Operational Coordination

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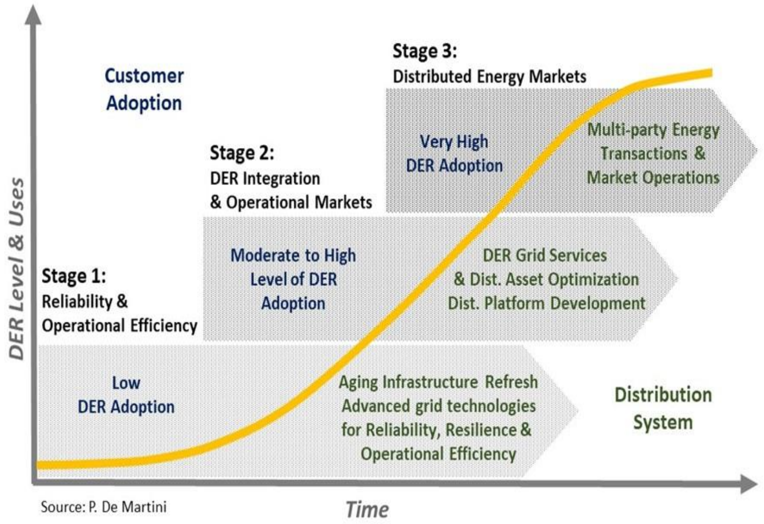
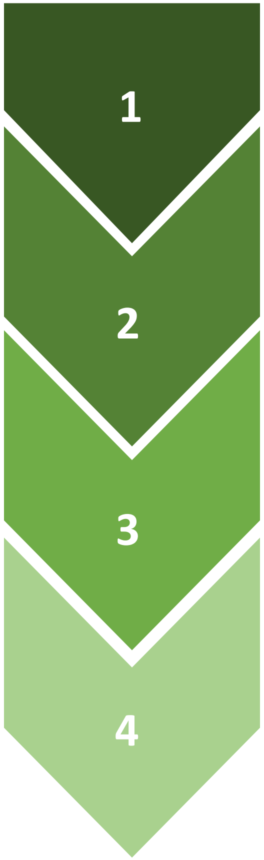
Operational Coordination

- Increasing Use of DER in Wholesale Markets (e.g., FERC 841) and for T&D Non-wires Alternatives is driving the need for greater Transmission-Distribution-Customer (TDC) Operational Coordination

- Creates industry structural changes that need to be addressed through a rigorous **Operational Coordination Architecture Model** (OCAM)



Operational Coordination Architecture Model (OCAM)



1. Identify Objectives & Capabilities
2. Document Existing/Emerging Structure
3. Develop Alternative Coordination Structures
4. Evaluate Coordination Alternatives:
    a. Operational Effectiveness/Risks
    b. Implementation Requirements & Costs

1. Identify Objectives, Capabilities & Constraints

- Identify state & federal objectives, policy and regulations driving industry structural changes
- Identify scale and timing factors
- Identify new capabilities needed to address emergent requirements identified from structural changes
- Identify any institutional and practical constraints

Capabilities
Planning
A. Scenario based, probabilistic distribution engineering analysis
B. Integrated T&D Planning
Operations
A. DER Interconnection & Grid Codes
B. Distribution Operational Engineering
C. Physical Coordination of DER Schedules
D. Distribution State Estimation
E. Operational Coordination at T-D interface
Markets
A. Sourcing Distribution Grid Services
B. Optimally Dispatch Distribution Grid Services
C. Aggregation of DER for Wholesale Market Participation
D. Operation of Distribution Level Energy Transactions
E. Clearing and Settlement for Distribution Level Transactions
F. Distribution Level Market Facilitation Services

