



# UI-ASSIST: ONLINE MINI WORKSHOP

## THEME 7

### DSO MARKETS AND REGULATORY ISSUES

21<sup>ST</sup> - 24<sup>TH</sup> JULY, 2020



U.S. INDIA COLLABORATIVE FOR SMART  
DISTRIBUTION SYSTEM WITH STORAGE

*Evolving future energy distribution grids*  
[www.uiassist.org](http://www.uiassist.org)

## Theme-7: DSO- Market and Regulatory Issues

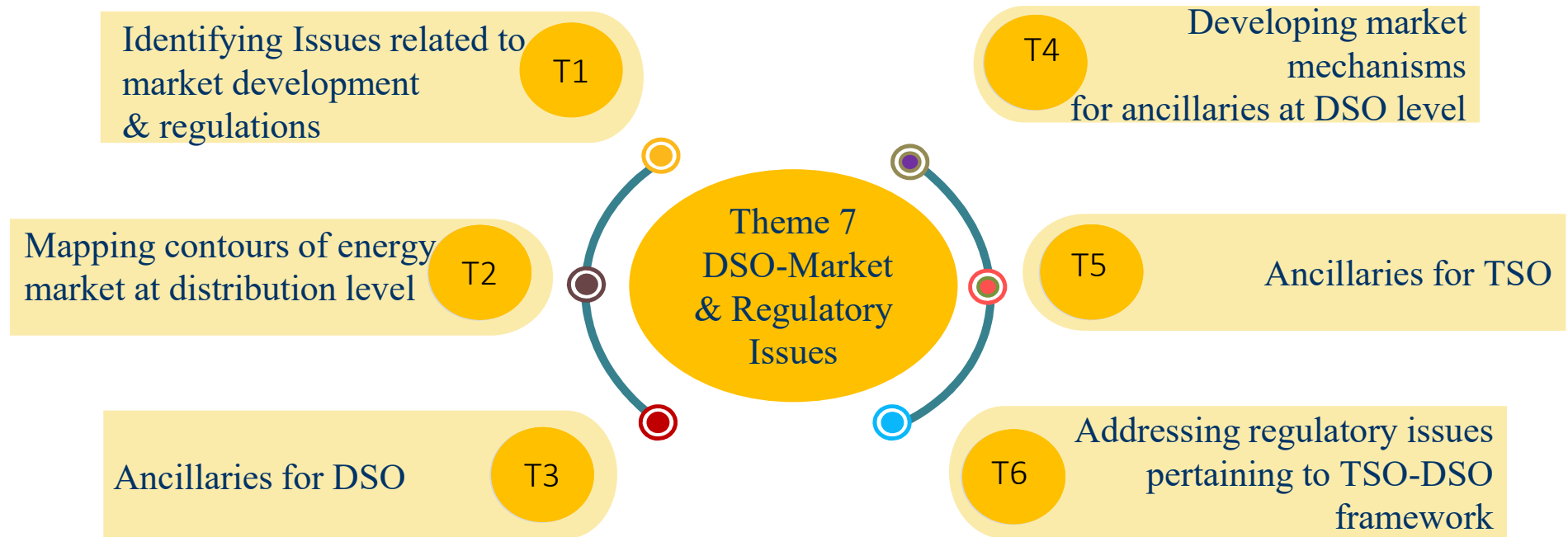


### Indian Collaborators and Co-leads

		
Indian Institute of Technology Delhi (IIT Delhi)	The Energy and Resources Institute (TERI)	Indian Institute of Technology Kanpur (IIT Kanpur)
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**BRPL, CES, IIT Roorkee, PGCIL**

