

# ***Role of Grid Digitalization and Renewable Energy in Building Smart Grids***

## ***ADB Support to address Digitalization of Grids in Sri Lanka***

### ***Driving Power Sector Reforms for Enhanced Renewable Energy Growth and Sector Performance Workshop***

**Jaimes Kolantharaj**  
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*Asian Development Bank*

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*Department Head, E. Eng*  
*Universidad de Málaga*

*Colombo, January 30, 2025*

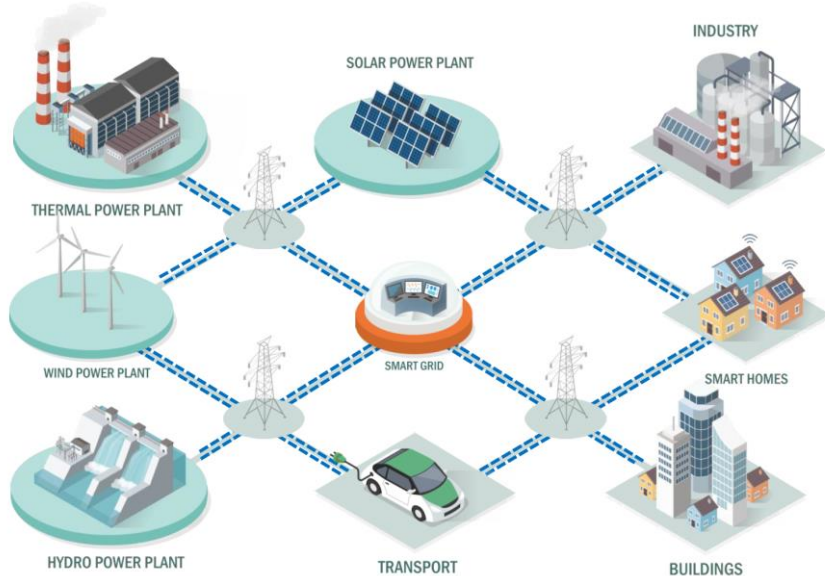


**Prof. José Aguado** is Full Professor and Head of the Department of Electrical Engineering at the University of Málaga, Spain.

*His expertise lies in the operation and planning of electric energy systems, renewable energy integration, energy storage and electric vehicles.*

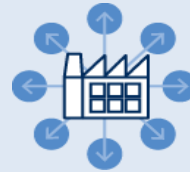
*His consultancy expertise spans over 30 developing countries, including Sri Lanka and other nations in Asia and in the Pacific.*

# The 4 'Ds' of Energy Transition: Opportunities for Sri Lanka



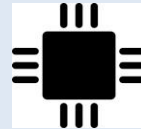
## De-carbonization

70% RE share by 2030



## Des-centralization

Highest Solar Roof-top penetration in the region (25%)



## Digitalization

Increase the adoption of digital tools (AMI, Power Grid AI-DT, Smart Grid)

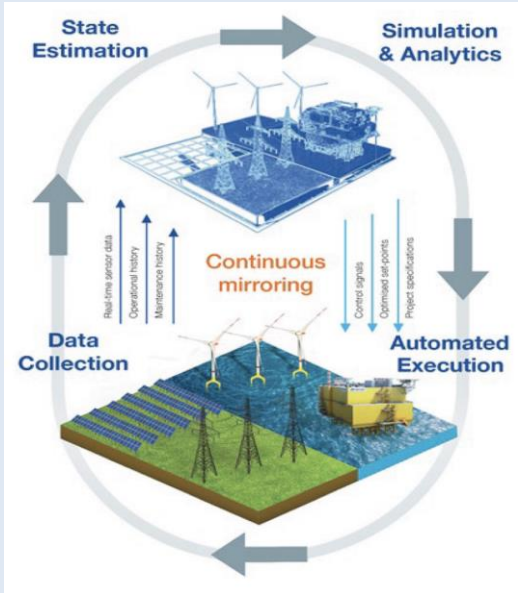


## Democratization

Energy-share models to empower citizens

# Grid Digitalization: From Smart meters to Power Grid Digital-Twins

## Power Grid Digital Twin



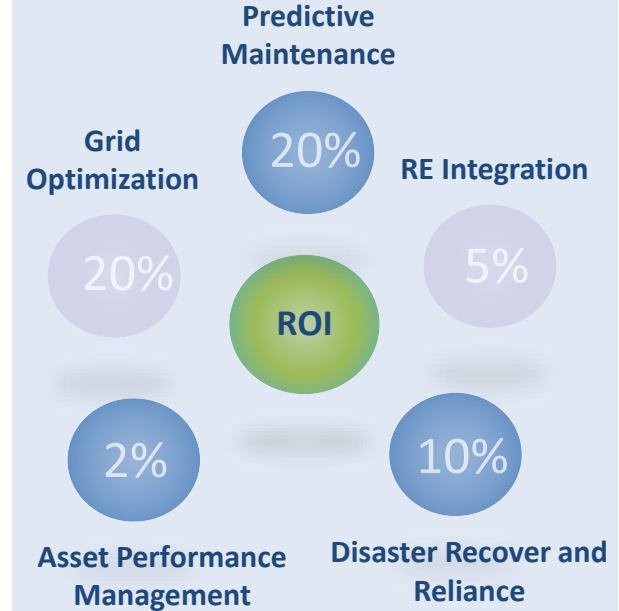
## AI-Assisted Control Room



(CERCE, RE Control Room in Madrid)

- Co-piloted Real-time Operations
- Medium and Long-Term Decis.
- Control Room Training
- Forensic Analysis

## Measurable ROIs



# Grid Integration Challenges: Soft- and Hard- Tools

## Front-Runners and Soft-Tools

**Front-runners:** Denmark, Ireland, South Australia and Spain are integrating up to 75% of VRE in their annual generation

### Essential Soft Elements:

- Modernize System Operation
- Improved Strategic Planning
- Overhauling Regulatory Frameworks (markets, business models, etc. )

