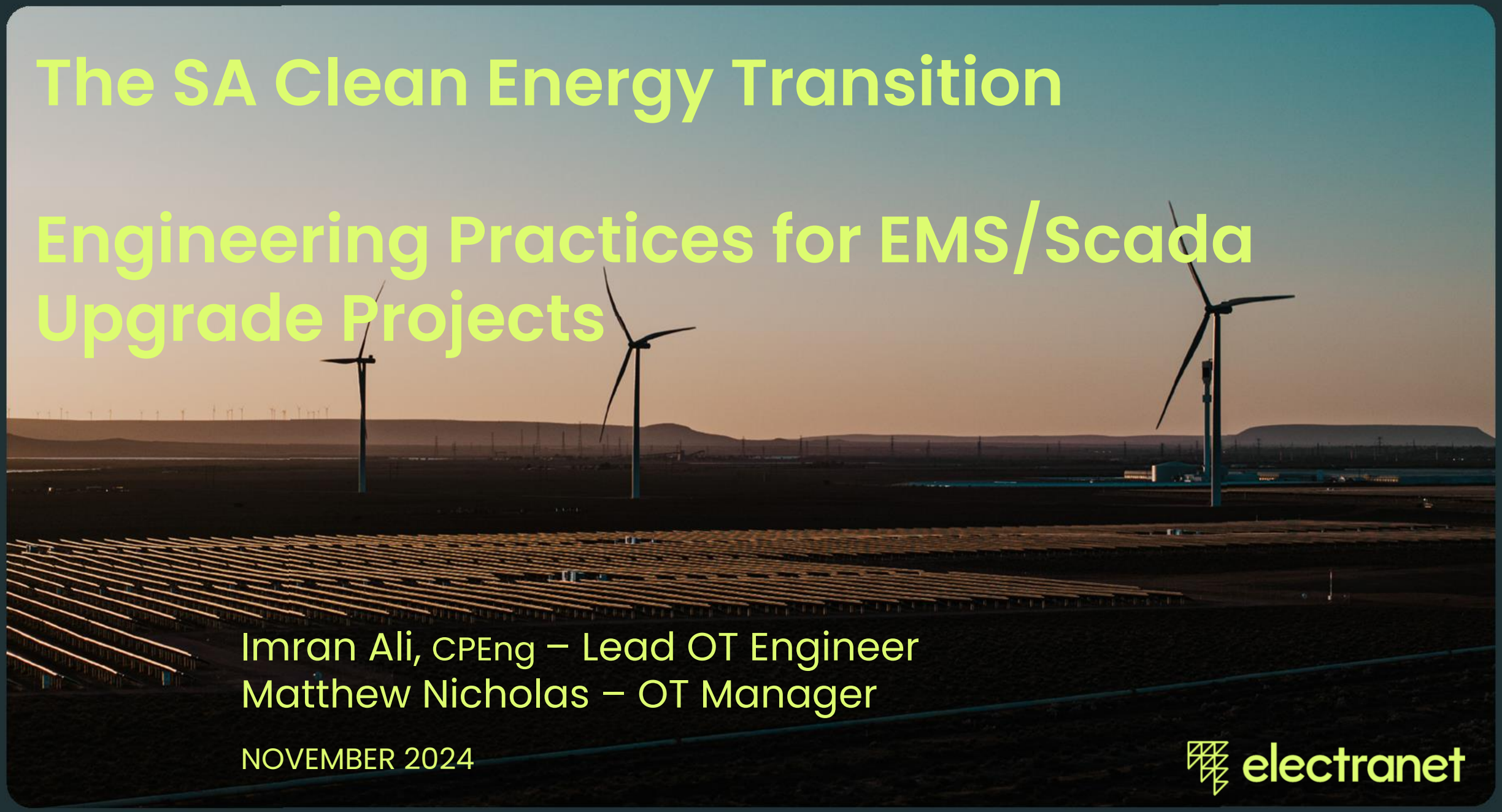
The SA Clean Energy Transition

Engineering Practices for EMS/Scada Upgrade Projects



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NOVEMBER 2024

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Agenda

- **Electranet's role in the SA Clean Energy Transition**
- Engineering Practices for EMS/SCADA Upgrade Projects
  - Challenges and Risk
  - Design phase
  - V&V Phase
  - Cutover
  - Operational Phase
- Q&A