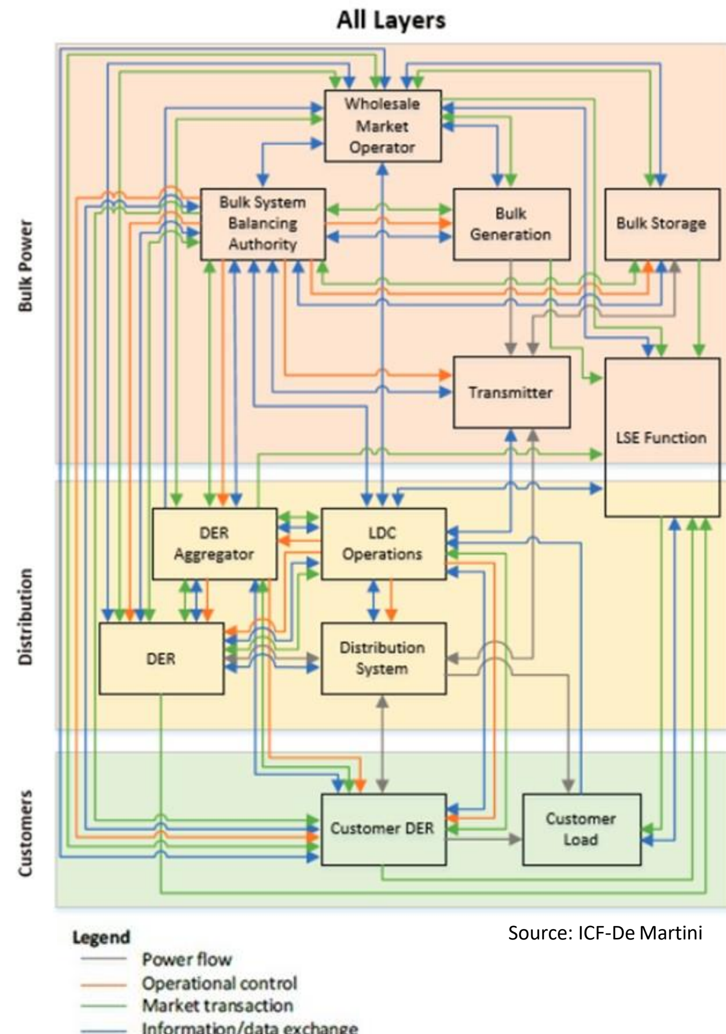
Example

Source: Adapted from De Martini – Kristov, LBNL

2. Document Existing/Emerging Structure

- Important to identify the current or emerging industry structure
- Structural diagram identifies the interrelationship of each of the principal entities as well as the roles and responsibilities
- Example shown includes power flow, operational control, market transactions and information/data exchange layers
- Additional layers can include regulatory and market oversight

