Smart Tools for Energy Markets

Range of control centre tools, processes and systems required for full integration with evolving energy markets

Our Team Today

ESB International Team :

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Outline of our Presentation

Our Presentation:

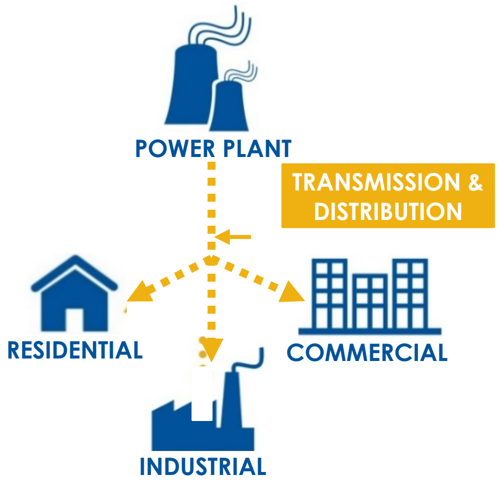
ESB International presents a roadmap for Transmission System Operators (TSO) and Market Operator (MO) Control Centre range of tools, processes and systems required for full integration with evolving energy markets.

- **Current Energy Markets Setup and Evolution Drives.**
- **Impact assessment of Energy Market evolution, identifying the changes required to the TSO and MO hardware and software tools, PPA and Grid Code to address the Energy Market Evolution.**
- **Specifying Market Model Structure, smart HW & SW IT/OT/SCADA/EMS/tools and function for the Energy Market evolution.**
- **Evaluating the existing ancillary services setup and determine an optimum strategy for evolving MVAR, Reserve, Black Start, Primary & Secondary Response, Outage Management and Congestion Management.**
- **Assessing the impact of Renewable Energy Sources (RES) observability and controllability and developing fan effective operational strategy or RES and delivering state-of-the-art tools, systems and processes to the control centre to meet the challenges of a RES-based energy system**

We shall conduct a 40 minute presentation followed by 5 minutes of Q&A.

Current Energy Markets Setup and Evolution Drives

Current State



Internal Drivers

Smart Grid Initiatives

Smart SCADA, GIS, DSM, etc.

System Optimization

Enable better T&D integration

Resilience & Reliability

External Drivers

Worldwide Trend

Policy & Regulation

Deliver clean and efficient energy

Changing Supply

Shift to solar & renewable
Balancing demand
efficiency

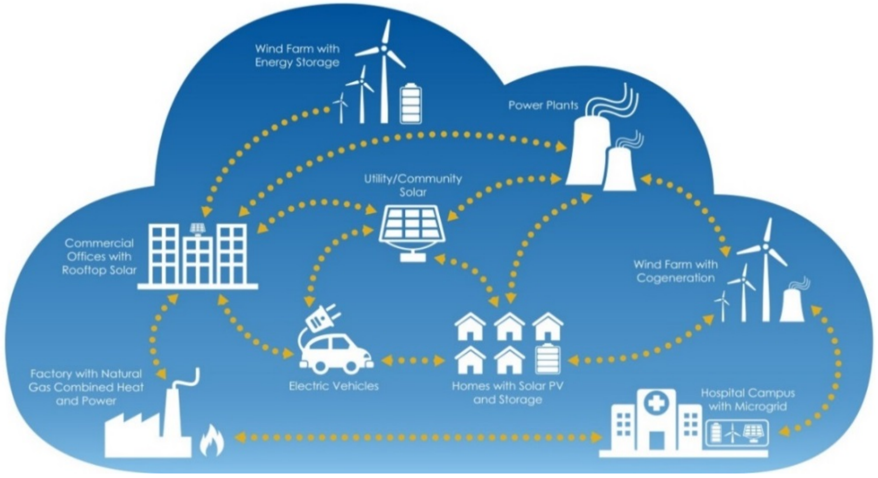
Changing Market

Interconnection, competition and end of parental states.
Evolving Energy Markets

Demand Increase

Demand Side Management

Future State



The Opportunity

Utilities Reputation as World Leading Utility Provider	Deliver Customers. Client societal Benefits.

Impact Assessment of Energy Markets Evolution

Target: "Meeting Transmission System Operator 's (TSO) Obligations following Introduction of Energy Market and Renewable Energy Sources.". The below area are assessed and actioned roadmap is stipulated.:

- **Assess TSO infrastructure H/W and S/W and communication tools related to SCADA & EMS role, facilities & interfaces, identify potential new IT System requirements needed. Ensuring adequate cyber Security level.**
- **Assess Market Rules, GC, PPA , existing & planned TSO dispatch procedures & tools, data obligations and congestion mgmt., interface agreements among all sector players.**
- **Review existing TSO Ancillary Services (AS) handling setup. Draw optimum strategy for handling the AS in particular the MVAR, Reserve, Black start, Primary & Secondary Response.**
- **Identify the data exchanges e.g. availability declaration, bid and offer, instructions between TSO and IPPs and MO. Draw strategy on the optimum mechanism to exchange the data.**
- **Assess metering and settlement mechanism. Advise on the potential changes required to implement with metering and sector settlement system as a result of MO/ Procurer Energy Market.**
- **Stipulate the strategy of Observability and Controllability of RES with the market in place**

Assessment Strategy & Approach

‘As-Is’ Assessment and Priorities

- Assessed Market rules, existing and planned TSO Dispatch procedures & tools , Data obligations and congestion management.
- Reviewed the current TSO Ancillary Services handling setup
- Assessed the agreements among SO, MO / Procurer, Regulator and other market players.
- Assessed the IT Tools and infrastructure that are currently deployed in TSO
- Assessed the security

Gap Analysis

Identify the presents & potential gaps that may arise due to SO’s role in the Energy Market. identify the necessary changes to bridge these gaps, ensuring that TSO meets its Obligations towards the Energy Market and RES.