## Measures to Integrate VRE

### Enhance Power Plant Capability

- Retrofit conventional power plants
- Increase VRE technical requirements

### Forecasting

- VRE generation
- Net Load
- Power Flows

### Demand Side Measures

- Industrial, Commercial, Residential Response
- Steer location on new demand

### Modify System Operation Rules

- Allow VRE Curtailment
- Balancing and Ancillary Service Market

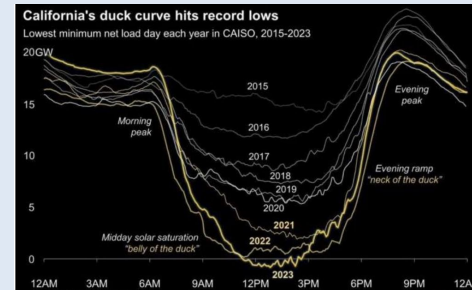
### Enhance Grid Capacity and Use

- BESS, SYNCON, STATCOM
- Interconnection/Redundancy/mesh
- Balancing and Ancillary Service Market
- Steer Location of new VRE

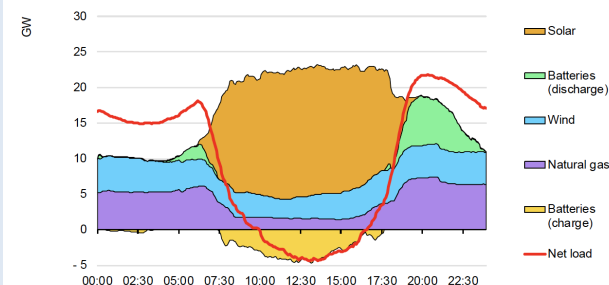
### Storage

- BESS
- Pumped Hydro, Long duration Storage

## Solar Duck Curve and Beyond



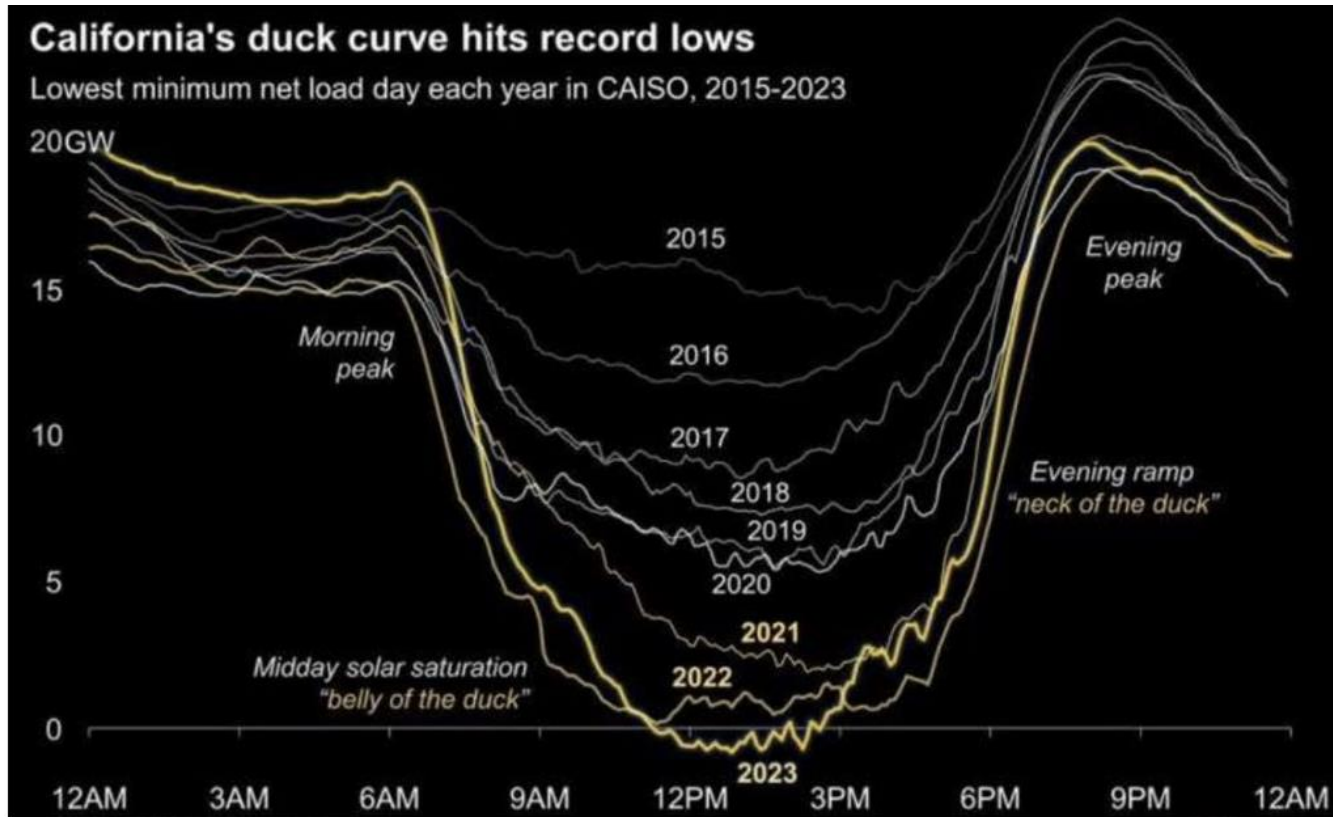
Generation profile in California (CAISO) for selected technologies, 30 April 2024



