UNSW
SYDNEY

Collaboration on Energy and Environmental Markets

PACIFIC POWER ASSOCIATION
29TH ANNUAL CONFERENCE
21-24 NOVEMBER 2022, BRISBANE, AUSTRALIA

Facilitation of High Penetration of Variable Renewable Energy in Pacific Island Country Utility Grids

JANENDRA PRASAD
Researcher PhD Candidate

Theme: "Supporting Utilities towards Environmental Stewardship, Operational Performance and Financial Stability"

UNSW SYDNEY

JANENDRA PRASAD

Researcher PhD Candidate

Janendra (Jay) is a Chartered Professional Electrical Engineer with 25 years' experience leading the delivery of innovative, technically sound, cost-effective, and safe engineering solutions for electrical infrastructure. He has held in senior engineering, management and capacity building roles in power system design and operations, asset strategy and project development in Australia and Pacific Islands.

Jay's research interest is in integration and optimisation of high penetration of renewable energy and sustainable energy solutions.

Presentation Topic:

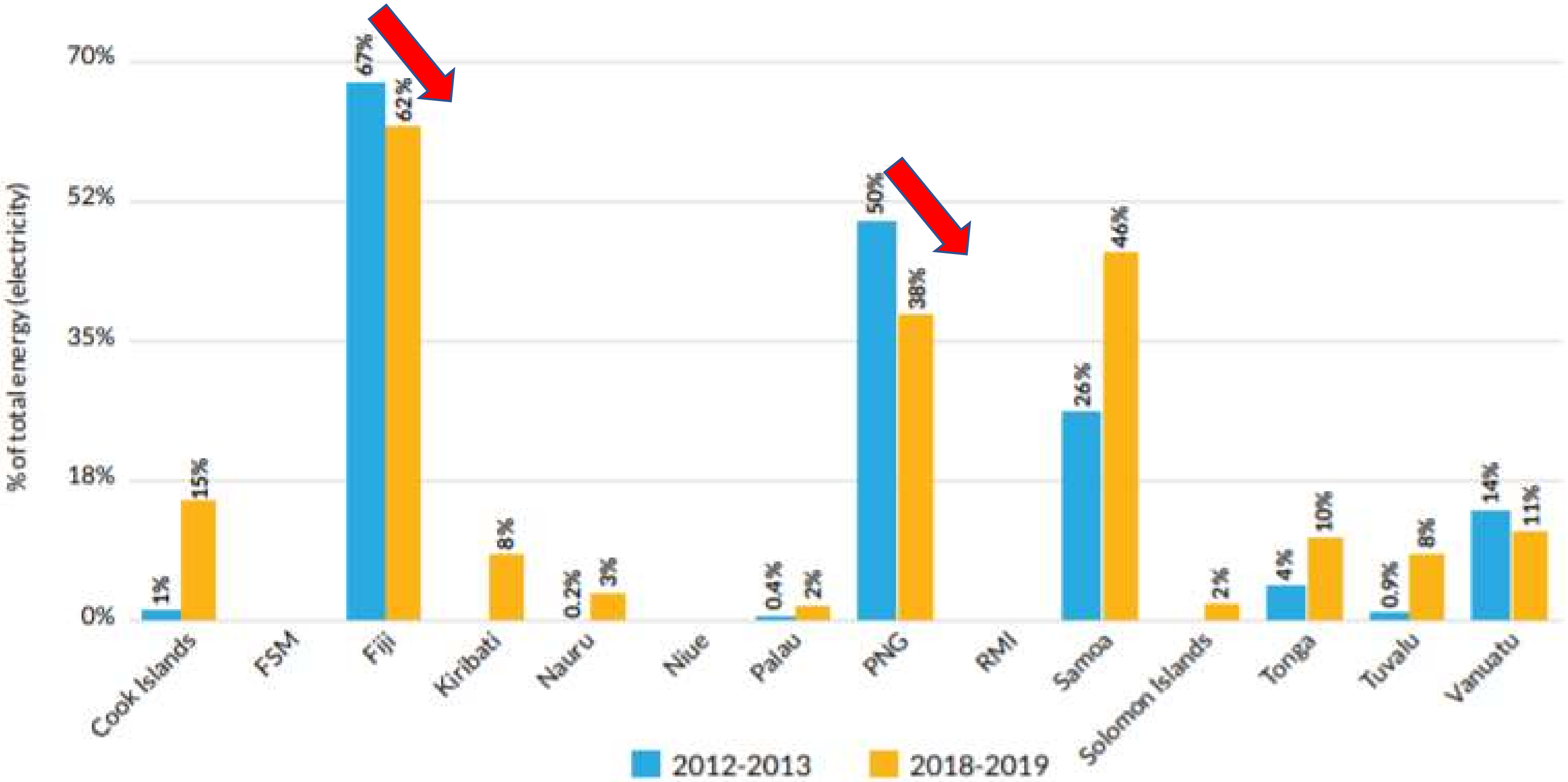
Facilitation of High Penetration of Variable Renewable Energy in Pacific Island Country Utility Grids

Renewable energy uptake remains considerably low despite significant efforts and investments over the past two decades in the Pacific Islands. Detailed study is needed that will provide a holistic view of technical issues, barriers, potential risks, limitations, benefits, and opportunities for VRE integration.