# Theme 7: Objectives



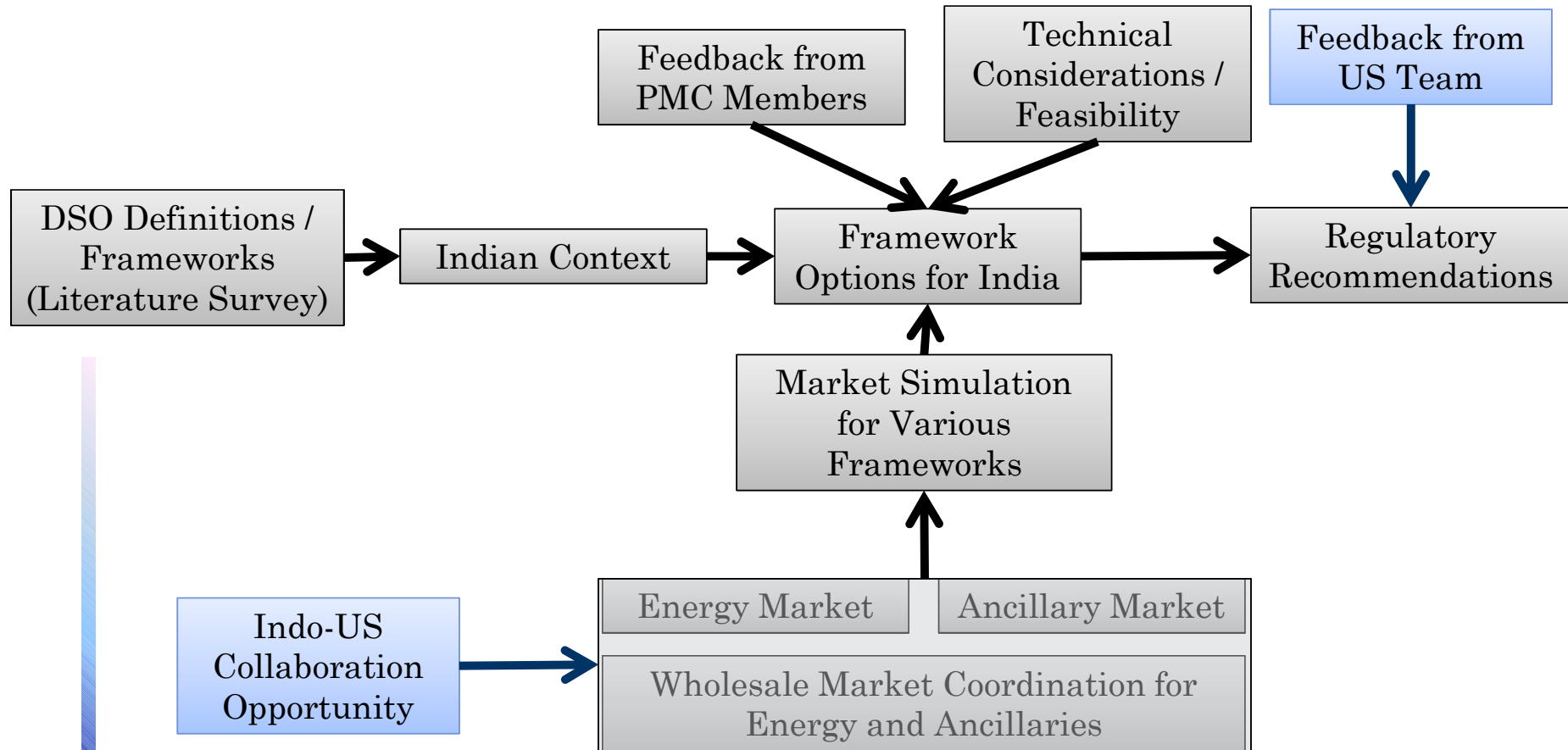
## Theme 7: Status



Task No	Task Objective	Description	Deliverables planned	Status of Work
T1	Survey of literature and practices	Identifying Issues related to market development & regulations, pertaining to distribution systems and its elements	A background paper that provides overview of DSO definitions and activities based on study of literature and industry practices	100%
T2	Mapping contours of energy market	Mapping contours of energy market at distribution level; market design, framework including various timelines and modalities involved, Alternative DSO models	<ol style="list-style-type: none"> <li>1. A research cum white paper suggesting role, activities, model and regulatory framework for DSO in Indian context</li> <li>2. Webinar on possible Indian DSO models</li> <li>3. Research papers on market model simulations</li> </ol>	60%
T3	Ancillaries for DSO	Developing various ancillary products arising out of integration of battery storage systems and micro-grid	Research papers in journals of international repute	20%
T4	Markets for DSO ancillaries	Market design for ancillaries at DSO level	<ol style="list-style-type: none"> <li>1. Research papers in journals of international repute</li> <li>2. White paper suggesting possible market models in Indian context</li> </ol>	10%
T5	Ancillaries for TSO	Frequency regulation ancillary services provided by battery storage systems	Research papers in journals of international repute	0%
T6	TSO-DSO transactive framework	Regulatory framework for TSO-DSO transactive model in Indian context	<ol style="list-style-type: none"> <li>1. A white paper</li> <li>2. Research papers in journals of international repute</li> </ol>	10%