### Challenges

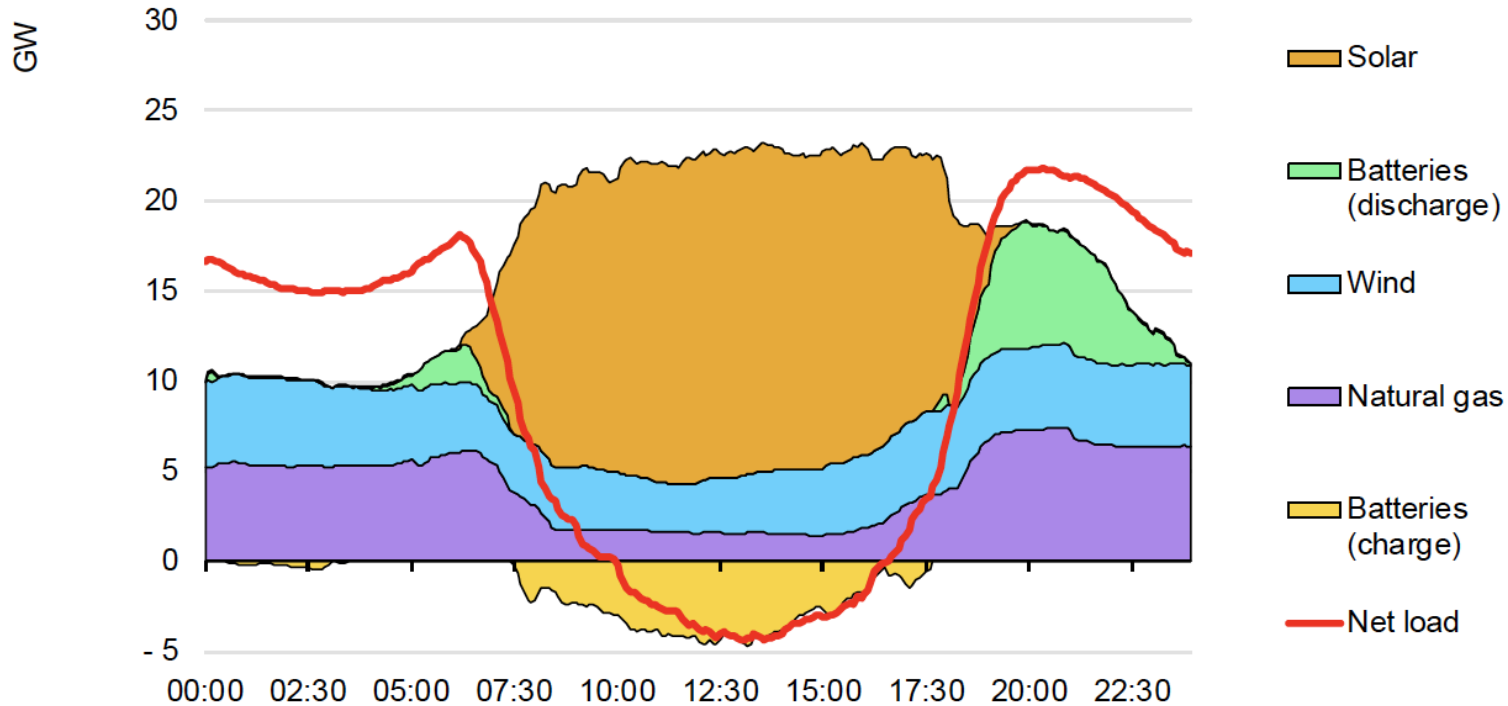
- Behind the meter Visibility
- Grid Stability
- Price Volatility and negative prices

# Grid Integration Challenges: Soft- and Hard- Tools



# Grid Integration Challenges: Soft- and Hard- Tools

Generation profile in California (CAISO) for selected technologies, 30 April 2024



# Grid Integration Challenges: Soft- and Hard- Tools

(4 min)

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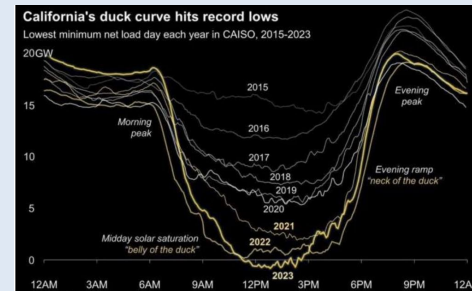
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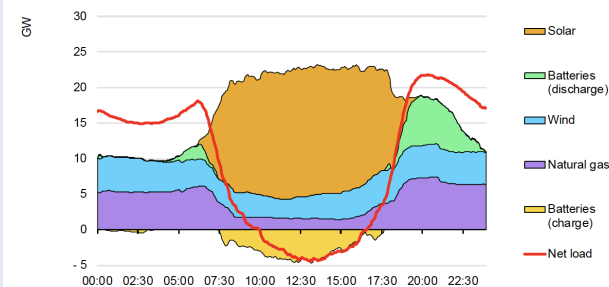
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### Challenges

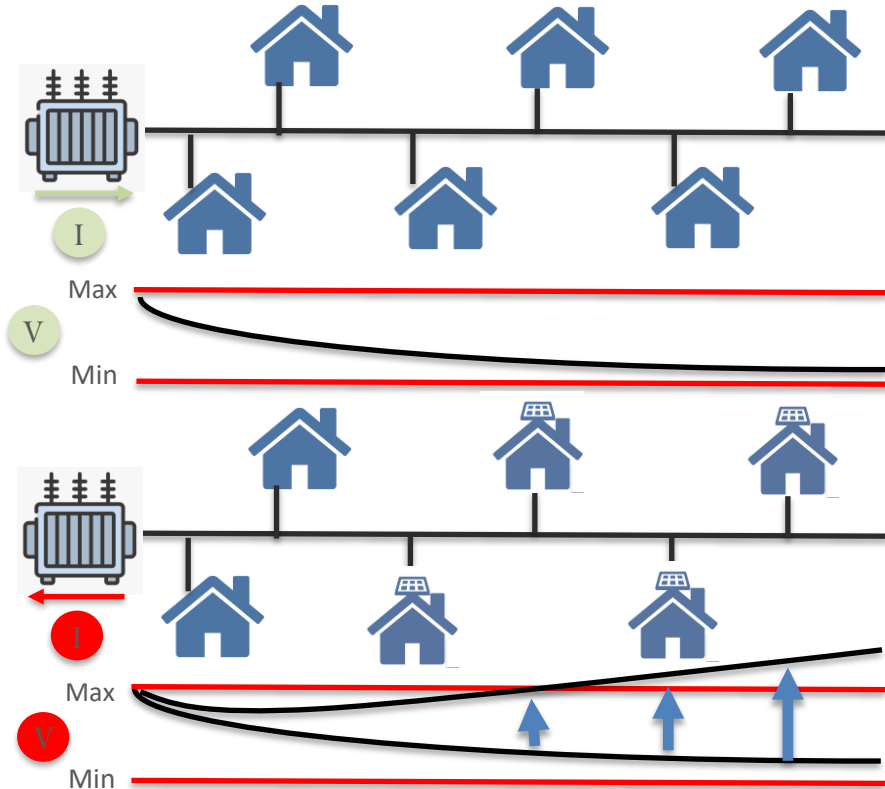
- Behind the meter Visibility
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- Price Volatility and negative prices