- TSO infrastructure H/W and S/W in particular SCADA and EMS role , tools, facilities.
- Grid Code gaps.
- IT System requirements needed Ancillary services setup
- Renewable Energy Sources and plan.

Implementation Plan

Gap identification for Energy Market operations and recommendation, e.g. followings:

- Modification requirements of the existing SOPs as well as new required procedures
- Business Readiness and Change Impact Assessment Tools.

Assessed Functions, Tools and Areas - 1

The following functions, IT Tools and areas were subjected to a thorough assessment:

- Procedures and documentations
- Short-term and long-term load forecast
- Scheduling and dispatch input static data & dynamic data & Optimisation tools
- Market system software
- Network analysis
- Long terms scheduling planning – yearly and weekly
- Short terms scheduling – day-ahead schedule (d-1)
- Real time 5-30 min ahead constrained dispatch
- Scheduling and dispatch schedule implementation at day (0)

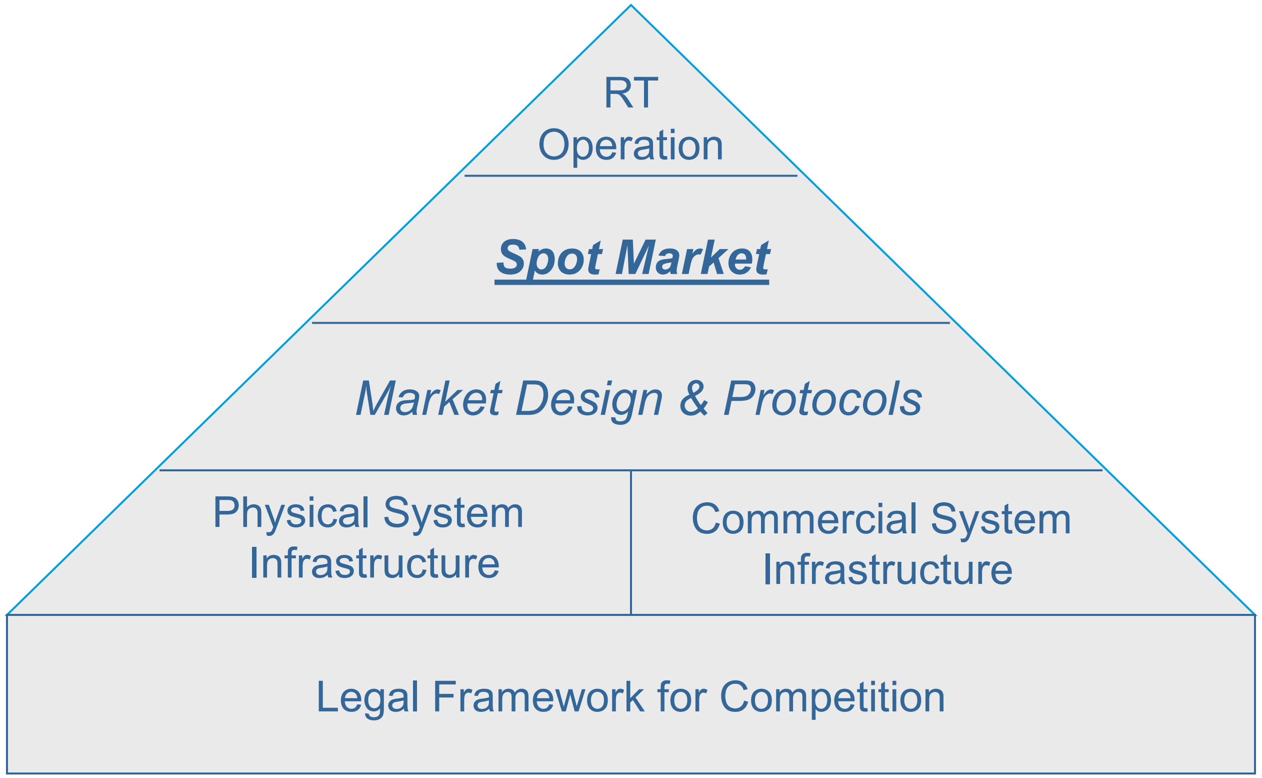
Assessed Functions, Tools and Areas - 2

- Reserve real time management
- Post-operational review to determine sub-optimal dispatch
- Review of frequency following generation or load loss
- Review of constraints applied in the day-ahead schedule
- Automatic generation control
- Manual dispatching
- Logging
- Real time control of network and instructions
- Penalties for non-compliance of TSO instructions
- Functional requirements and staffing for control room
- Training
- Stakeholder collaboration