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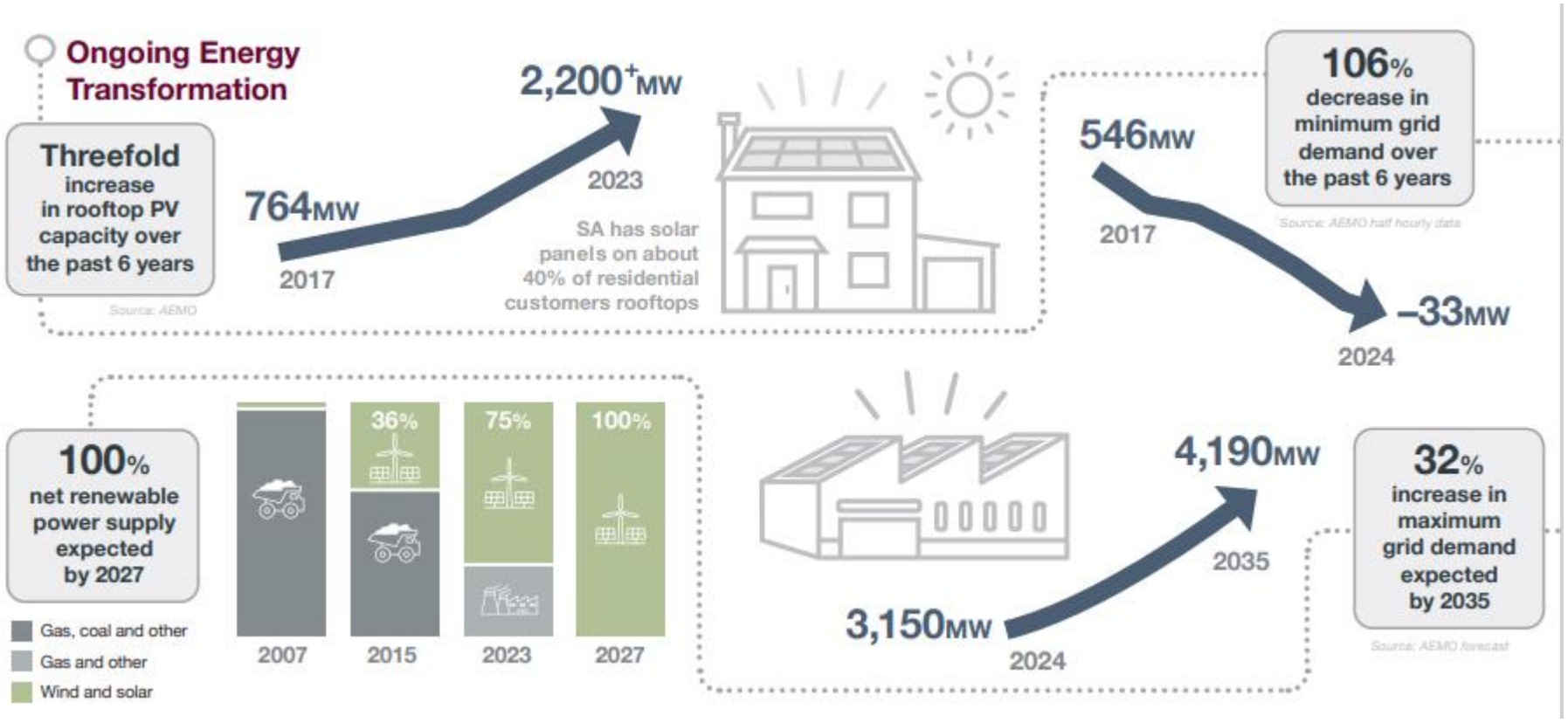
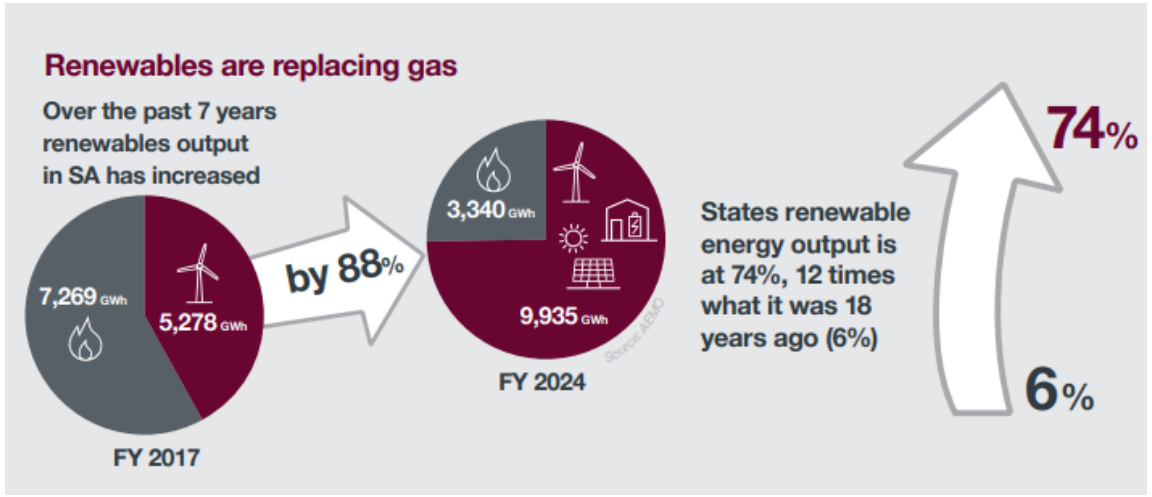
SA's Network Transition to 100% Net Renewables by 2027