This presentation discusses the most critical energy issues for the Pacific Islands region and sets the agenda for further research.

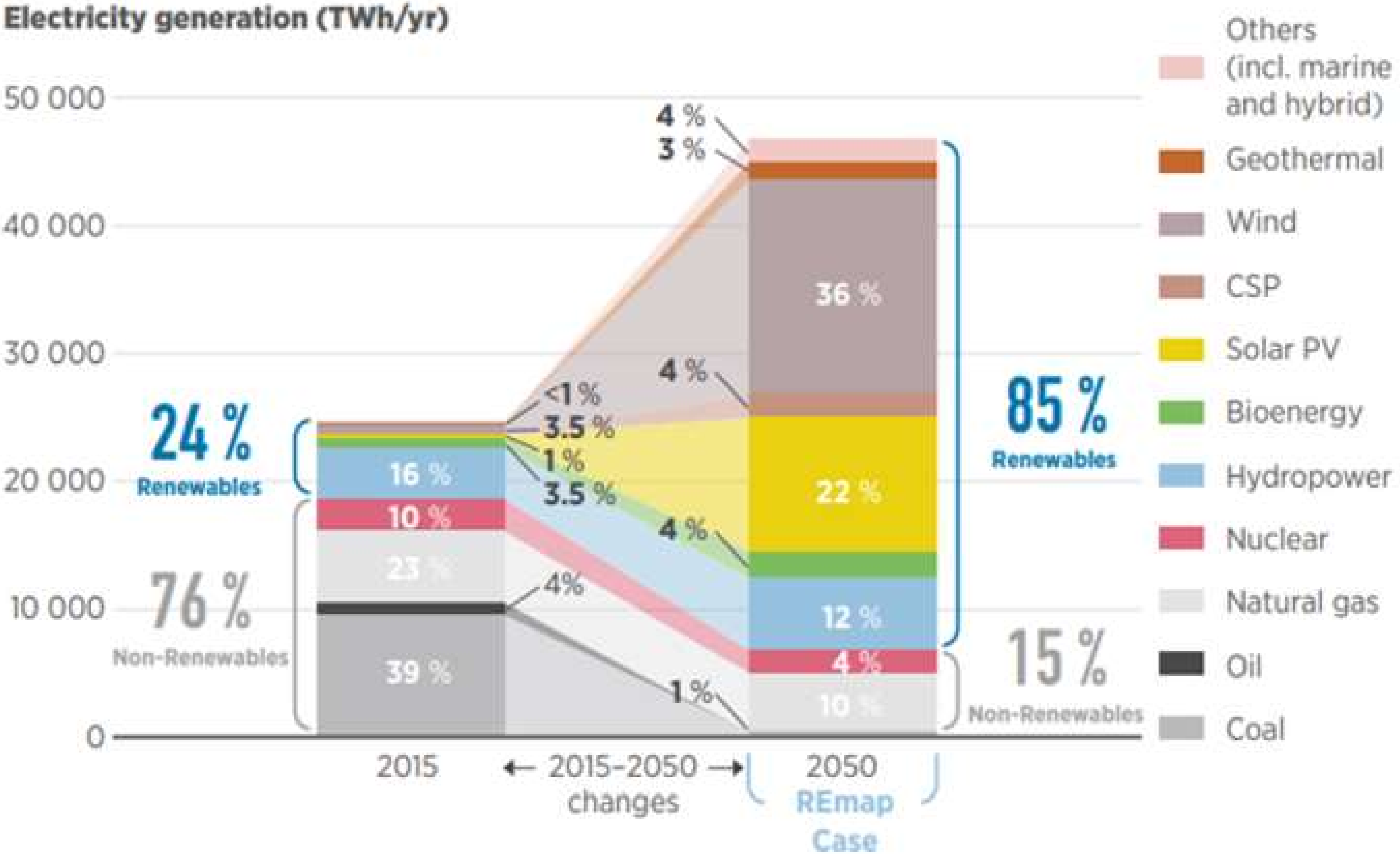
Renewable Energy Trends- Pacific Islands

SDG Target 7.2: RE as a Percentage of Total Energy (Electricity)



Source: Pacific Infrastructure Performance Indicators Report, 2021

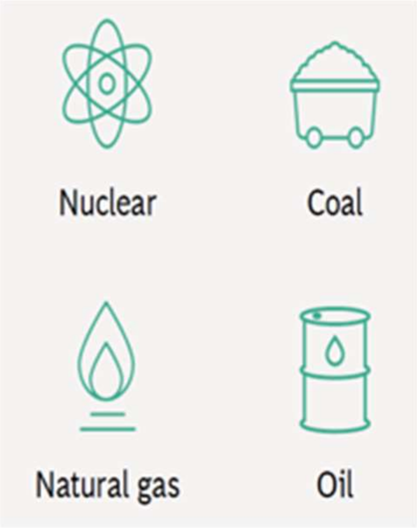
RE Composition in Future (2050)