Market Model Structure

Broad Scale Change: technical and non-technical

Continued Evolution: manage the rate of change, improve with experiences



TSO Scheduling and Dispatch Process

Long Term Plan

- Long Term Plan
- Yearly Outage plan

Pre-Market: Day-1

- Week Ahead Plan
- SLF
- Generation Model
- Network Status

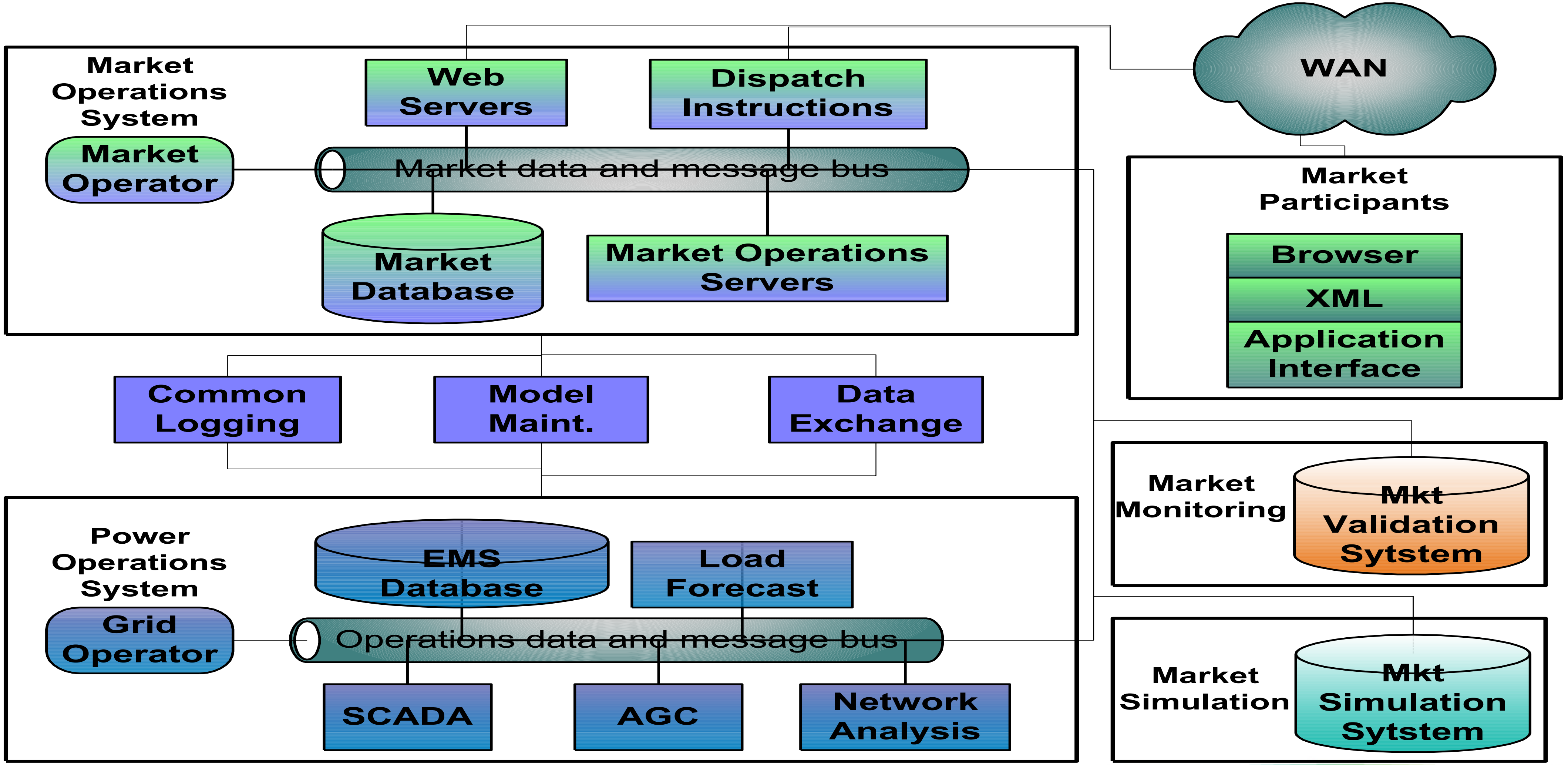
Real Time Operation D0

- Scheduling plan

Post market Operation

- Compare Plan to actual

TSO/MO Interfaces - Overview and IT/OT Identified Smart Tools