Provides a pathway and framework for working with our customers and stakeholders to manage the challenges and opportunities of the energy transition

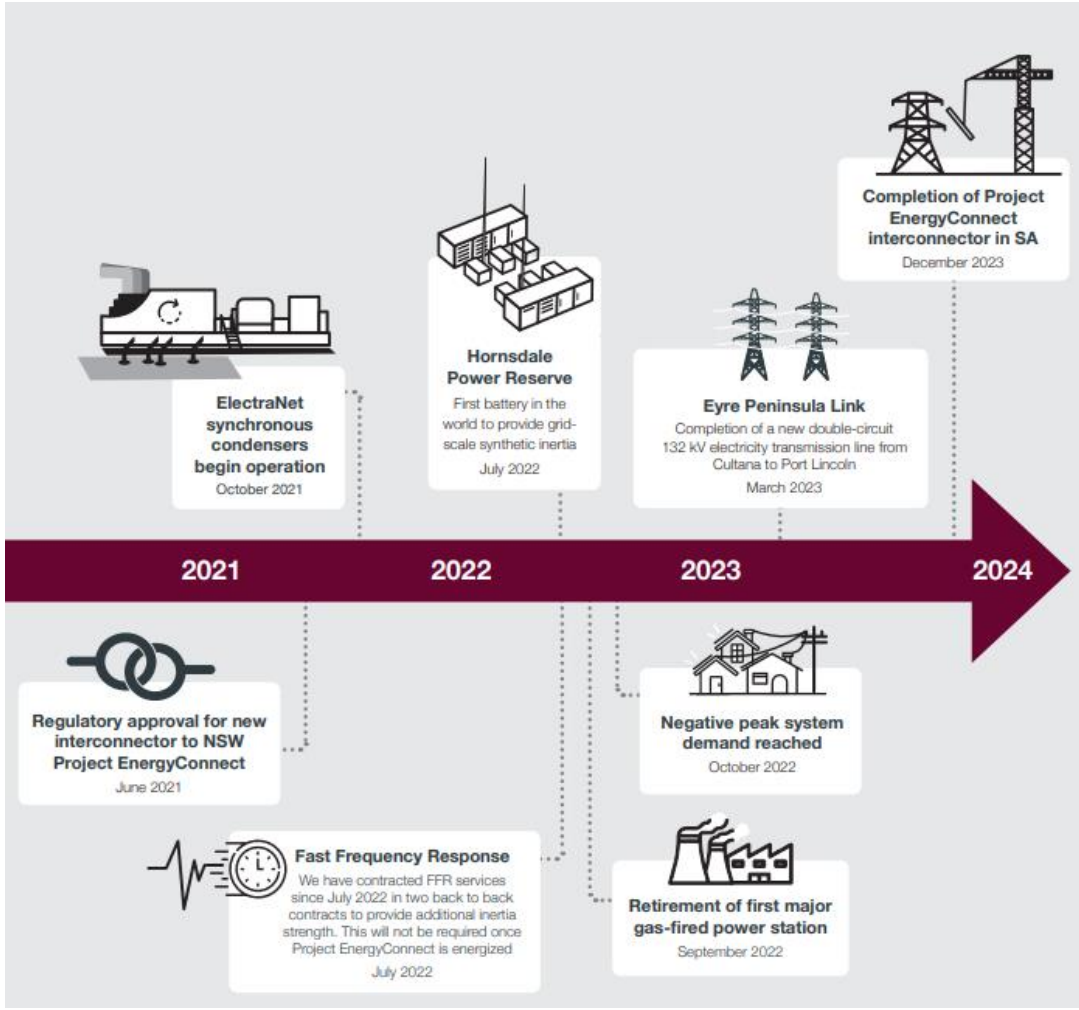


SA's Network Transition to 100% Net Renewables by 2027

We are quickly moving from gas to renewables



These key projects are improving reliability in parallel to increasing VRE projects



Challenges and opportunities

Energy transition is creating a range of challenges and opportunities for maintaining power system security and resilience

Challenges and opportunities

- Unlocking demand growth and renewables
- Supply and demand variability
- System security services
- Voltage control
- Protection adequacy
- Increasing system complexity and risk
- Harnessing customer energy resources
- Extreme events