# Distribution Grids with high RE penetration: Voltage Control

(3 min)

## Distribution Feeders Voltage with high PV



## How is this solved today?

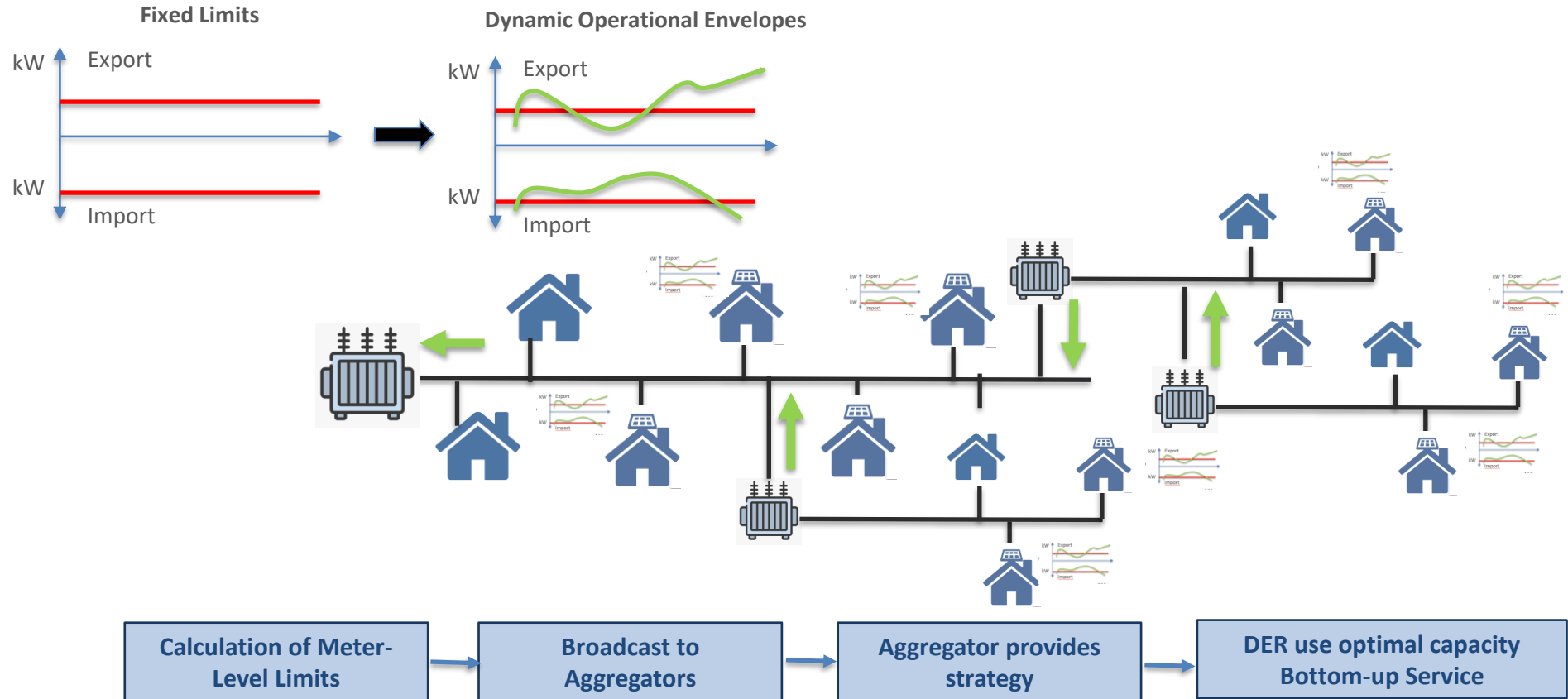
Enhanced Grid Codes (home/community BESS)

Using PV Smart Inverter functions

Voltage Regulating Devices

Fixed Export Limits

# Distribution Grids with high RE penetration: Operational Envelopes

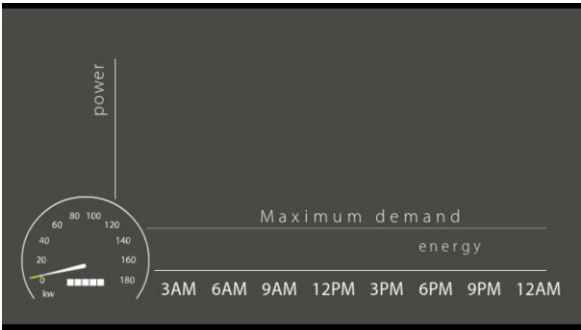
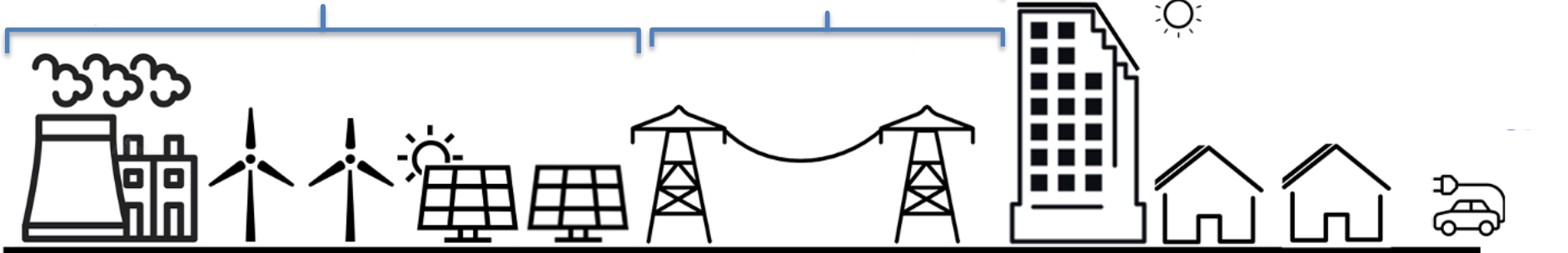