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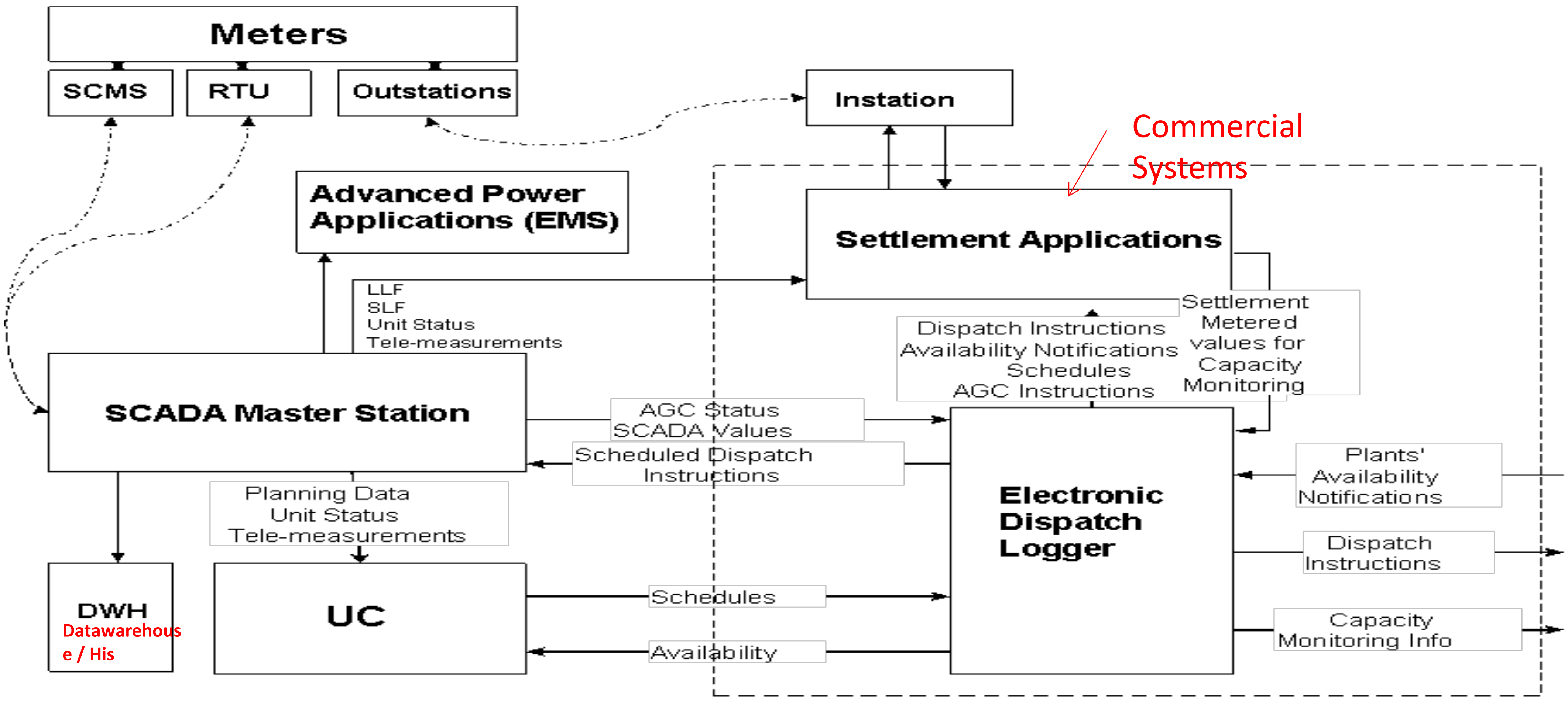
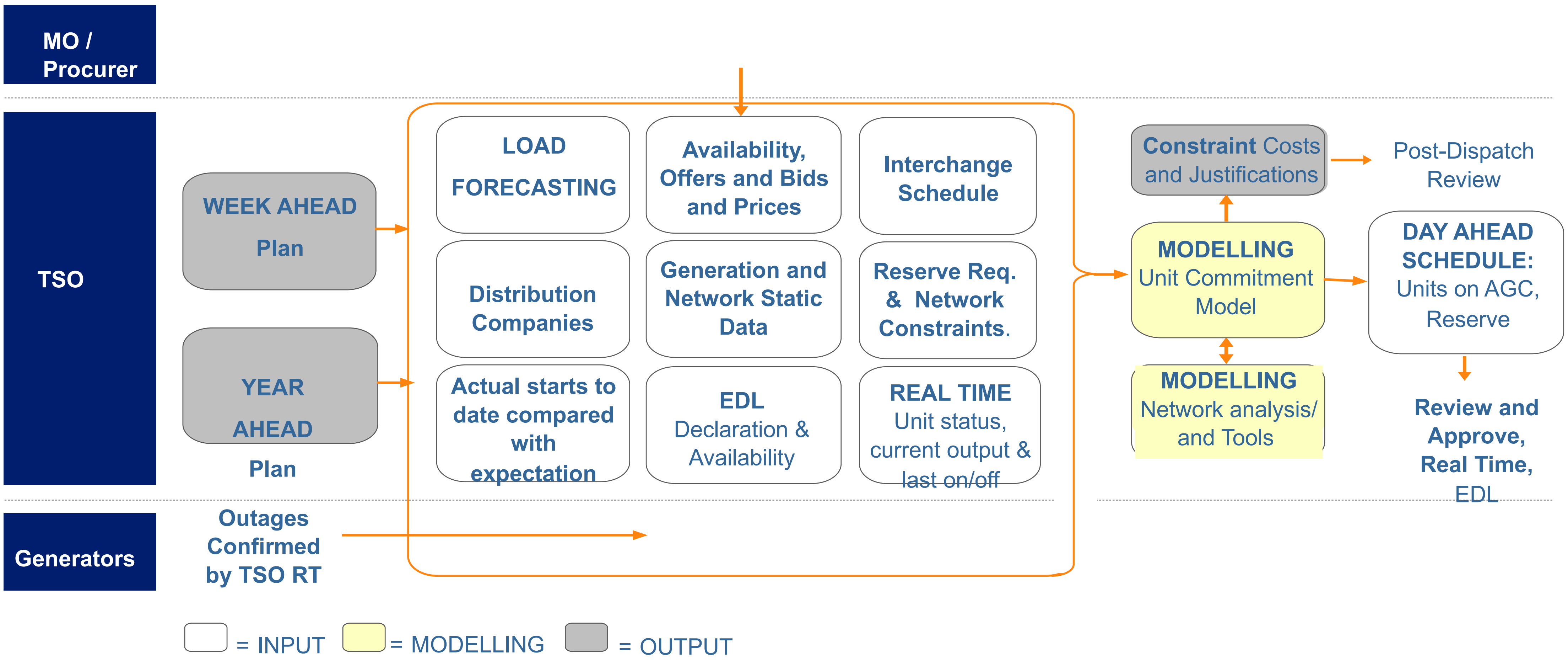
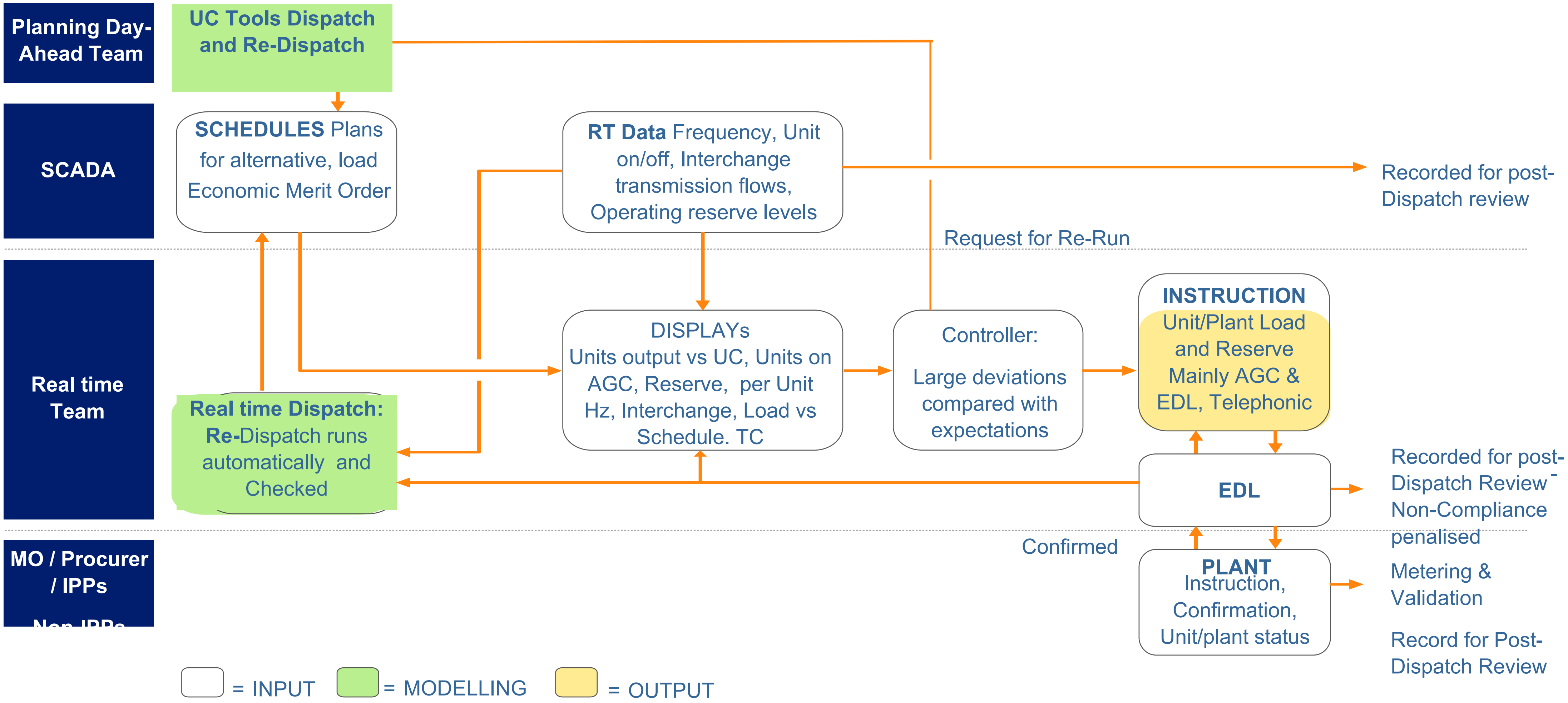
TSO IT Change - Overall Merged Market Tools Concept