- Underlying Network Challenges

System security

Shortfalls in frequency control, system strength and inertia services, historically provided by synchronous generators

Voltage control

Increasing VRE, reducing minimum demand and changes in customer load characteristics (more capacitive) are increasing voltage control challenges

Protection adequacy

Changing requirements require more frequent review, including for minimum fault level conditions

Increasing system complexity and risk

Wider range of system operating conditions with more frequent stress points, including under minimum, zero and negative grid demand conditions

Extreme events

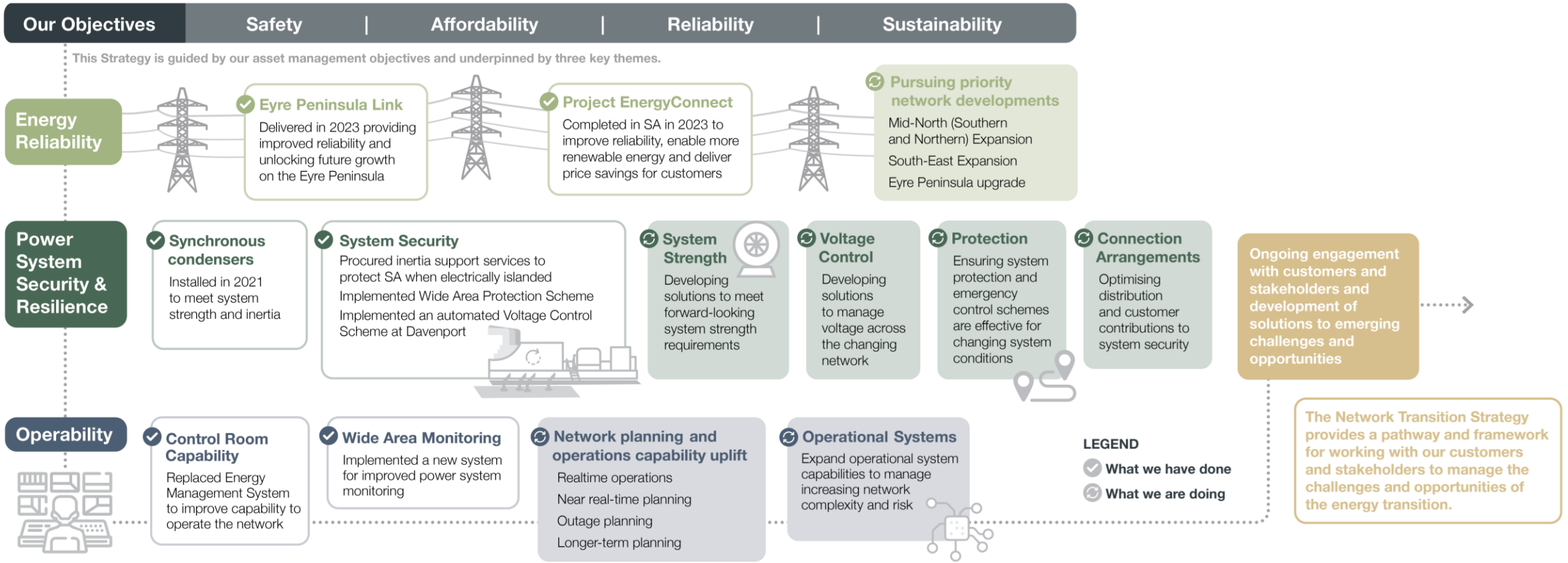
Greater reliance on complex special protection schemes to manage risk and maximise power transfer capability