# Battery Energy Storage Systems

Arbitrage  
Capacity Firming  
Curtailment Minimization

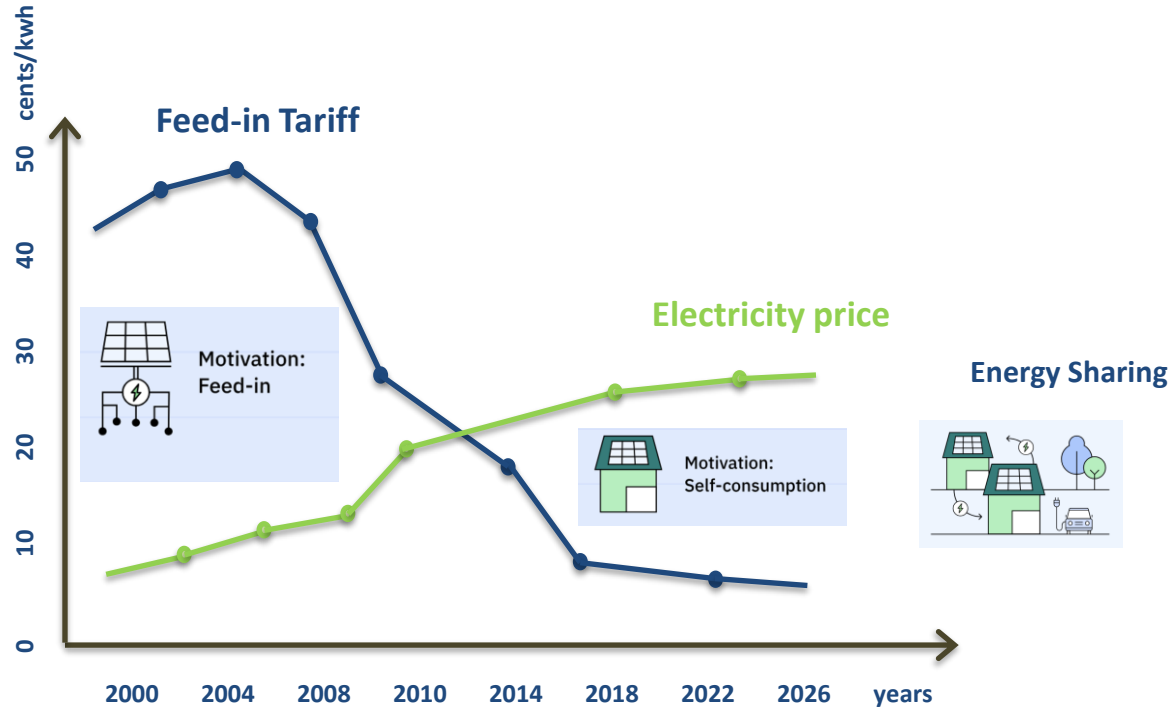
Frequency Control & Stability  
Voltage Control  
Investment Deferral

Peak Shaving  
Time-of-Use energy cost management  
Continuity of energy supply



# New Business Models for Digital and Clean Energy Systems in SRL

## From Feed-in to Self-Consumption to Energy Sharing



### Emerging Business Models

Aggregation

Virtual Net Metering

Community Solar

Energy as a Service

Virtual Power Plants

Green Bonds

## ***ADB Support to address Digitalization of Grids in Sri Lanka***

*In Sri Lanka, ADB is leading a holistic effort to digitalise, increase RE share, enhance technology, processes and institutions in order to enable a clean and secure electricity system for the future*



**Jaimes Kolantharaj**  
*Principal Energy Specialist.*  
*Energy Sector Office*  
*Sectors Group*  
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# Key Transformations in Power System

## Generation



*Regulated Generation Plants*  
*Synchronous Generators*  
*Dispatchable Energy*



*Variable RE Generation (VRE)*  
*Inverter Based Systems (IBS)*  
*Non-Dispatchable Energy*

## Networks



*Centralized Generation Plants*  
*Directional Power Flows*  
*Passive Distribution Networks*  
*Centralized Energy Storage*



*Distributed Generation*  
*Bi-directional Power Flows*  
*Active Distribution Networks\**  
*Distributed Energy Storage\**



## Business Models



*Ownership Models*



*Market / Service Oriented Models\**

## Utilization



*Consumers*



*Prosumers*

*Electric Light and Power*

*Electric Light, Power and E-mobility*



Digital framework an essential requirement.

\* Presently not available in Sri Lanka

# Digitalization and Green Energy Transition: Challenges & Strategies

Renewable Energy  
Sources



RE Grid  
Integration

Transparency and  
Competition

## Key Challenges

Intermittency  
Uncertainty  
Inverter  
Characteristics  
Network Flexibility

Limited transparency  
in Investments  
Limited Competition  
Static Energy  
Markets

## System Impact

Reliability Issues  
Stability Issues  
Bi-directional power flows  
in distribution networks  
Voltage and Frequency  
Regulation  
System strength and inertia

High RE Prices  
Reduced RE deployment

## Solutions

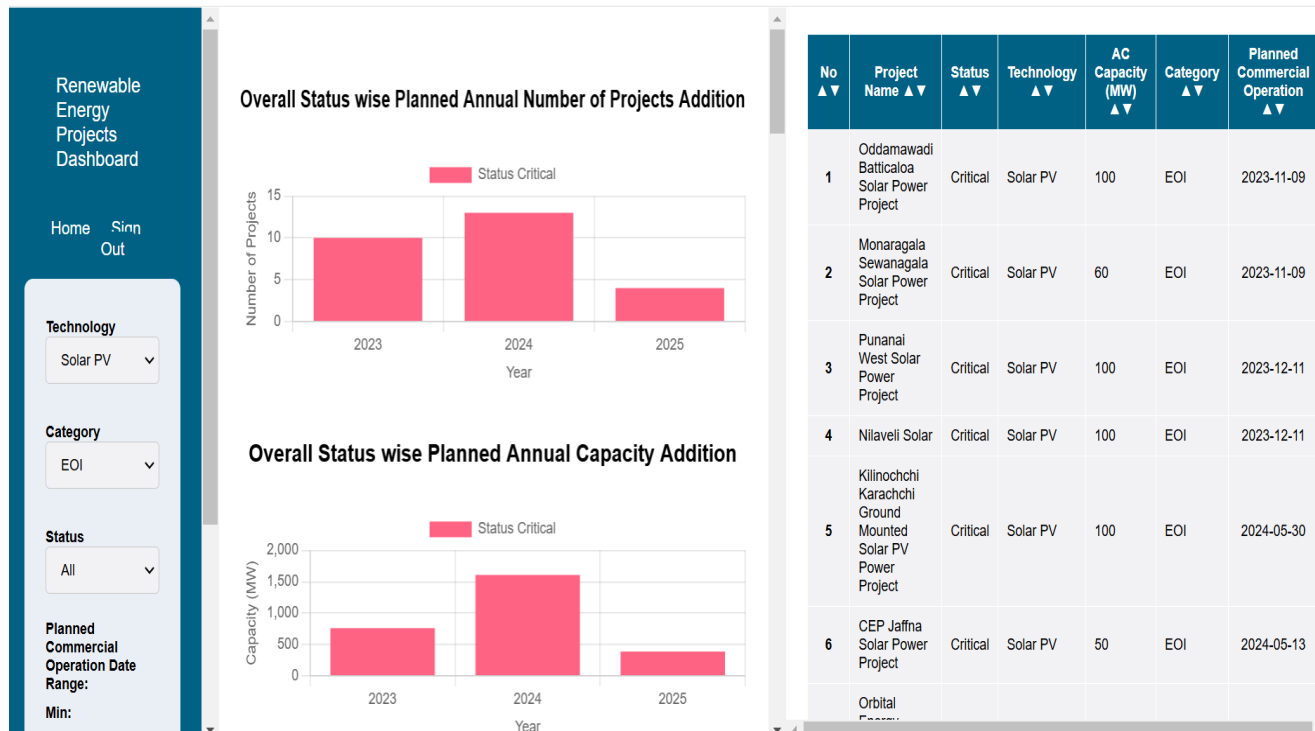
Short Term, Medium /  
Long Term Strategies  
No quick fix  
Develop a time-based  
approach for  
systematic  
implementation