TSO Process Changes: Typical day Ahead Scheduling Process



TSO Process Changes : Typical Real Time Dispatch Process



Ancillary Services – impact of structural changes

Typical Current situation:

- Ancillary Services are provided only by Generators;
- Generators have PPAs
- AS are "bundled" within PPAs - already "bought and paid for"
- No explicit commercial arrangements for AS

(Energy Market Evolution):

- There will be
  - Generators with PPAs
  - Generators without PPAs
  - Potentially other AS Providers (important to widen supply base, given likely future AS scarcities)
- Need to provide a "level playing field" (and to ensure secure operation while optimising costs).

Ancillary Services – physical changes

- Changes in Generation fleet
  - Development of large new CCGT plants (and future RES & Coal) .
  - OCGT plant is being marginalised or closed – reducing component of the overall fleet.
  - OCGT plants provided a lot of the flexibility, and were well placed on the system for voltage control .
- RES integration
  - RES targets (Solar and Wind Turbines).
  - Large-scale RES generation (non-synchronous) fundamentally changes nature of a power system.
- Network developments
  - Large-scale HV Transmission e.g. 220kV/400kV development is likely to increase voltage control challenges – could (on its own) be partially addressable by changes in operating practices.

RES integration and system impacts - 1

- Historically, generation in power systems consisted mainly of synchronous generation machines with high inertia, such as thermal units.
- Synchronous generators provide inertia or “weight” to the system, defining system behaviour during normal and fault (disturbance) conditions.
- Integration of power electronic converter-based generation (solar, wind) raises a complex range of issues:
  - Variability, predictability, limited dispatchability; impact on running patterns and ramping requirements from other generation;
  - Reduction in system inertia: increases rate of change of frequency following system disturbances;
  - Active power response during and after voltage dips (can be) inferior to conventional generation;
  - Reduced system strength is expected to bring several new issues such as the lack of enough short circuit current to trigger protection systems;
  - Oscillation due to resonances and especially at sub-synchronous frequencies is being envisaged as a further limitation to be caused by the introduction of control interactions.