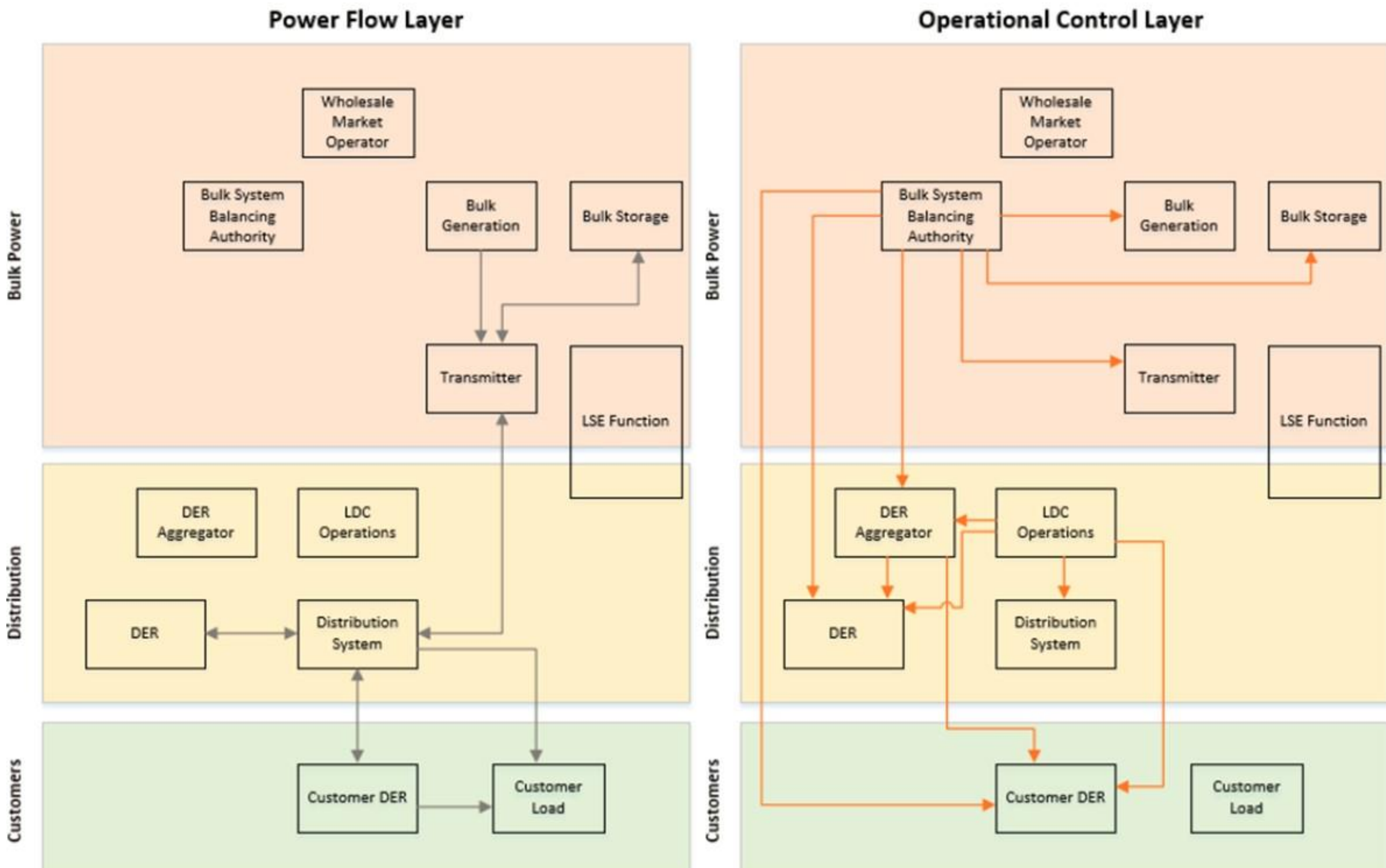
IESO Example



Source: ICF-De Martini

IESO Example

Figure 2: Ontario emerging industry structure diagram



Source: ICF-De Martini

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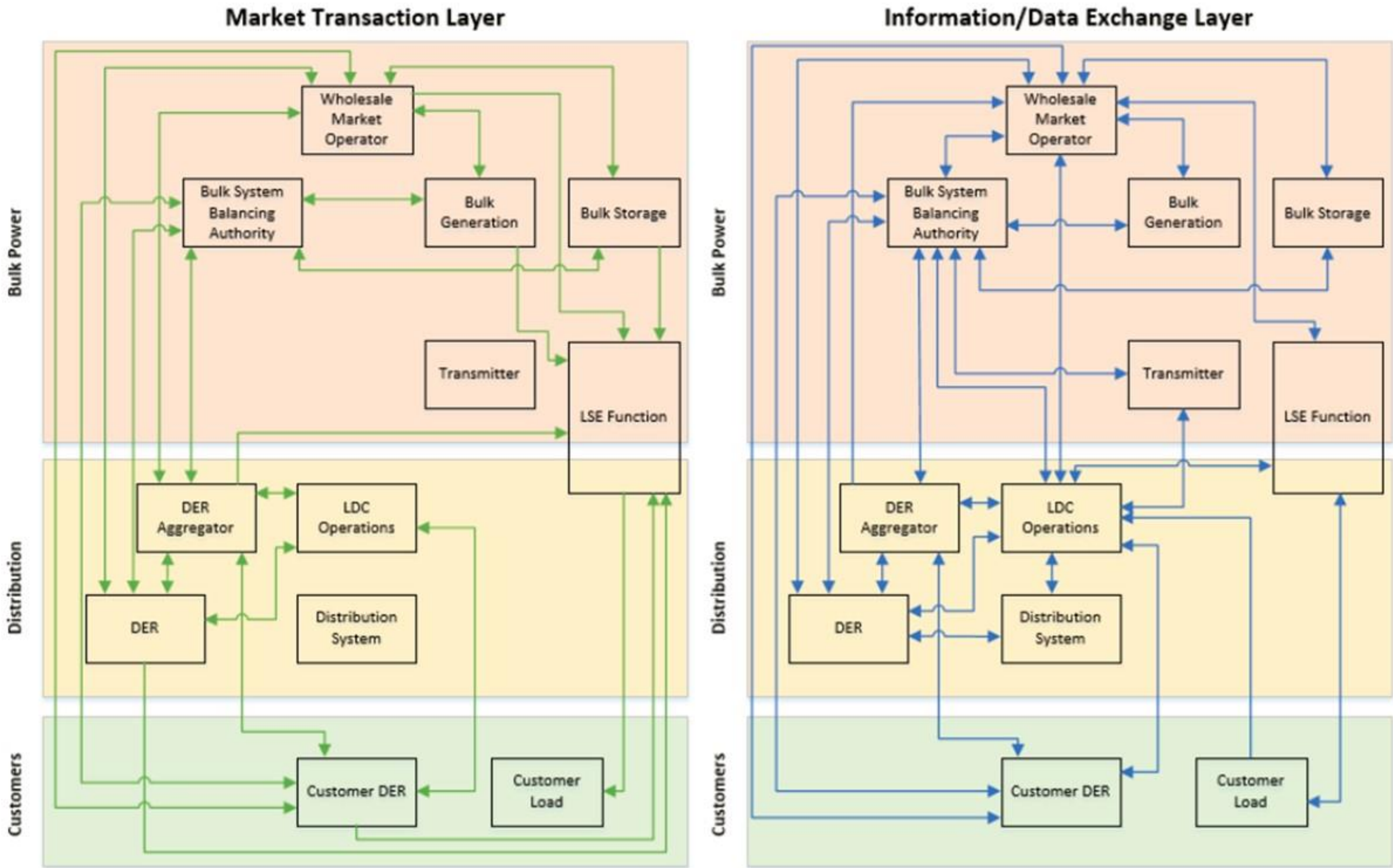
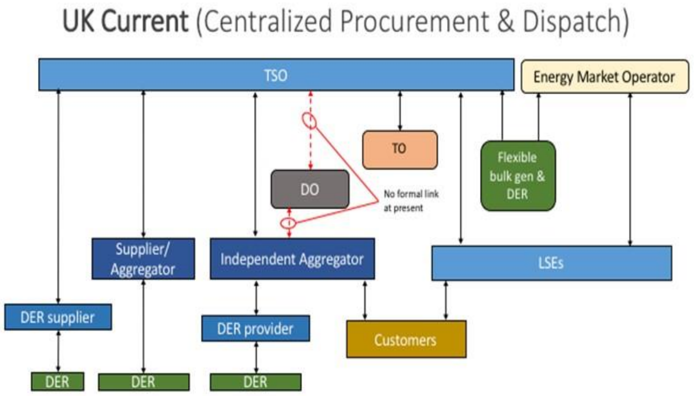
IESO Example