Access to RE project  
info to stakeholders  
Establish Competitive  
Energy Markets /  
Business Models



# Digitalization and Green Transition: Critical for Competitive Market & RE

## Immediate Interventions: Transparency in Investments and its Monitoring



## Renewable Energy Dashboard

- Online Monitoring Tool
- Provide Access to relevant stakeholders

### ADB Support:

- RED is ready for Monitoring
- Installed in SLSEA server
- Request MOE Support in Publishing

## Immediate Interventions: Digitalization framework



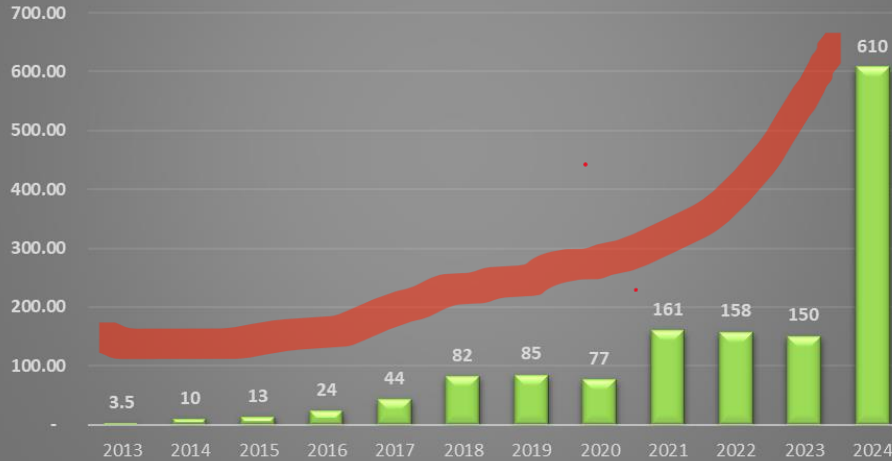
- Develop Policy and Roadmap
  - Create Clear Guidelines for future entities
  - Follow international Best Practices
- 

### ADB Support:

- Draft framework being prepared working with various stakeholders
- **Urgent action required to implement the immediate Interventions**

# Generation Scenario in SL : Critical Need for Digitalization

Rooftop Solar Growth Trend



**2024 Rooftop Capacity : 600 MW**  
**Total rooftop Capacity : 1,420 MW**

GENERATION STATISTICS

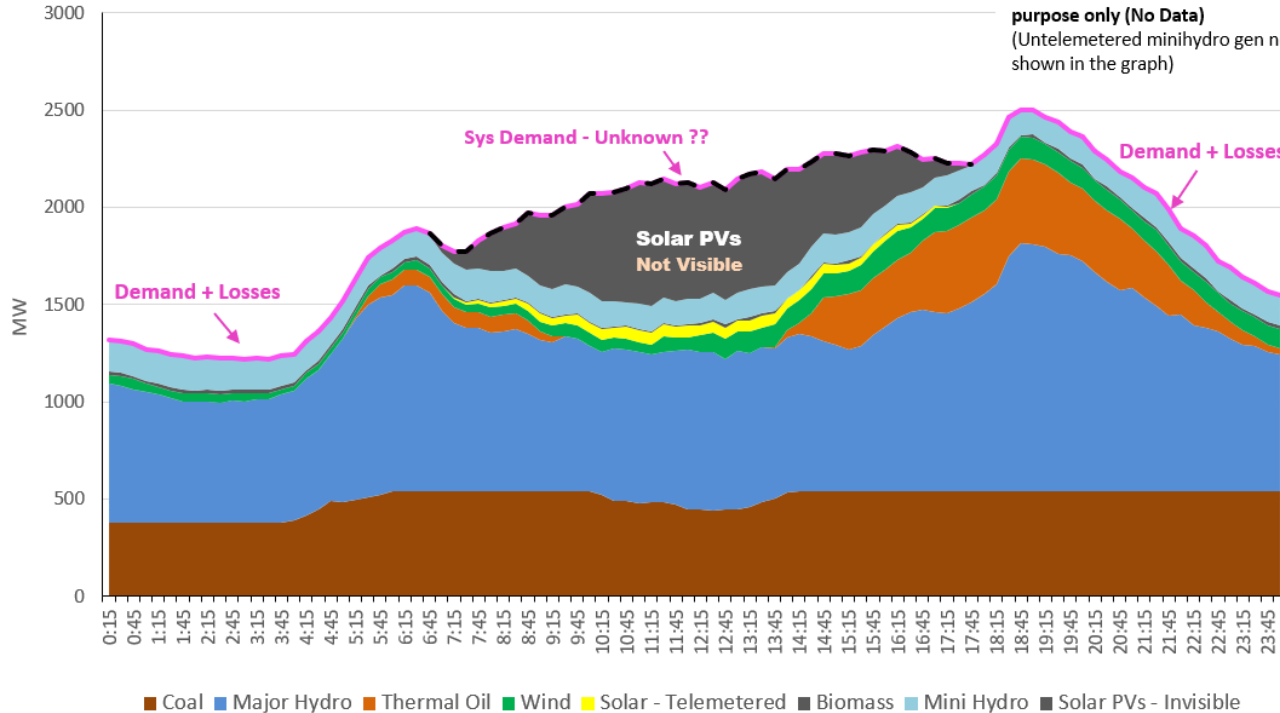
Ownership & Type of Power Station		No. of Power Stations			Installed Capacity (MW)		
		2022	2023	% Change	2022	2023	% Change
<b>CEB :</b>	<b>Total</b>	30	30	-	3,071	3,218	4.8%
	Major Hydro	18	18	-	1,413	1,413	-
	Thermal (Oil)	10	10	-	654	801	22.5%
	Thermal (Coal)	1	1	-	900	900	-
	NCRE (Wind)	1	1	-	104	104	-
<b>IPP :</b>	<b>Total</b>	321	334	4.0%	1,013	1,163	14.8%
	Thermal (Oil)	1	3	200.0%	270	387	43.2%
	NCRE (Mini Hydro)	211	212	0.5%	414	419	1.3%
	NCRE (Wind)	17	19	11.8%	148	163	10.1%
	NCRE (Other)	14	14	-	50	51	7.9%
	NCRE (Grid Connected Solar)	78	86	10.3%	130	139	6.9%
<b>Total</b>		351	364	3.7%	4,084	4,381	7.3%