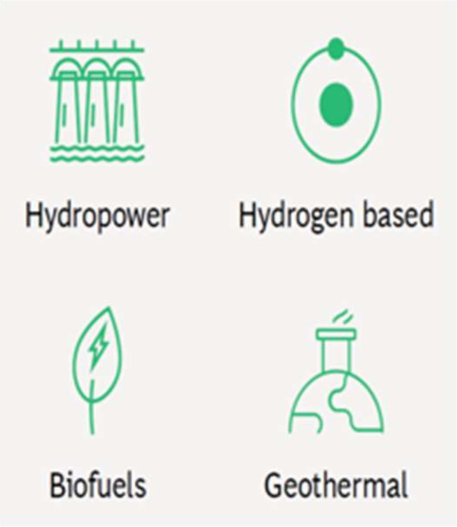
Source: IRENA

Electricity is produced using different types of generators

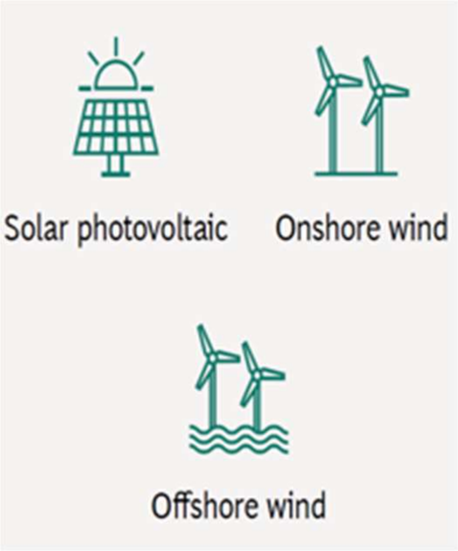
Conventional Power Plants



Dispatchable Renewable-Energy Plants



Variable Renewable Energy (VRE) Sources



Source: BCG Analysis

Generating VRE is different from producing conventional power

Variable
Generation depends on the sun shining or the wind blowing; energy is not available on demand

Uncertain
Generation remains challenging to predict perfectly, despite increasingly accurate weather-forecasting tools

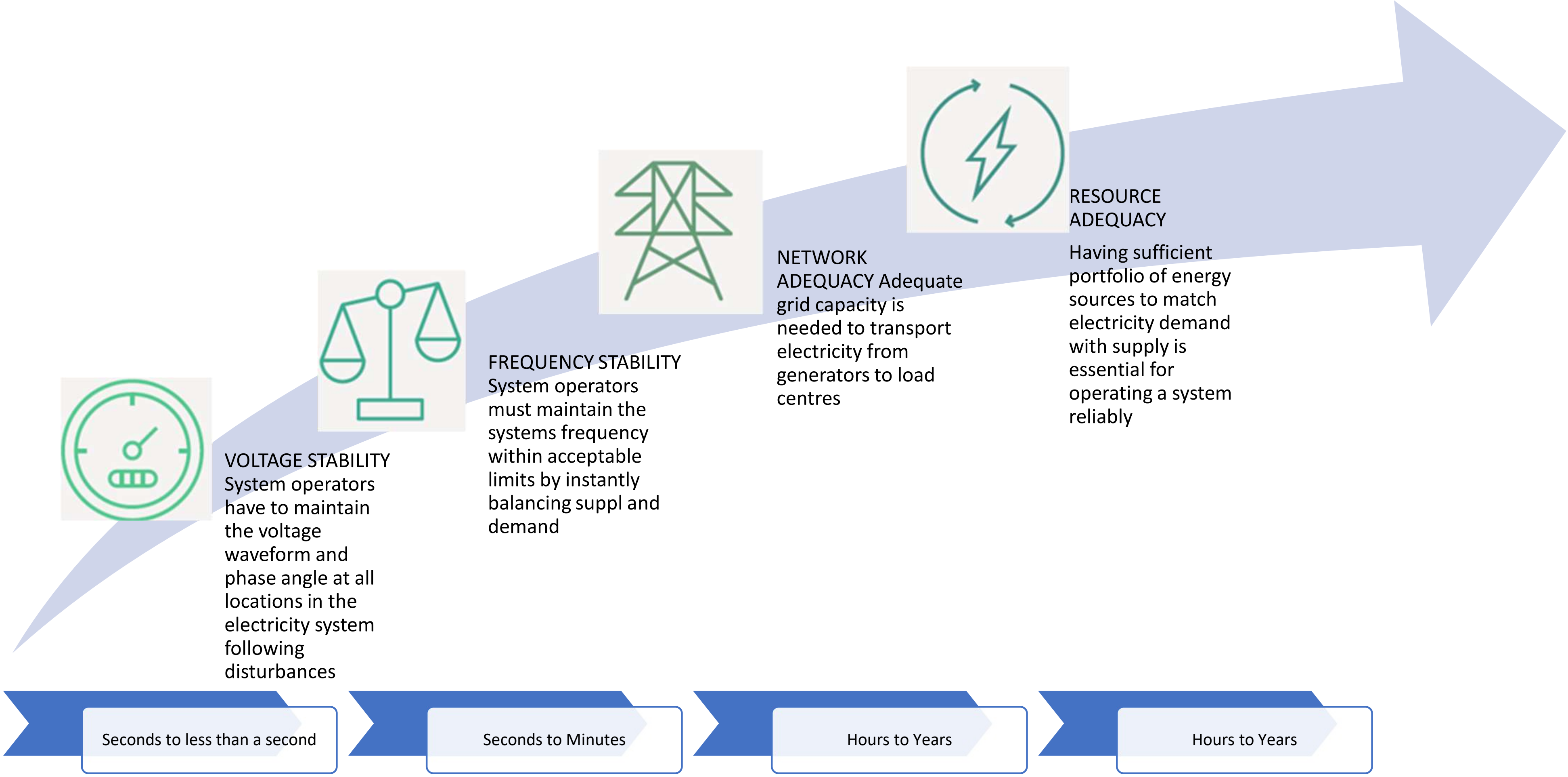
Inverter based
Power electronic devices interface solar panels and wind turbines with the grid, changing direct current into alternating current