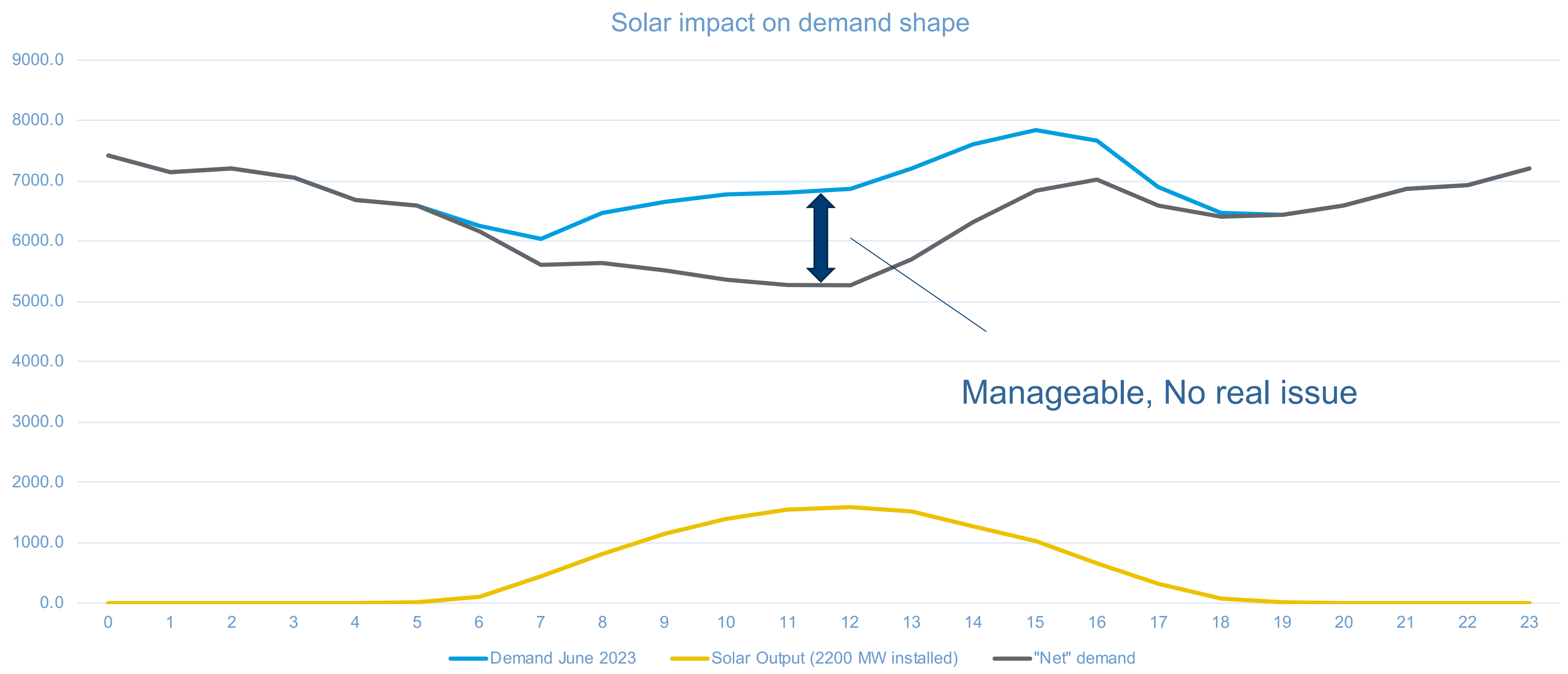
RES integration and system impacts - 2

- Conventional Thermal plant uses Transmission level, smaller PV farms and Wind Farms often connect at distribution level.
- Results in greater number of generating sites. Often regionalise the sectors so that wind farms or PV can be grouped so as to get better load forecast.
- Reliant on DSO to pass data to TSO via SCADA ICCP connections. Ensure accurate, reliable connection between two systems

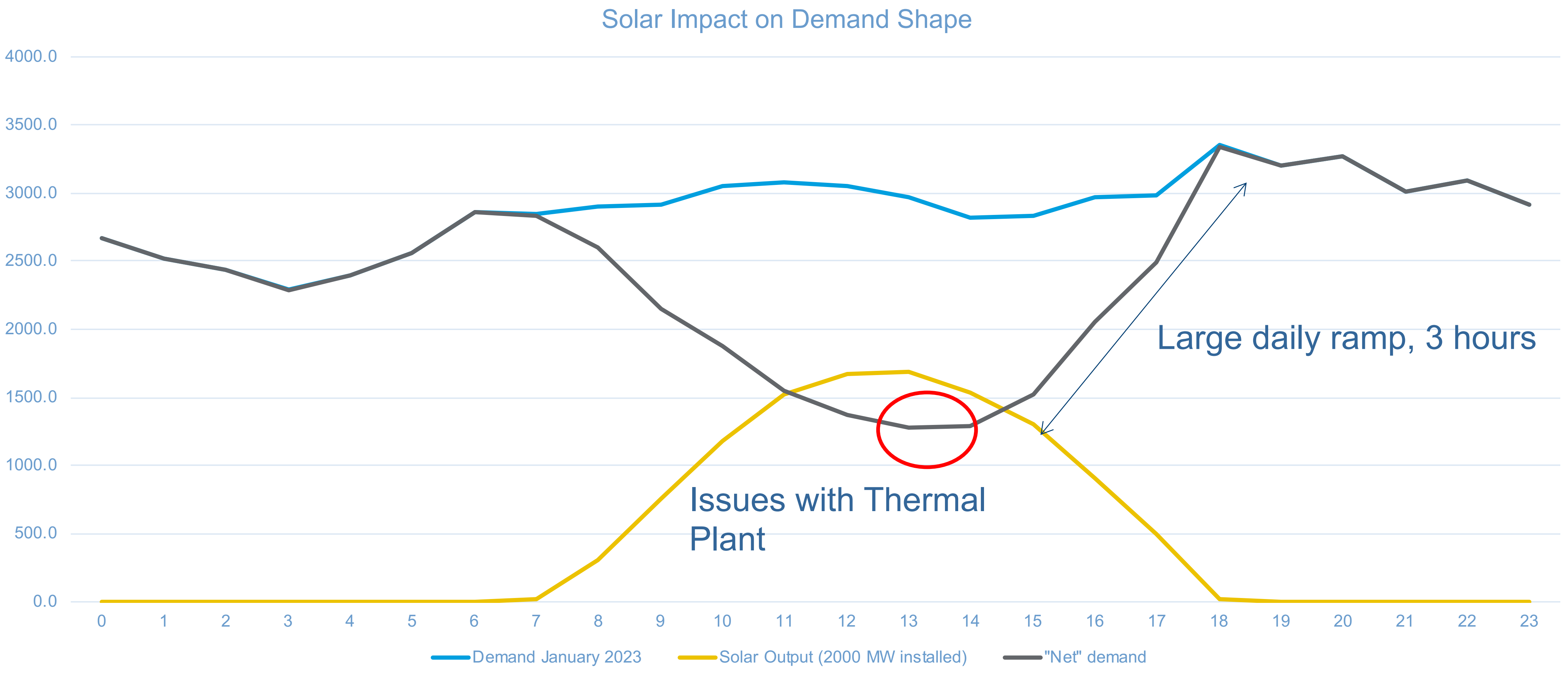
Impact of Solar generation on “net demand” profiles

- Typical demand for two current representative days in
  - June (peak season)
  - January (off-peak season)
- Scaled demand to 2023
  - Additional 25.6% (Seven-year projected system growth)

Sample day – Peak season



Sample Day – Off-peak Season



Low demand hours (challenging)

Hours at low demand (low conventional generation)		
Range (MW)	**Gross demand**	**Net of RES**
<1,000	0	2
1,000 to 1500	0	155
1,500 to 2,000	0	334
2,000 to 2,500	77	508
2,500 to 3,000	809	825

Ramping requirements from conventional generation (within 1 hour)