**Rooftop solar installed capacity is about 25% of the installed capacity**

# Generation and Demand Curve: Critical Need for Digitalization

Example Generation and Demand Curve  
20 Jan 2021 (Normal Weekday)

Source : CEB & PUCSL  
Black Region (Solar PVs) :  
Added by ADB for illustration  
purpose only (No Data)  
(Unmetered minihydro gen not  
shown in the graph)



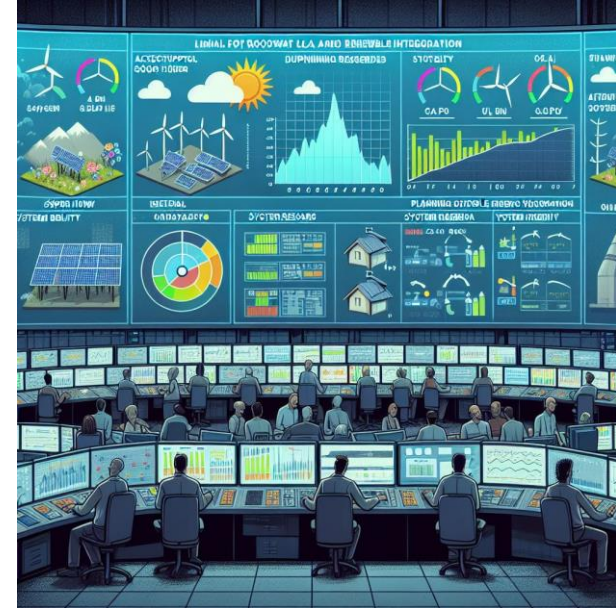
- Over 50% of day-time demand will be met through distributed RE
- No Visibility
- Limited predictability
- Limited Control
- Reduced system strength and inertia
- Constraints on economic dispatch and maintaining system stability

# Challenges in Power System Operation : Need for Digitalization



**Limited Visibility**  
**Limited predictability**  
**Limited Control**

**VS**

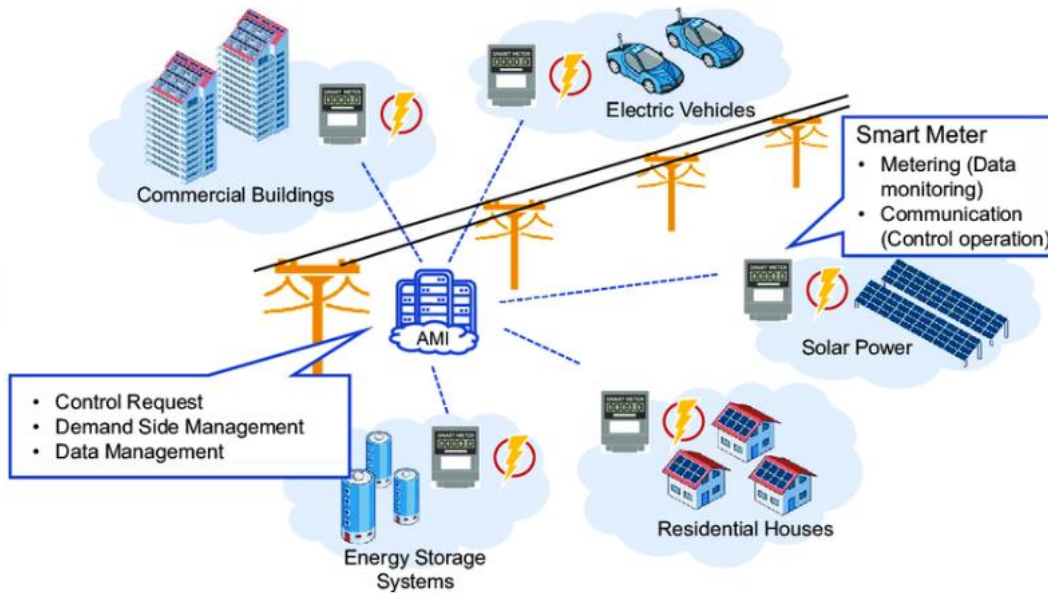


**Power Grid**  
**Digital-Twins**

**Full Visibility**  
**High predictability (AI driven)**  
**Flexibility and Control**

# Digitalization and Green Transition: Critical for Competitive Market & RE

## Immediate Interventions: Automatic Metering Infrastructure (AMI)



Smart metering configuration and functionalities.

