YOU FOR YOUR ATTENTION

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