### Theme 7: DSO Market and Regulatory Issues

## Theme 7: Flow of Activities...



# Theme 7: In this presentation...



## Regulatory

1. DSO in India – Considerations...
2. DSO Functionalities in India
3. Approach

## Market

1. Retail Market Simulation with Heterogeneous Players
2. Coordinated Market Framework
3. P2P Trading of Rooftop Solar Energy

# Theme 7 - DSO Definition/s in Indian Context



A DSO in India can be defined as an entity that can securely operate and develop active distribution network, balance the accommodation of higher penetration levels of variable REs as well as penetration of EVs in the distribution network along with the provision of flexibility services.

## Flexibility at distribution level in India



Who could perform the new roles?  
Is the DISCOM capable to perform the new roles?  
or need new entity namely DSO?

Deployment of DER in the distribution network necessitates- Appropriate planning to avoid unbalance and peaking effect in the electricity network

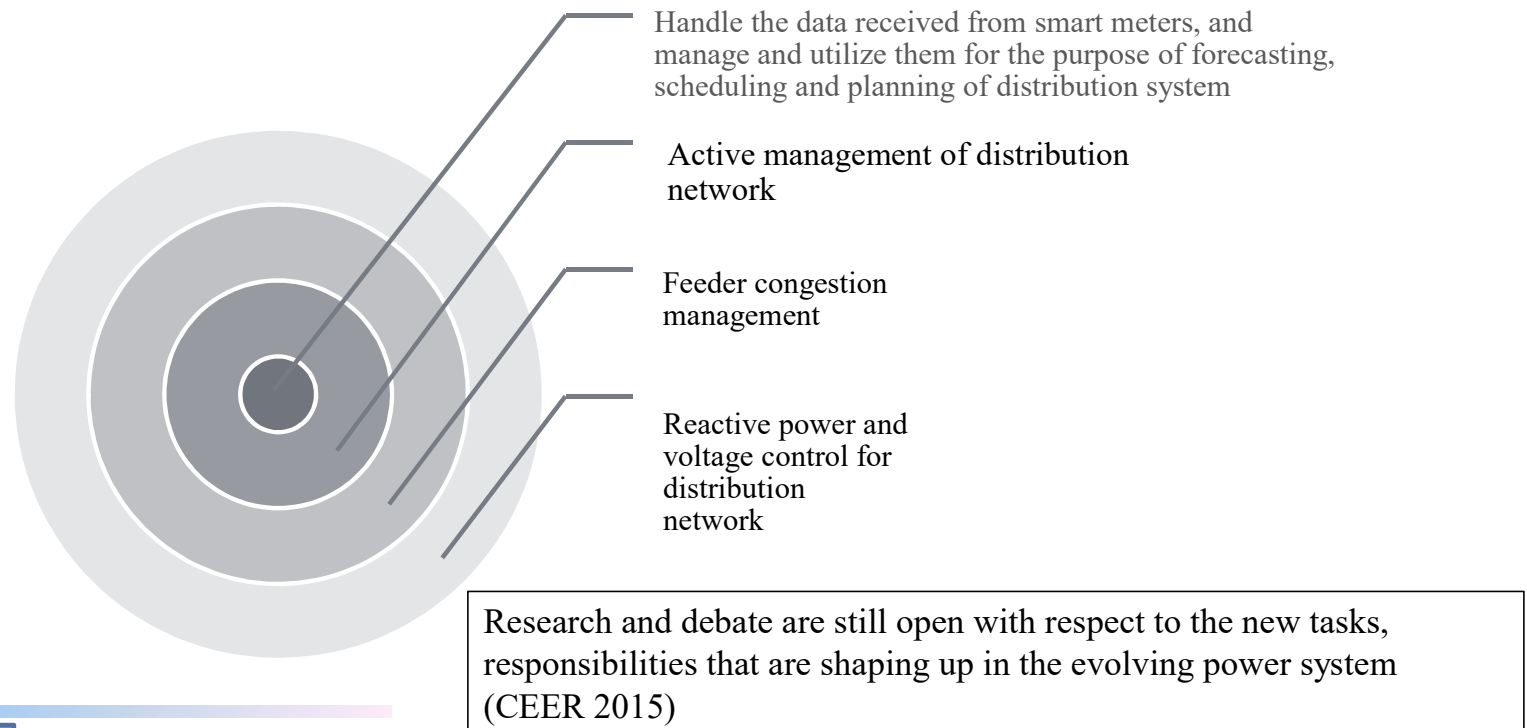
Therefore, in India, traditional roles and responsibilities of DISCOMs are going to change considerably in near future