- Smart Metering ++
- Key and first step of Digitalization
- Progressing Slow

### ADB Support:

- Roadmap for AMI implementation (Draft Prepared)
- Urgent action is required to implementation

## 1 Immediate Intervention: Voltage Response Settings for PV Inverters

- Current Situation : Over voltage Tripping in LV networks with high rooftop solar penetration
- Reduced PV Utilization and hosting capacity

### ADB Support:

- Committee has been formulated to recommend Voltage Response settings within the current statutory limit (230+/-6%)
- Urgent action is required for its implementation (new installations and Old ones)

## 2 Next step: Increase Statutory Voltage limit to 230+/-10%

- Current Situation : This is being followed in countries Like Australia and Germany complying with international standards.
- Further consultations with Sri Lanka Standards Institution and other stakeholders are required
- Committee shall continue to work towards it.

# NSO Modernization and Digitalization:

## Immediate to medium Term Interventions:

### 1 Renewable Energy Center (REC) for NSO Operations

- Immediate: Prepare technical specifications covering modern technologies and international best practices including AI-DT (digital Twinning)
- Medium: Investment to support development of REC

### 2 Battery Energy Storage Solutions (BESS)

- Immediate: Prepare technical specifications and bid documents for Grid Scale BESS
- Identify BESS requirements in distribution system to manage power quality issues and improve hosting capacity
- Medium: Investment to support deployment of BESS

ADB Recently approved Loan has allocation to support both development of renewable energy Center and Grid scale BESS



# ADB's Support on Futuristic Digitalization and Distributed Generation

## Digital Microgrid Pilot with Universities

**Project :** AI-Powered Microgrids to Enable a Futuristic and Reliable Distributed Renewable Energy System

**Implementing agencies :** LECO

**Design Team:** UoJ, UoM, UoP, UoR

### **Key Outputs :**

Develop, Establish and Pilot Test ; (a) Digitilization-framework for microgrids (b) AI-based network management platform (c) Lifeline power market through Microgrid (d) Enhancing PV hosting capacity through BESS and Voltage Regulating Equipment

**Status :** In Progress

## Network Upgrading to facilitate RE, Grid Scale BESS, RE Control Centre and Virtual Net Metering

**Project :** Power System Strengthening and Renewable Energy Integration Project

**Implementing agencies :** CEB, LECO

### **Key Outputs :**

(a) Tx and Dx grid development and modernization to facilitate RE integration (b) **Implement Grid-scale battery energy storage system (50 MWh)**( c) **Establish Renewable Energy Control center**

**Status :** In Progress

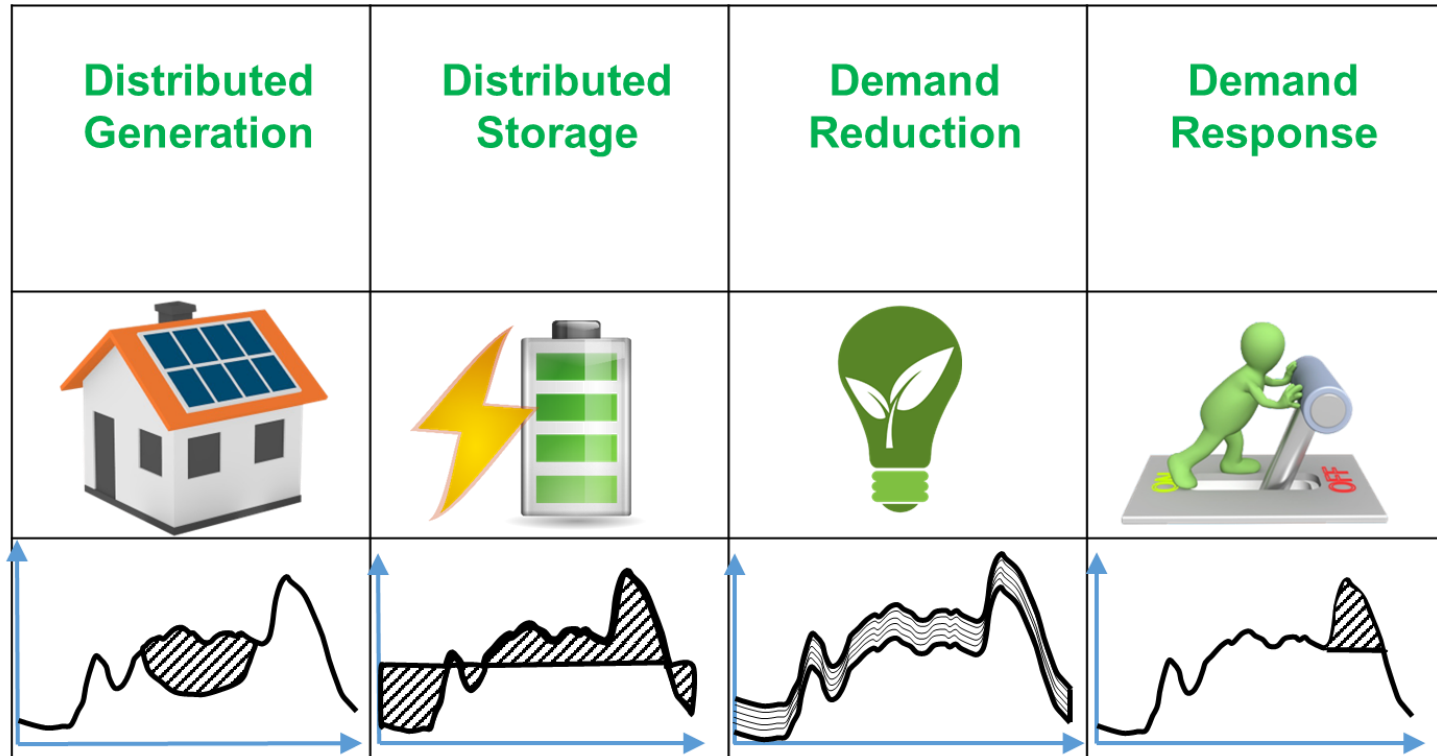
**Project :** Virtual Net Metering Project (concessional loan and grant funding)

**Key Outputs :** (a) **Virtual Net-Metering System** to develop a utility-driven aggregator rooftop PV business model (b) **Establish Social Compensation Electricity Pool** through VNM

**Status :** Being Processed ( Support from EU and JFJCM)

# Digitalization : Critical for future Distributed Generation

The Outcomes of DIGITALIZATION is Critical for Distributed Generation:



Thank You