Distributed
Generators are typically small in scale and distributed broadly across the electrical grid

Zero marginal cost
Cost structures are almost entirely fixed, with few if any variable running costs

Source: BCG Analysis

Characteristics of VRE generation create challenges in four areas



VOLTAGE STABILITY System operators have to maintain the voltage waveform and phase angle at all locations in the electricity system following disturbances

FREQUENCY STABILITY System operators must maintain the systems frequency within acceptable limits by instantly balancing suppl and demand

NETWORK ADEQUACY Adequate grid capacity is needed to transport electricity from generators to load centres

RESOURCE ADEQUACY

Having sufficient portfolio of energy sources to match electricity demand with supply is essential for operating a system reliably

Seconds to less than a second

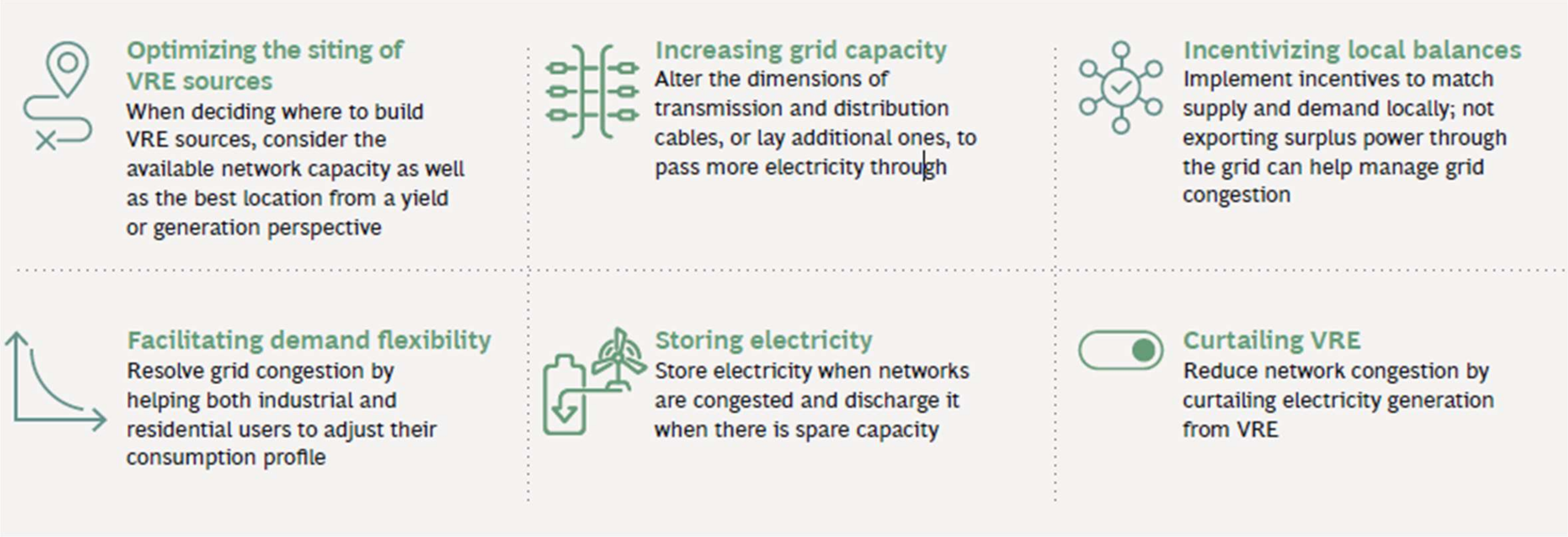
Seconds to Minutes

Hours to Years

Hours to Years

Time Frame in Which System Operators and Designers Need to Act in Order to Meet These Requirements