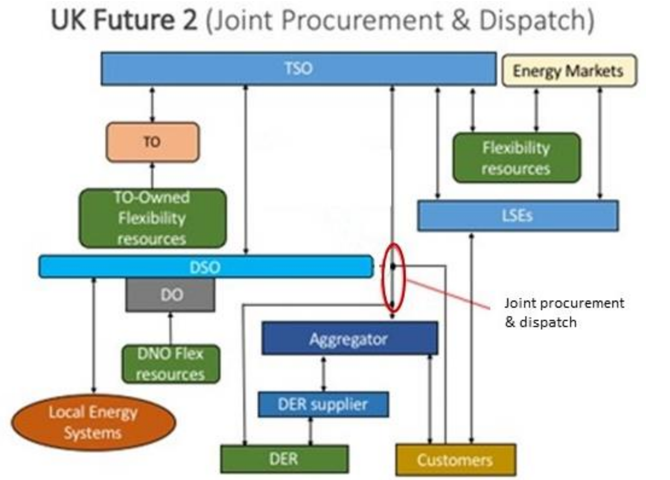


Source: ICF-De Martini

3. Develop Alternative Coordination Structures

- Develop alternative coordination structure thru stakeholder engagement
- Alternatives should address the objectives driving the needed changes, grid architectural principles and any practical constraints
- Typically more than one alternative is developed given the practical/political trade-offs in relation to ideal structures that may be required