Ramping requirement from conventional generation (within 1 hour)		
Range (MW)	Gross demand	Net of RES
> 1000	0	38
800 to 1000	8	105
600 to 800	58	248
400 to 600	349	639
200 to 400	1322	1000
0 to 200	2783	1775
0 to -200	2745	2805
-200 to -400	951	1486
- 400 to -600	324	563
-600 to -800	139	122
-800 to -1000	75	18
> -1,000	6	1
Highest rise	874	1540
Highest drop	-1113	-1102
Average change per hour (absolute)	194	246

Ramping requirements from conventional generation (within 3 hours)

Ramping requirement from conventional generation (within 3 hours)		
Range (MW)	Gross demand	Net of RES
> 2000	0	33
1600 to 2000	0	206
1200 to 1600	26	409
800 to 1200	269	610
400 to 800	1569	1147
0 to 400	2846	1495
0 to -400	2284	2078
-400 to -800	1226	1643
- 800 to -1200	346	928
-1200 to -1600	139	205
-1600 to -2000	55	5
> -2,000	0	1
Highest rise	1425	2418
Highest drop	-1909	-2015

AS: Irish System Services (15 defined services – several new)

- Synchronous Inertial Response (SIR)
- Fast Frequency Response (FFR) – 2 seconds
- Dynamic Reactive Response (DRR)
- Ramping Margin 1 Hour (RM1) , Ramping Margin 3 Hour (RM3) , Ramping Margin 8 Hour (RM8)
- Fast Post-Fault Active Power Recovery (FPFAPR)
- Steady-state reactive power (SRP)
- Primary Operating Reserve (POR)
- Secondary Operating Reserve (SOR)
- Tertiary Operating Reserve 1 (TOR1)
- Tertiary Operating Reserve 2 (TOR2)
- Replacement Reserve (De-Synchronised) (RRD)
- Replacement Reserve (Synchronised) (RRS)
- Black Start

Under the recent procurement exercise in Ireland, a number of wind units are now contracted to provide a number of services such as POR, SOR, TOR1, FFR and SSRP as well as emulated (synthetic) inertia

Australia: Frequency Control products (8 services)

- Regulation Raise,
- Regulation Lower,
- Fast Raise (within 6 seconds),
- Fast Lower (within 6 seconds),
- Slow Raise (within 60 seconds),
- Slow Lower (within 60 seconds),
- Delayed Raise (within 5 minutes)
- Delayed Lower (within 5 minutes)

All 8 services were successfully tested at Hornsdale Wind Farm in South Australia to demonstrate the feasibility of these services being offered by inverter-based generation.

South Australia now requires all inverter-based generators seeking to connect to the network to have the capability to supply these services

Response

- Enhanced flexibility and increased supply of Ancillary Services from existing providers
- Widen the supply base of AS
  - Demand side; RES generation; others
- Best practice commercial framework
  - Define AS requirements (volumes and functional specifications) – current and future;
  - Technology neutral (to maximise supply base)
  - Specific valuation and payments mechanisms for AS – support level playing field and widen supply base; promote flexibility and innovation;
  - Payments should reward performance and penalise non-performance;
  - Contractual and commercial arrangements; procurement mechanisms
  - Implementation issues: Dispatch/instruct delivery; measuring; monitoring; testing.

Suggested Approach

- Focus first on design of the “final arrangements” for Ancillary Services
  - What is the appropriate framework for AS in that area, under the future arrangements (Energy Market, RES etc.)
- Only then, look at transition arrangements
  - Generation under PPAs
  - Interconnected systems areas and interfaces
- Anticipate (in so far as is practical) AS requirements for several years’ into the future
  - What horizon year? What level of RES penetration should we consider? What technologies?
    - RES will change the operation of the system and potentially affect required services and service volumes.
    - There may be other factors changing the operation of the system into the future.
  - Roadmap or concept as to how to evolve AS arrangements
  - Take “no-regret” (or low-regret) steps at the outset.

Stakeholder management and buy in

Identify Stakeholders

- People
  - TSO
  - Market Operator
  - Regulator

  Regular meetings, update and reviews.
- Legislative
  - Grid Code
  - TSO Licence

    Often these two are not 100% aligned, Grid code does not reflect the licence. Economic Dispatch Vs Operational requirements for stability

    Be aware of any upcoming changes, Propose changes. Identify conflicts

Grid, SCADA and RES

- Conventional Thermal plant uses Transmission level, smaller PV farms and Wind Farms often connect at distribution level.
- Results in greater number of generating sites. Often regionalise the sectors so that wind farms or PV can be grouped so as to get better load forecast.
- Reliant on DSO to pass data to TSO via SCADA ICCP connections. Ensure accurate, reliable connection between two systems.

Summary

- Operation of the power system is fundamentally changing in the coming years (RES; generation fleet; other factors)
  - Analysis of available data supports indicates that there will be challenging aspects

- Ancillary Services:
  - Requirement will increase, while traditional sources will diminish (need to get “more from less”)

- Our recommendations (AS):
  - Careful definition of requirements (services and volumes),
  - Widen supply base,
  - Good-practice commercial framework, rewarding improved performance and encourage innovation
  - Supported by contracts (or other instruments) and implementation procedures for measurement, monitoring and settlement.

Questions and Answer

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Thank You, for your attention