There are number of ways to address network adequacy challenge



Optimizing the siting of VRE sources

When deciding where to build VRE sources, consider the available network capacity as well as the best location from a yield or generation perspective

Increasing grid capacity

Alter the dimensions of transmission and distribution cables, or lay additional ones, to pass more electricity through

Incentivizing local balances

Implement incentives to match supply and demand locally; not exporting surplus power through the grid can help manage grid congestion

Facilitating demand flexibility

Resolve grid congestion by helping both industrial and residential users to adjust their consumption profile

Storing electricity

Store electricity when networks are congested and discharge it when there is spare capacity

Curtailing VRE

Reduce network congestion by curtailing electricity generation from VRE

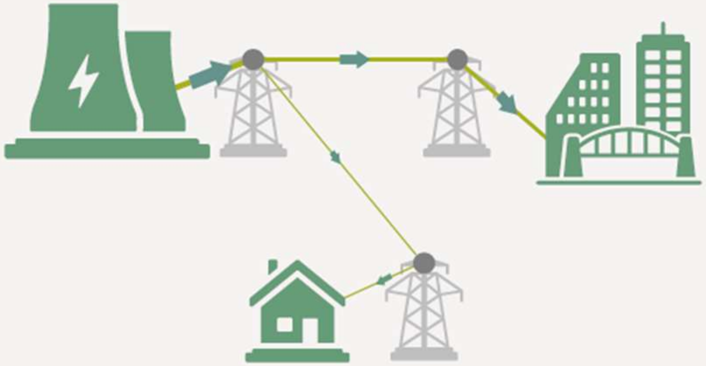
Source: BCG Analysis

Shifts in power flows through electrical grids can lead to network congestion

Conventional electricity systems

Large conventional power plants generate the bulk of the electricity, and networks are designed to transport it to consumption centers

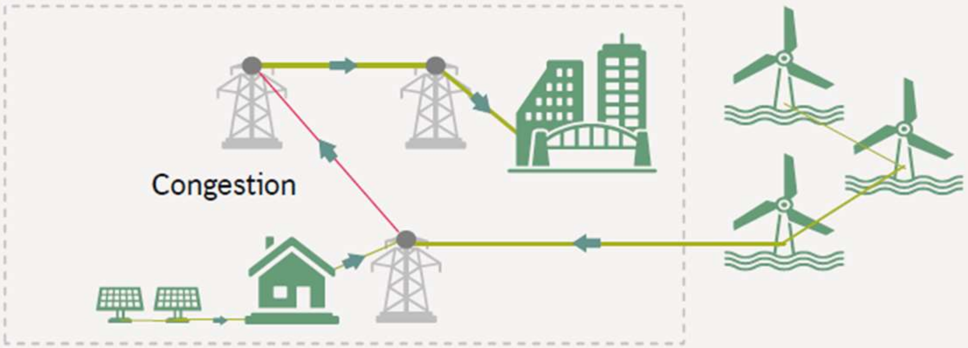
A conventional power plant supplies a city and a village



VRE-driven electricity systems

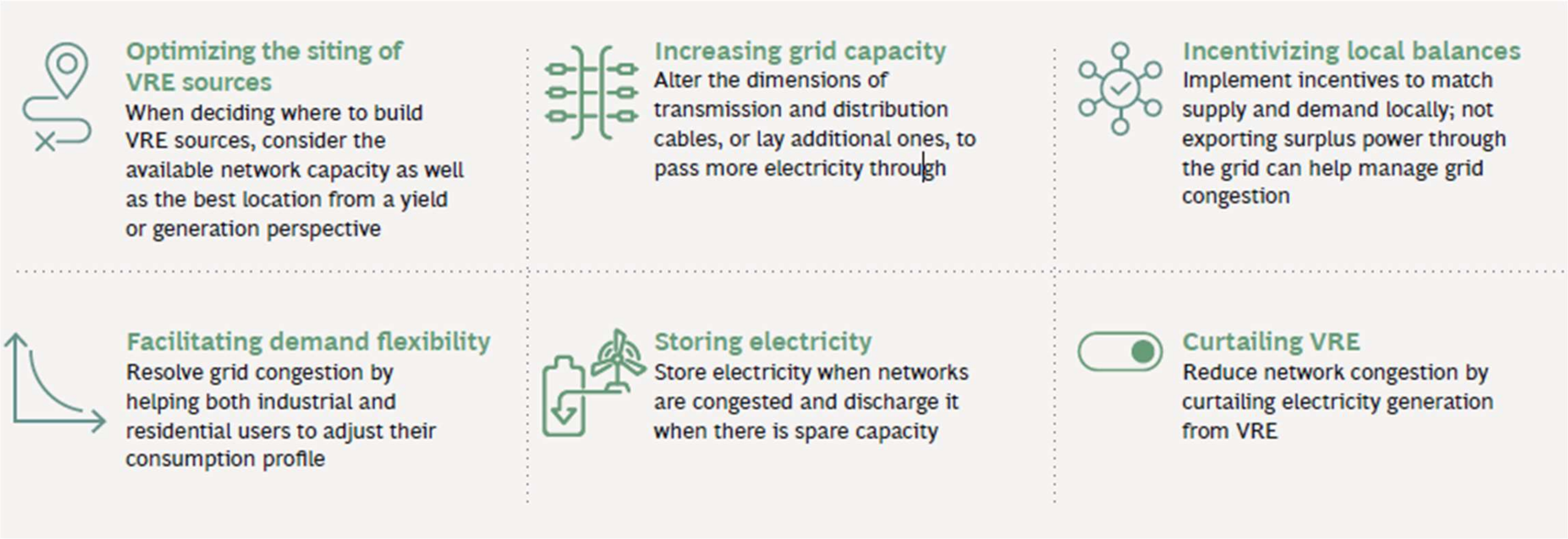
Wind farms and solar systems generate most of the electricity, but they are more distributed and may be in areas with weaker connections to the main electricity grid, resulting in congestion issues[1]