Source: Newport Consortium for AEMO

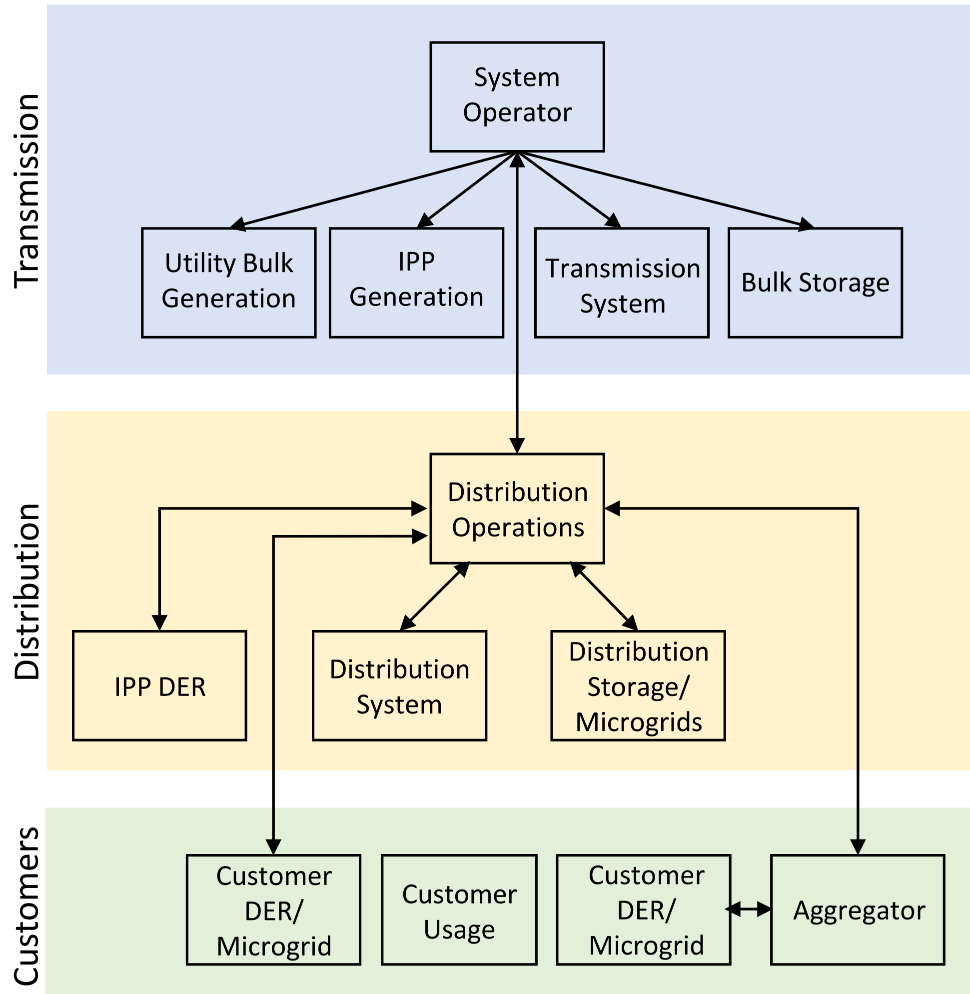
Operational Architecture Considerations

	Considerations	Description
Effectiveness	**Observability**	Function related to operational visibility of the distribution network and integrated DER. Observability needs of DSO and TSO depend on how the coordination framework is specified.
Effectiveness	**Scalability**	Ability of system's processes and technology design to work well for very large quantities of DER resources. Coordination architecture can enhance or detract from this desired capability.
Effectiveness	**Cyber security vulnerability**	Reduce cyber vulnerability through architectural structure. Structure can expose grid systems to more or less vulnerability depending on data flow structure, which depends on coordination framework.
Effectiveness	**Layered Optimization**	Large-scale optimization problems are decomposed into multiple sub-problems at discrete layers of the electric system within a coordinated structure.
Risks	**Tier bypassing**	Creation of information flow or instruction/dispatch/control paths that skip around a tier of the power system hierarchy, thus opening the possibility for creating operational problems. To be avoided.
Risks	**Hidden coupling**	Two or more controls with partial views of grid state operating separately according to individual goals and constraints; such as simultaneous, but conflicting signals DER from Customer, DSO and TSO. To be avoided.
Risks	**Latency cascading**	Creation of potentially excessive latencies in information flows due to the cascading of systems and organizations through which the data must flow serially. To be minimized.

Source: J. Taft, Pacific Northwest National Laboratory

Coordination Framework Skeleton Diagram

- Derives from Complex Industry Structure Diagram
- Focuses on key issues to address (e.g., architectural considerations)
- Use layered decomposition model (i.e. Laminar Framework) as basis for the diagrams and analysis



Source: J. Taft & P. De Martini

4. Evaluate Coordination Alternatives

a. Operational Effectiveness/Risks

- Assess Structures based on Architectural Considerations
- Clarify & Assess Role Assignments
  - Responsibility/role matching
  - Assignments cannot just be arbitrary
- Identify & Assess Control Paths
  - Physical Controls
  - Economic Signals
- Competing or conflicting objectives
  - For example, Local independent optimization vs. global coordination
- Identify & Assess Information Flows
  - Gaps
  - Feedback loops
  - Latencies

UK Coordination Models Example

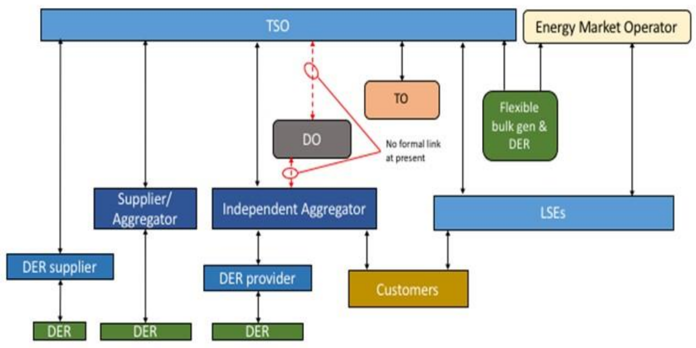
Example Grid Architectural Analysis:

UK Option 2, the responsibility for DER coordination is shared, leading to a more complicated arrangement involving these parties and the aggregators, although the sharing mechanism is not clear.

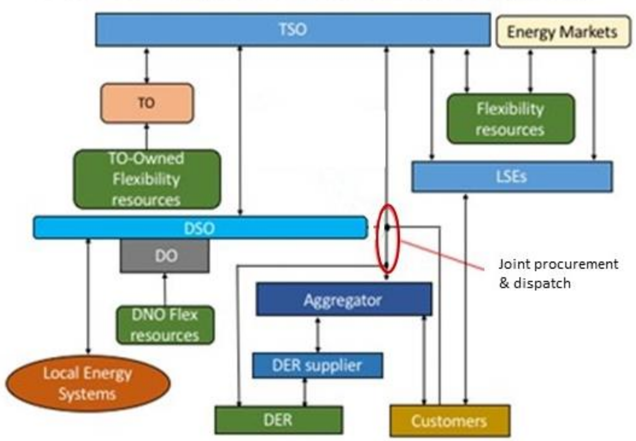
Option 2 partially **degrades the layered decomposition** structure and allows for **some tier bypassing**, although the proposed function-sharing ("joint procurement and activation") may prevent that from being an issue. This structure **increases the coupling** between the TO and DO (not hidden in this case), since the DO cannot manage the DER in its service area alone while interfacing to the TO in a modular fashion.