This can create new opportunities for DISCOMs and emergence of new business models

## Theme 7 - DSO in India – Various Functionalities



- ❖ The role varies from country to country mainly due to variations in national regulation, ownership structure, climate and geography







## Theme 7 - How India can approach?

- ✓ Based on international learning India's DISCOMs will require a new cultural mindset and partnership models
- ✓ Investment in tools, people and infrastructure is needed within the next few years
- ✓ DSOs will need to co-design relevant and value-creating markets, in which all network customers can connect and exchange energy services.
- ✓ It will be a phased journey to the future energy system
- ✓ In order to successfully implement DSOs, it is of utmost importance for the industry to develop a vision of how DSOs will operate and a tool that can support the design of complex DSO functions

### Phase I

- Investment in active network devices
- Upgrading network assets to handle large reverse flows of power
- Evaluate and plan for their likely impact on network

### Phase II

- Investment in digital solutions and in technology
- Develop communication protocol
- Improve communication with consumers

### Phase III

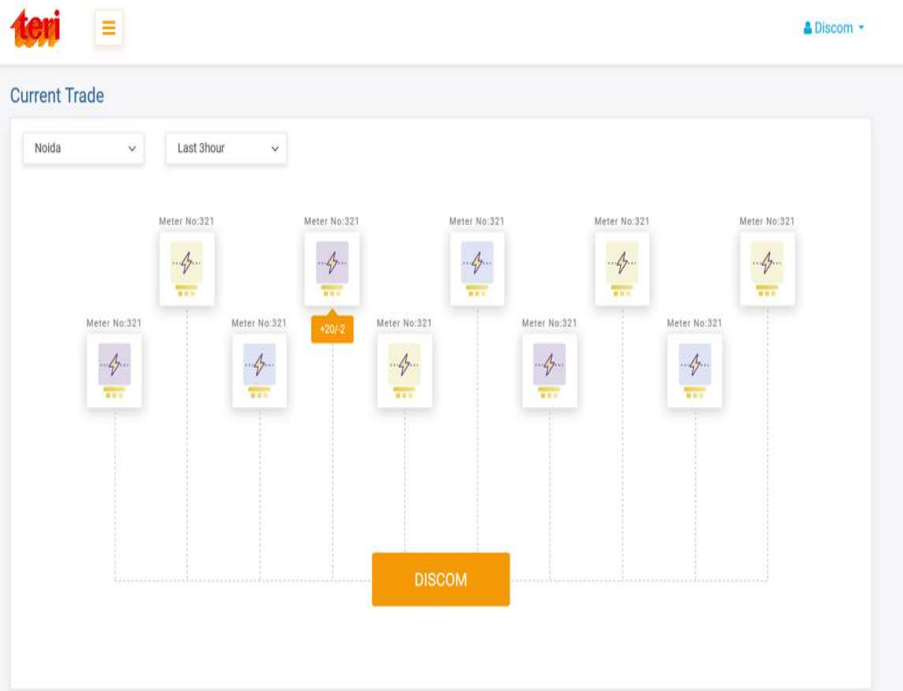
- Market facilitation
- Regulations to mandate implementation of smart grid infrastructure
- Defining rules for DSO-TSO co-ordination between transmission and distribution system operators