The city is powered by wind and solar, and a village supplies itself with solar power; such networks can suffer from congestion without line upgrades



Source: BCG Analysis

There are number of ways to address network adequacy challenge



Optimizing the siting of VRE sources
When deciding where to build VRE sources, consider the available network capacity as well as the best location from a yield or generation perspective

Increasing grid capacity
Alter the dimensions of transmission and distribution cables, or lay additional ones, to pass more electricity through

Incentivizing local balances
Implement incentives to match supply and demand locally; not exporting surplus power through the grid can help manage grid congestion

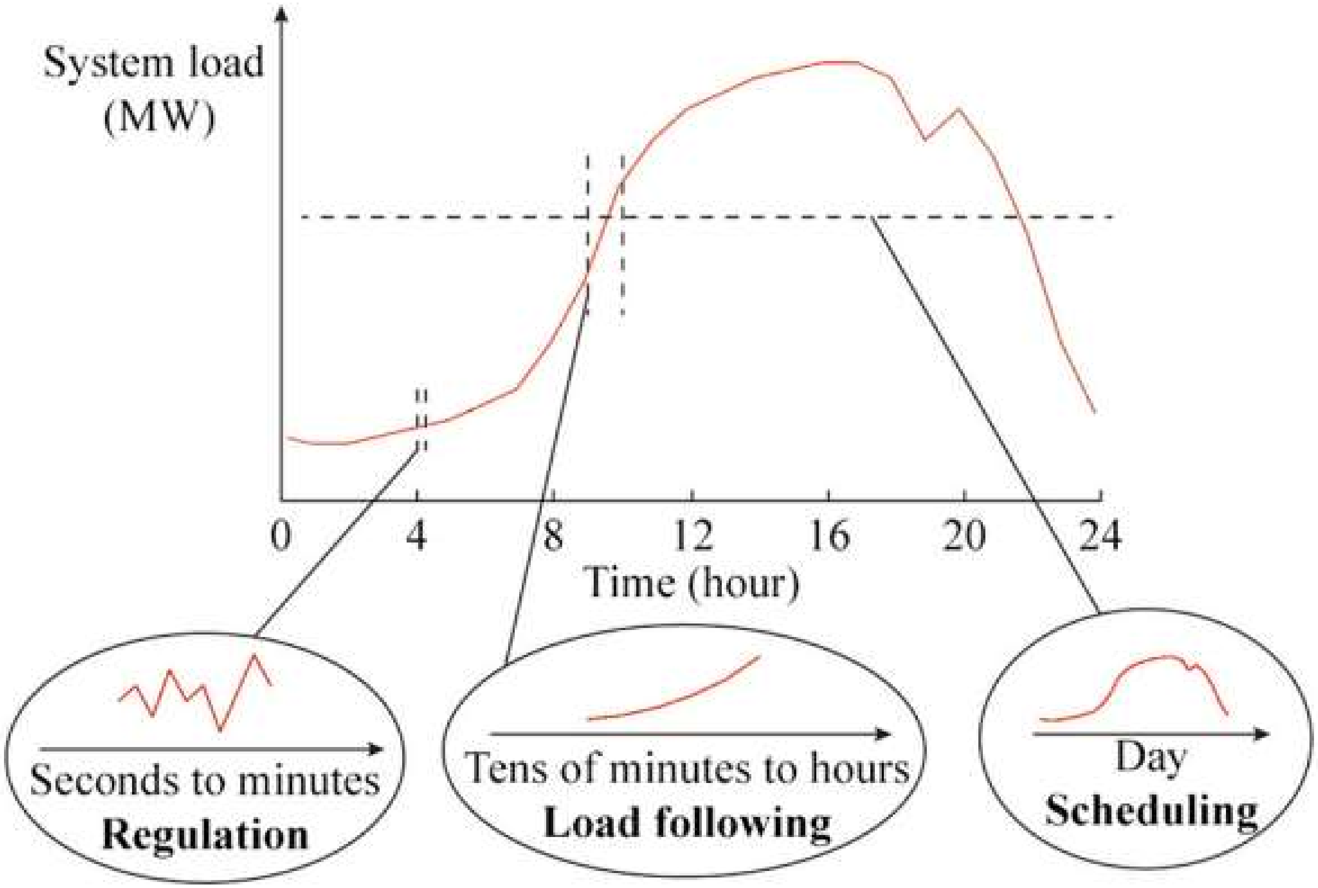
Facilitating demand flexibility
Resolve grid congestion by helping both industrial and residential users to adjust their consumption profile