The joint arrangement results in **data flow complexity** involving the DO, the TO, the aggregators, the customers, and DER. This is a result of the structure shown in the red oval which comes about due to the definition of **joint roles instead of clean separation of functions**.

UK Current (Centralized Procurement & Dispatch)



UK Future 2 (Joint Procurement & Dispatch)

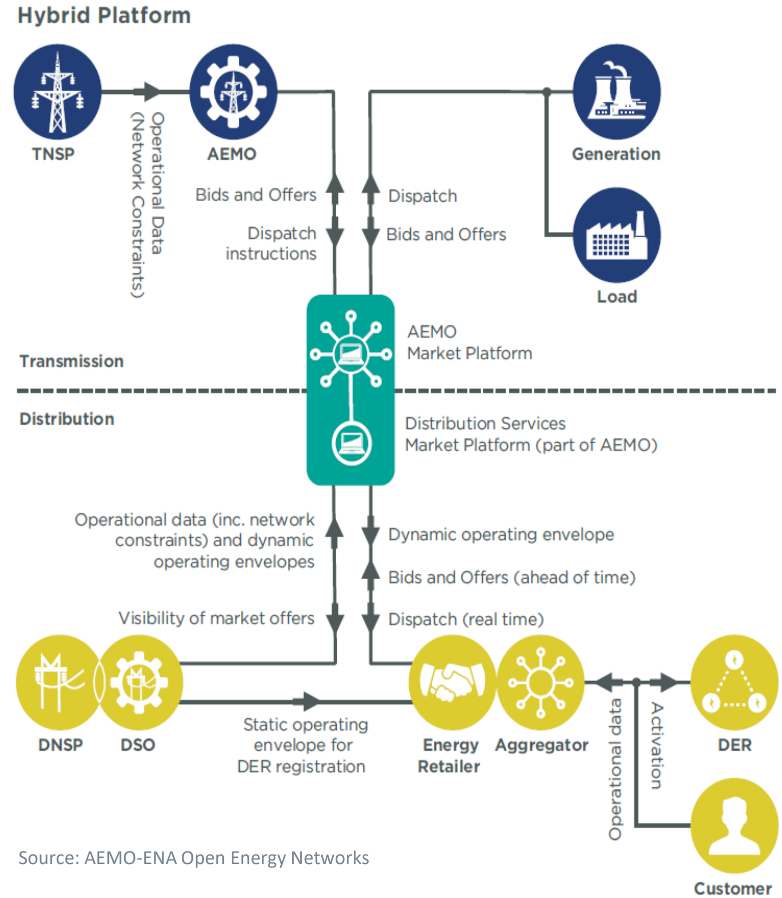


Source: Newport Consortium for AEMO

AEMO Coordination Model Example

Example Grid Architectural Analysis:
This is a TSO centric model that is proposed to only use market mechanisms for T-D coordination and distribution operational services control. Note there are **no operational or physical coordination links between the AEMO (TO) and the DO/DNSP** only market visibility.

This model **exhibits tier bypassing** due to the path from DER to aggregator/retailer to TO that bypasses the DO. In addition, the potential for **hidden coupling exists, with some aggregators and LSEs and the TO market all have dispatch potential with DERs** unless some coordination mechanism is worked out. The presence of the DER aggregator-to-TO connection also presents a moderate cyber vulnerability to the bulk energy system.



Source: AEMO-ENA Open Energy Networks

NY Coordination Models

Current & Future Models Under Discussion

Example Grid Architectural Analysis:

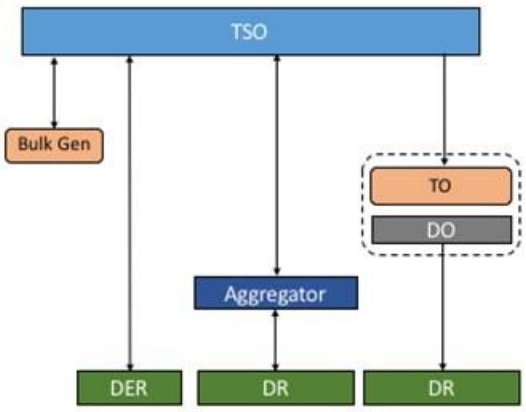
Future 2, the removal of the link between the aggregator and the NYISO creates **some of the layered decomposition** structure by **eliminating one source of tier bypassing**, but the presence of a link from DER to the NYISO **still allows for tier bypassing, hidden coupling, scalability issues, and cyber vulnerability** at the NYISO level.

Future 2, the DSP is potentially somewhat better able to manage the DER, and if coordination between NYISO and DSP is well organized, the **tier bypassing problem may be mitigated**.