## Theme 7: P2P Trading of Rooftop Solar Energy

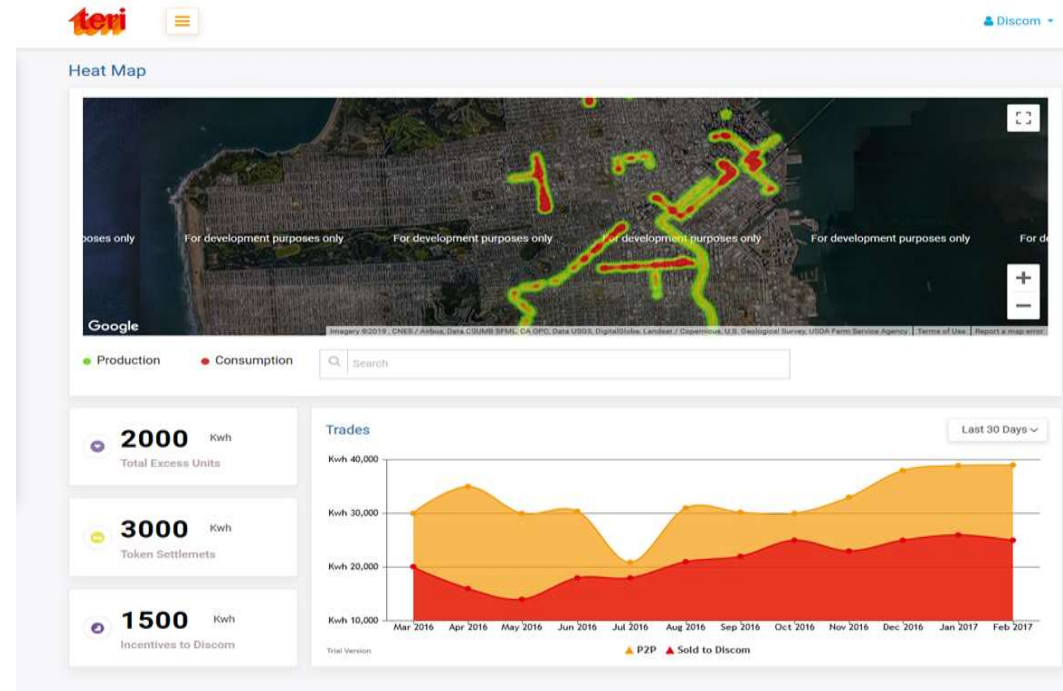


- Local energy markets – one of the stepping stones towards evolution of DISCOMs into DSOs
- Peer to Peer (P2P) sharing/trading of excess rooftop solar PV electricity among consumers can unlock one of the most potent demand flexibility options for a DSO
- A Proof of Concept (PoC) was prototyped for demonstrating community-level energy sharing in a DISCOM service area
- Blockchain enabled software platform was developed and various pricing mechanism including cooperation game theory based were evaluated
- Such a platform can enable a future DSO to perform its role of optimizing locally available RE assets for demand-supply balance at the local level and to provide demand flexibility and also administer demand response programs
- DISCOM was made the central entity and one of the ‘nodes’ on the platform
- Concept of energy tokens with a secure energy sharing mechanism was showcased