Storing electricity
Store electricity when networks are congested and discharge it when there is spare capacity

Curtailing VRE
Reduce network congestion by curtailing electricity generation from VRE

Source: BCG Analysis

Need for Research



"Grid flexibility is defined as the capability of a power system to cope with the variability and uncertainty that RE sources introduce at different time scales, from the very short to the long term, avoiding curtailment of power from VRE sources and reliably supplying customer energy demand" (IRENA)

Managing increasing penetration and complexity of VRE is a major challenge

Transition from fossil fuels to diversified RE sources will require careful planning, financial investments and technology intervention

What does it mean for PICT Utilities

Renewable electrical energy uptake in Pacific Island Countries has been low despite investments and efforts

Grid integration of VRE is a complex and expansive topic, significant knowledge gap and lack of coordinated efforts for PICT utilities to address this issue

Intervention Strategies are required including better understanding of CEM tools and long term capacity expansion planning including cross sector energy integration issues.

Challenges

Engagement/Ownership

Capital Investment

Management of Change

Flexible Grids

E-mobility

Need for Tangible Outcomes

Resilient Power Grids

Grid Integration and Planning Studies

Grid integration and planning studies: use the available power system data, validate the dynamic characteristics of the existing generators, collaborated with utilities to build and populate models for specific islands. identify grid stability and reliability issues for different VRE penetration levels and different demand scenarios.

Assessment of energy storage applications in power utilities: assess the interest and cost-effectiveness of the energy storage systems, and the role that it can perform as grid support including identification and probable solutions to implementation challenges that may arise.

Grid code: written after assessing the requirements relating to voltages and frequency range of the island, understanding different options to integrate RE sources into the system and how Renewable Energy generators could respond to grid disturbances. In the grid code, special emphasis was to state the grid support capabilities that are expected from RE generators

Technology Capability: assessment of the needs for Supervisory Control and Data Acquisition (SCADA) and Energy Management System (EMS)