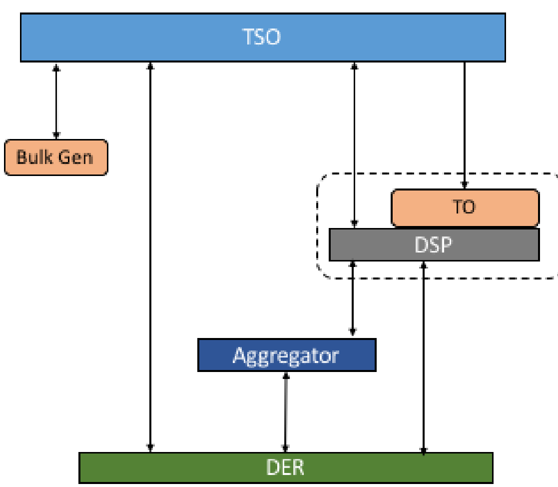
If some **DER are bidding into the wholesale markets and some into a DSP market**, for example, then the **potential for mis-coordination exists**.

The potential **ability of aggregators to participate at the NYISO level is eliminated** in this model that **reduces tier bypassing**. However, it **does not eliminate tier bypassing** as some DERs can still bypass. The **hidden coupling problem remains** but likely at a low level.

New York Current



NYISO Proposed Future 2

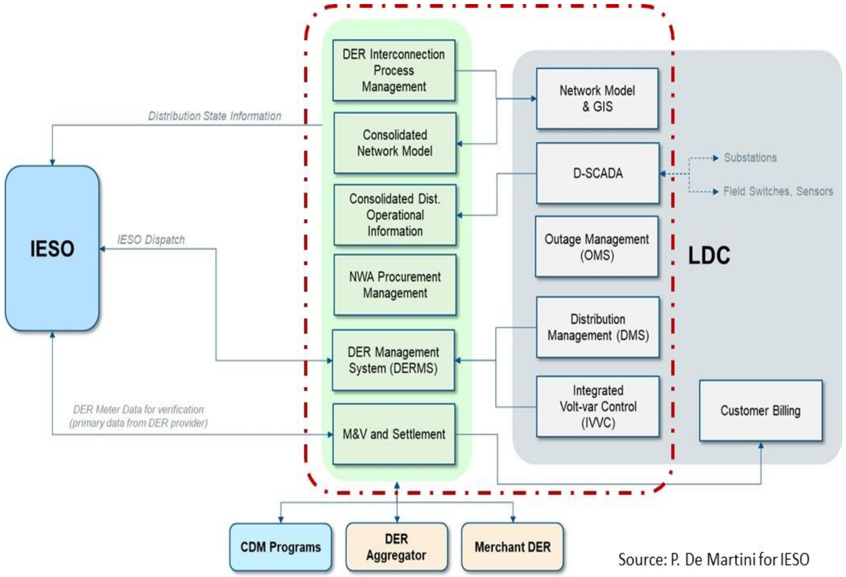


Source: Newport Consortium for AEMO

4. Evaluate Coordination Alternatives

b. Implementation Requirements & Costs

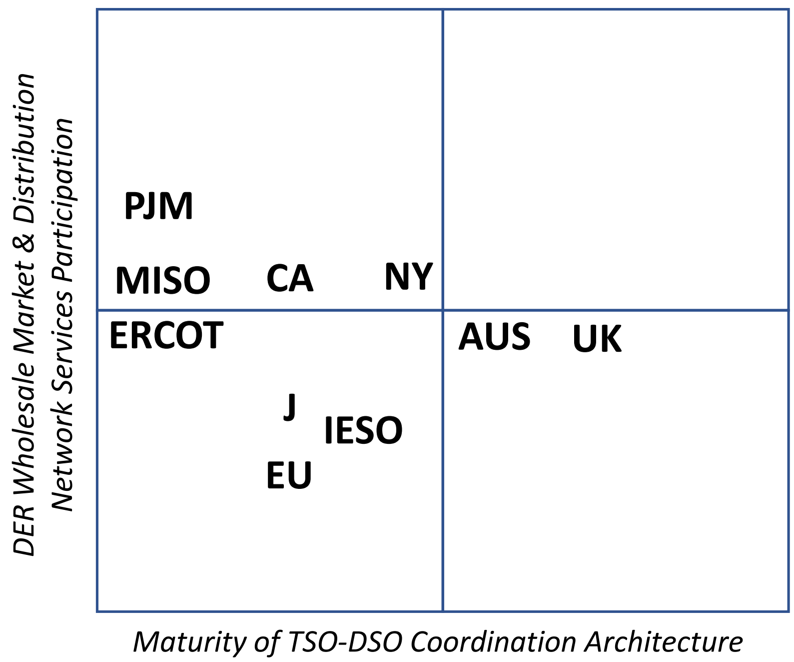
- Structural changes and new capabilities required will impact people, processes and technologies (PPT) in the respective organizations.
- These changes including functional requirements, system architecture and technologies that may be required should be identified for each alternative (e.g., SGAM application).
- The collective PPT implementation scope, requirements, associated risks and costs should be included into the overall risk-based evaluation.