# Theme 7: Blockchain based P2P Energy Sharing Prototype

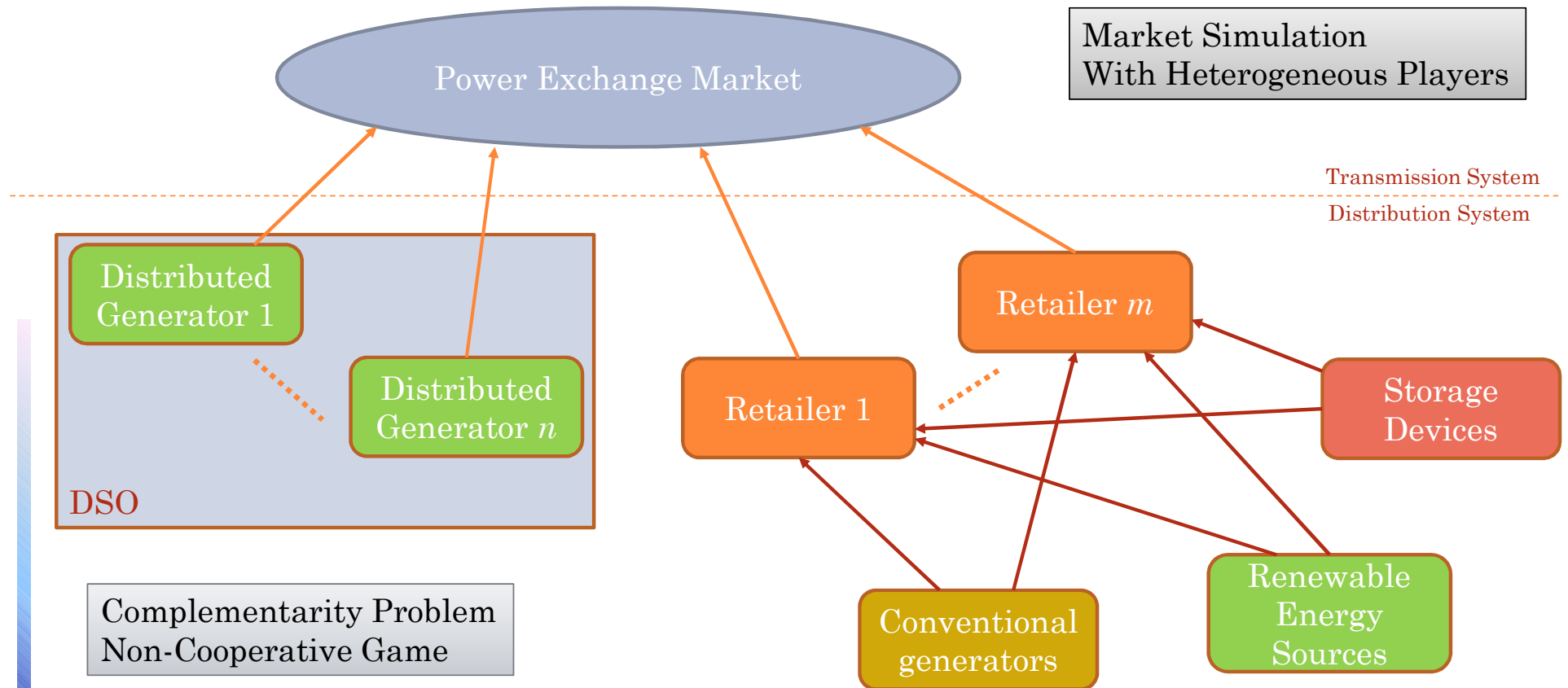


Platform screenshot showing number of subscribers



Dashboard displaying analytics

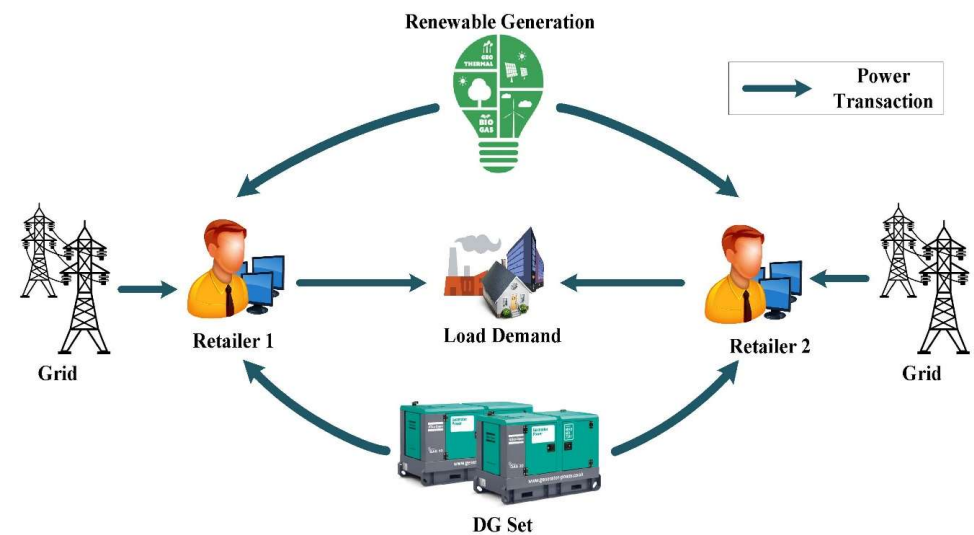
## Theme 7: Retail market Simulation with heterogeneous players



# Retail market with heterogeneous players: Example



- Number of players=4
  - Player 1 & 2 - Retailers,
  - Player 3 - Renewable generator,
  - Player 4 - DG set.
- Action: Each player's set of actions is the set of its possible outputs (nonnegative numbers).
- Objective: Maximization of individual player's profit
- Nature of game: Non-cooperative Game



Four player non-cooperative game

Network Compliance is a must!