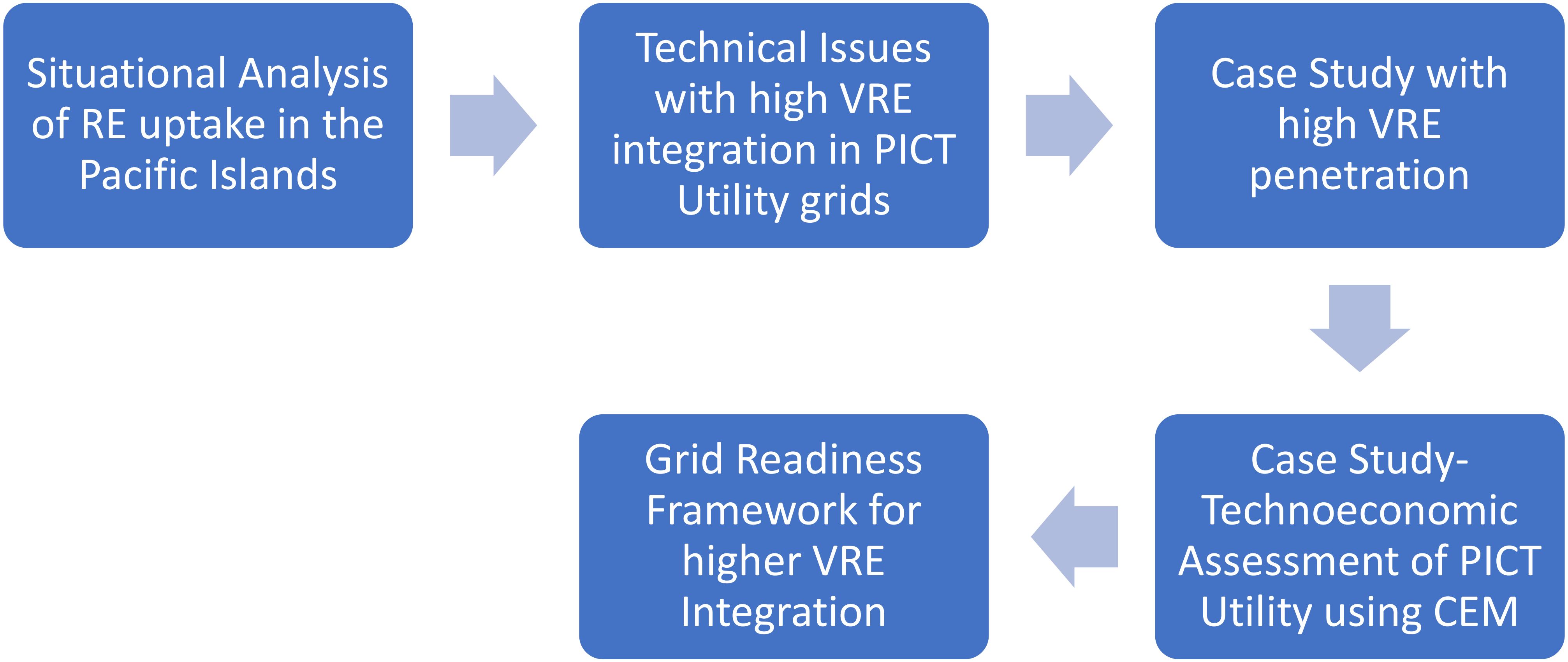
Some Progress…

Pacific Island Countries	**Assessment of VRE Grid Integration Evaluation of SCADA and EMS system**	Grid Connection Code for Renewable Power Plants and Battery Storage Plants
Chuuk, FSM	28/05/2019	July 2018
Majuro, Marshall Islands	28/05/2019	July 2018
Pohnpei, FSM	15/05/2019	May 2019
Kosrae, FSM	23/05/2019	July 2018
Yap, FSM	05/04/2019	
Samoa	30/05/2019	May 2019
Tonga	28/05/2019	July 2018
Tuvalu	23/05/2019	July 2018

Research Objectives

1. Investigate the barriers faced by PICT utilities in uptake of RE and assess the technical issues and challenges of integrating high VRE on their electricity grids.
2. Explore strategies and technology solutions for higher penetration of VRE, thus reducing usage and dependency of fossil fuels.
3. Critical review and assessment of CEM software tools suited for PICT region; and undertake utility based case study to demonstrate scenarios and strategies to push high VRE penetrations to grid
4. Investigate impact of EV as flexible load on the grid and discuss cross sector energy integration issues.
5. Develop a grid readiness framework to address required institutional changes and targeted investment plans to facilitate higher VRE to grid.

Methodology



Situational Analysis of RE uptake in the Pacific Islands

Technical Issues with high VRE integration in PICT Utility grids

Case Study with high VRE penetration

Case Study- Technoeconomic Assessment of PICT Utility using CEM

Grid Readiness Framework for higher VRE Integration

The Approach.

PICT Utility grids each have underlying grid stability issues, caused primarily because these are small island networks with very little inertia and support to maintain system stability and frequency.

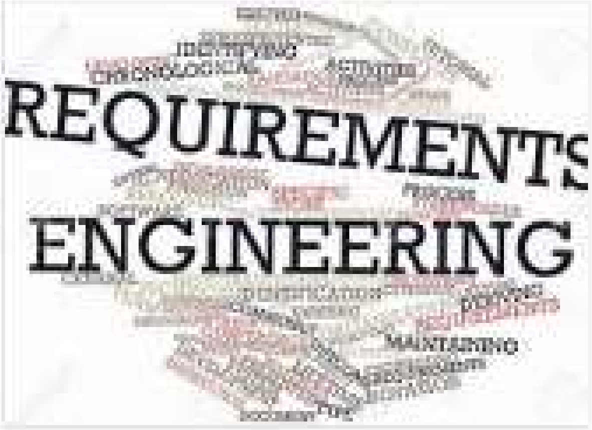
The generation that is connected to these networks often does not have the appropriate control systems in place to manage behavior during disturbances; and this also impacts the overall stability of these grids

The move towards a more sustainable and reliable power sector will result in more renewable generation technologies connecting to these networks.

Need to:

- Assess the operational and stability characteristics of the existing networks,
- Assess and understand the capability of each of the studied networks to accommodate renewable, intermittent generation;
- Identify operational limitations and optimal range of power generation mix between existing and new generation to prevent adverse impacts; and
- Provide recommendations on strategic reinforcements and other methods of increasing VRE penetration.

The future....



- Enabling environment (policy/regulatory readiness)
- Smart grids, communications, SCADA and control systems
- Capacity building, engineering, project implementation, integration
- Grid scale BESS as form of grid smoothing, spinning reserve, black start capabilities.
- Domestic rooftop solar PV, In home storage systems
- Credible data for system performance and economic modelling, automated data repositories
- Climate resilience electrical infrastructures
- Grid readiness for VRE integration

Strategies to push the RE penetrations to higher levels for the PICT utilities

In Summary….

Renewable electrical energy uptake in Pacific Island Countries has been low despite investments and efforts.

Managing increasing penetration and complexity of VRE is a major challenge.

Transition from fossil fuels to diversified RE sources will require careful planning, financial investments and technology intervention.

“Need to be genuine talk, communication and dialogue and story telling”. Mr Jamie Isbister.

Thank you

Theme: “Supporting Utilities towards Environmental Stewardship, Operational Performance and Financial Stability”