Source: P. De Martini for IESO

2019 International T-D Coordination Assessment

Primary and secondary research supporting comparative assessment of T-D Operational Coordination development efforts in 10 regions/countries



UK & AUS have undertaken the most thorough analysis conducted to-date. But, are hampered by a strong institutional and stakeholder bias towards real-time centralized markets despite the significant operational issues and risks.

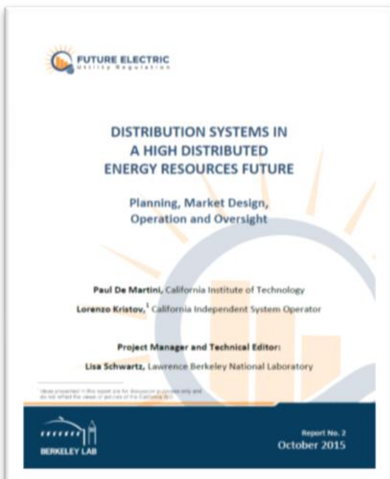
Takeaways

- Holistic architectural view is necessary to properly evaluate structural changes to the electric system
- Rigorous risk-based evaluation, such as OCAM, is necessary when considering structural changes and potential alternatives
- Grid Architecture provides a practical the methodology for conducting thorough operational effectiveness and risk assessments (global case examples available)
- Implementation evaluation of alternatives require a full assessment of people, process and technology changes involved

Most proposed coordination models globally exhibit considerable distribution operator bypassing, introducing significant operational risk at scale.

References

T-D Operational Coordination


FUTURE ELECTRIC

DISTRIBUTION SYSTEMS IN A HIGH DISTRIBUTED ENERGY RESOURCES FUTURE

Planning, Market Design, Operation and Oversight

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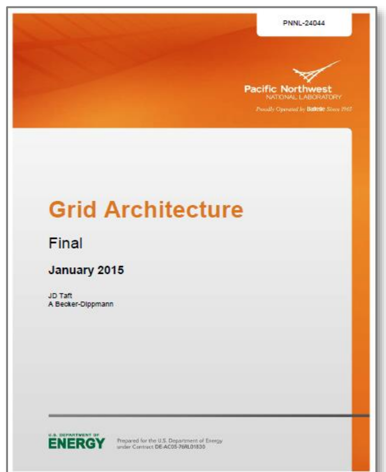
Grid Architecture


PNNL-24044

Pacific Northwest NATIONAL LABORATORY

Grid Architecture

Final

January 2015

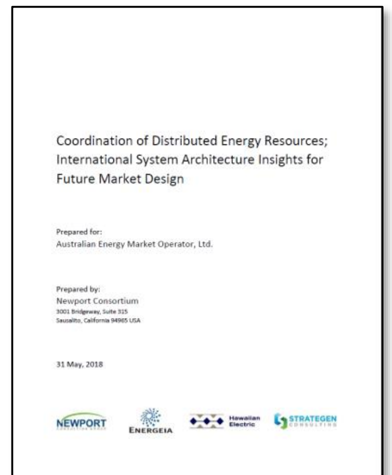
JD Taft

A Becker-Dippmann

ENERGY

http://gridarchitecture.pnnl.gov

AEMO Intl Survey


Coordination of Distributed Energy Resources; International System Architecture Insights for Future Market Design

Prepared for:

Australian Energy Market Operator, Ltd.

Prepared by:

Newport Consortium

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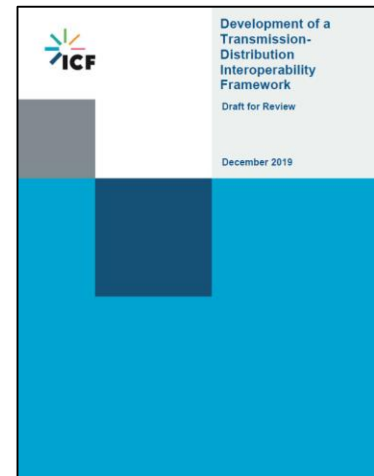
Sausalito, California 94965 USA

31 May, 2018

https://www.aemo.com.au/-/media/Files/Electricity/NEM/DER/2019/OEN/Newport-Intl-Review-of-DER-Coordination-for-AEMO-final-report.pdf

IESO Evaluation


ICF

Development of a Transmission-Distribution Interoperability Framework

Draft for Review

December 2019

http://www.ieso.ca/-/media/Files/IESO/Document-Library/engage/isewp/ICF-IESO-Development-of-a-Transmission-Distribution-Interoperability-Framework-draft.pdf?la=en