## Theme 7: Coordinated Markets for Electricity Commodities

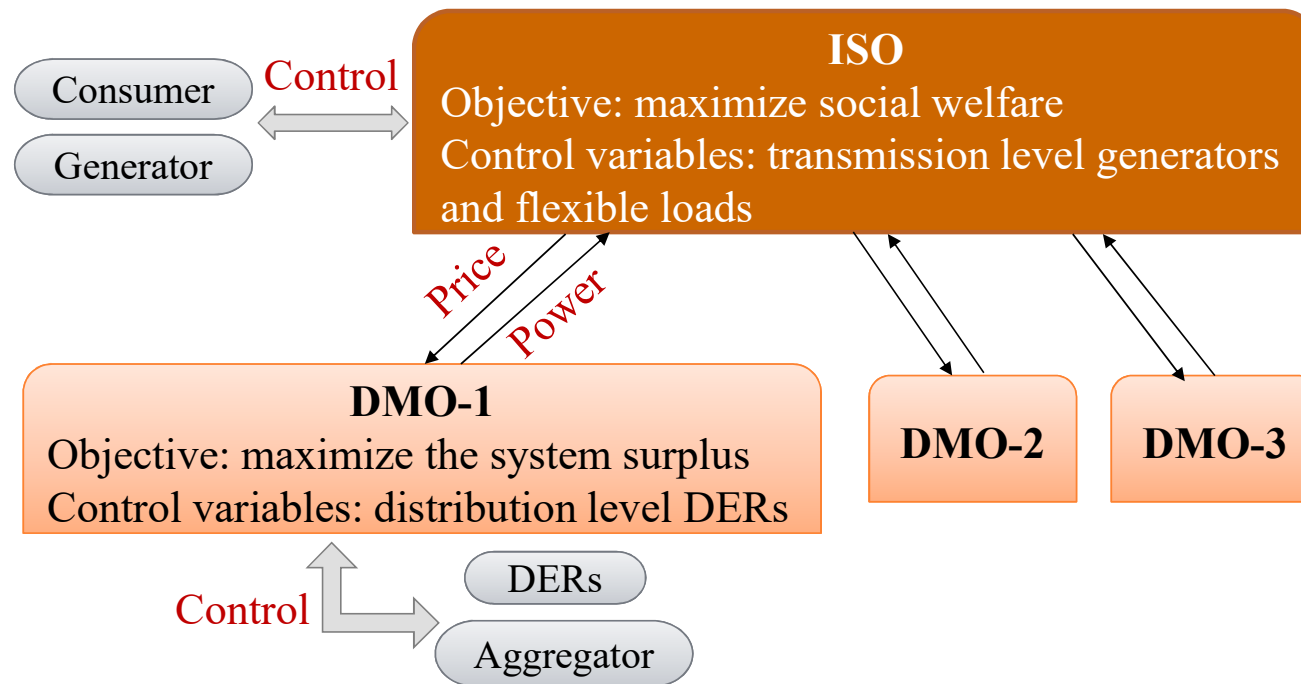


- Setting up a coordinated market framework for an integrated transmission-distribution system:
  - DERs –key drivers in making distribution system active
  - DMO - distribution market operator takes charge of the dispatch of all the DERs.
  - ISO to coordination with all the DMOs – efficiency (market and operational)
  - Essence of coordination - Exchange of boundary power flows and control signals,



# Theme 7 – Coordinated Market Framework

Interaction between ISO, DMO, energy resources and consumers





# Theme 7: Coordinated Market Framework

## Conventional ISO problem:

$$\max_{\substack{P_{g,i} \\ P_{d,i}}} \sum_{i \in \mathcal{N}^{fl,A}} U_i(P_{d,i}(t)) - \sum_{i \in \mathcal{N}^g} C_i(P_{g,i}(t))$$

subject to network constraints and line flow constraints

- Here, DSs are considered as flexible loads, that provide energy bid and price to ISO.
- While in our proposed scheme DSs are treated differently to provide DMO a chance to effectively and economically utilize its resources.

## ISO sub-problem:

$$\max_{\substack{P_{g,i} \\ P_{d,i}}} \sum_{i \in \mathcal{N}^{fl}} U_i(P_{d,i}(t)) - \sum_{i \in \mathcal{N}^g} C_i(P_{g,i}(t))$$

## DMO sub-problem:

$$\max_x \sum_{i \in \mathcal{N}^a} \mathcal{U}_i^a(P_{d,i}^a) - \pi_a^0 d_a - \sum_{i \in \mathcal{N}^{DG,a}} \mathcal{C}_i^a(P_{g,i}^a)$$

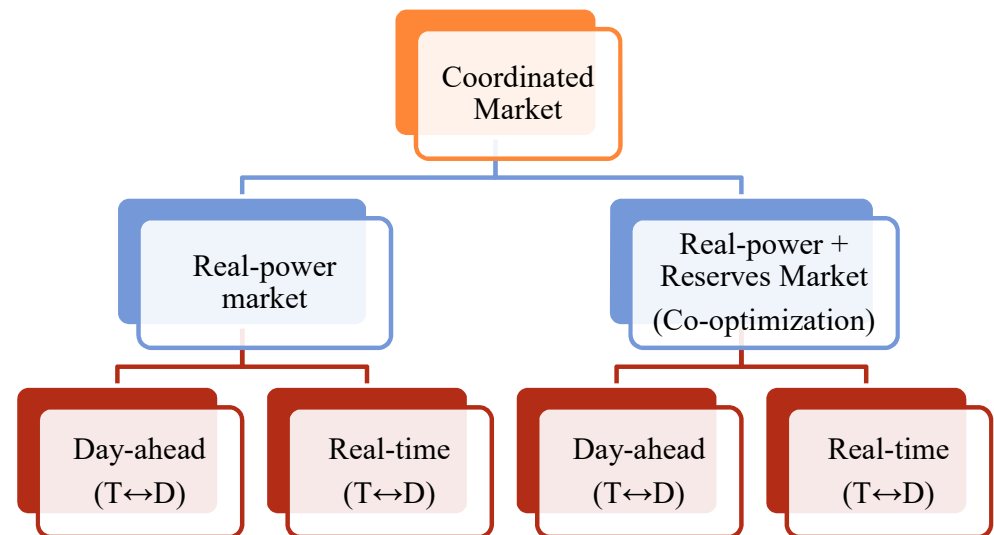


# Next Steps...



- Designing different types of market that include coordination between ISO and DMOs, to effectively utilize the potential associated with DERs.
- To study various possible ways of interaction between ISO and DMOs to attain a certain social objective.

## Coordinated Market Models



IIT Delhi is collaborating with MIT on this particular topic

# Theme 7: Objectives & Deliverables



Objective	Deliverables	
	DSO	Consumer
Adoption of new technologies	Risk averseness: CAPEX vs OPEX model	<ul style="list-style-type: none"> <li>• Appliance scheduling</li> <li>• Demand response</li> <li>• Control over energy consumption</li> </ul>
Energy management as a system (Micro-grid) and individual (P2P)	<ul style="list-style-type: none"> <li>• Energy trading in decentralized market</li> <li>• Balance management &amp; settlements</li> <li>• Energy forecasting &amp; planning</li> </ul>	<ul style="list-style-type: none"> <li>• Energy consumption, production and storage</li> <li>• Access to green technologies (EV/RES)</li> <li>• Decision on energy trading (P2P/FiT)</li> </ul>

# Theme 7: Progress Updates



Objective	Progress	
	DSO	Consumer
Adoption of new technologies	NA	<ul style="list-style-type: none"><li>• A model prototype is proposed defining the optimum appliance scheduling mechanism for consumers</li></ul>
Energy management as a system (Micro-grid) and individual (P2P)	NA	<ul style="list-style-type: none"><li>• A decision making model is developed to encourage the P2P market targeting the optimization of player's revenue</li></ul>

## Theme 7: Future Tasks



### IIT Delhi

1. Developing market framework for various commodities and carrying out simulations using Game Theoretic Models for validation
2. Coordination framework for ancillaries
3. Balancing and Default Service Considerations in Market design

### TERI

1. Fine tuning P2P Block-chain based solar rooftop energy trading mechanism
2. Firming up DSO definitions and functionalities

### IIT Kanpur

1. To optimize the consumer's decision making of appliance scheduling and bill saving through DR
2. Design a future market framework for Micro-grid