Harnessing customer energy resources

Integrating CER to deliver lowest cost outcomes while addressing system security risks

How Electranet are responding

The Network Transition Strategy frames how we are responding to the challenges and opportunities of the energy transition



Last updated March 2024

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1 – Challenges of Upgrading EMS / SCADA Systems

What's so special about Scada systems upgrades?

- **Safety-critical** - High risk activity with potential of various different consequences
- **Risk** - Require various different techniques of risk identification, assessment, management and mitigation (SiD, HAZOP, CHAZOP, FMEA etc. etc.)
- **Capability** - OT projects are very different from corporate IT and field infrastructure projects, and require different skillset than what are available and in everyday use.
- **Capability** - System upgrades are not carried out often, no established in-house procedures, processes and controls. Capture knowledge.
- **Scope -** Very difficult to scope correctly due to complexity, scale, loss of inhouse knowledge of the existing system over time
- **Knowledge -** Lack of experienced resources, system knowledge distributed across various departments

1 – Challenges of Upgrading EMS / SCADA Systems

- **Scope** of the project and its complexities are typically misunderstood, significantly less than what it is both in terms of time, money and resources /skills
- **Vendor platform** - No two SCADA systems are identical, different capabilities and limitations of vendor software
- **Contract** - The term "Like for Like" does not have much weight in contractual terms - the required functionality should be explicitly defined in functional requirement specifications
- **Specs** - Functional requirement specifications can be very difficult to write, clarity is important which requires a good understanding of your existing system and business processes.
- **Acceptance Criteria** in contracts is recommended for both parties.

✓**Studies suggest 10 to 15% of safety incidents are due to scope / specs deficiencies**

1 – Challenges of Upgrading EMS/SCADA Systems

- **Who is the Systems Integrator?** Some vendors only provide a configurable product. Be clear on where a vendor's capability ends, and your obligations.
- Accurate budgeting of these projects can be quite difficult due to its inherent complexity
- Internal cost of project execution can be higher than the vendor cost
- Vendor may be under 30% of the project cost, if they are not the Systems Integrator.
- Requirements of specialized skills, availability can impact both time and cost.

✓**A safe and a quality outcome will take its time!**

1 – Challenges of Upgrading EMS/SCADA Systems

- Large no. of operationally critical real time RTU interfaces with Substations, Power plants, Wind and Solar farms, Storage batteries, Big industrial loads, Distribution network service provider, Market systems or Regulatory bodies.
- Interfaces with non real time systems such as Corporate asset management, Network outage management, metrological data and other plant maintenance modules
- Project will be successful only when the stakeholder's inputs are implemented!

✓Comprehensive stakeholder engagement within the business is highly recommended to understand how deep these systems penetrate in business processes.

1 – Challenges of Upgrading EMS/SCADA Systems

- Fully integrate with the field RTUs and back end corporate systems, any in house development can be quite costly
- Must meet the legal and regulatory requirements
- Must comply with current and near future cyber security requirements e.g. ISA, IEC, NERC, ISO…
- Ease of conversion and conversion accuracy from the existing database, displays and functions
- Look for Vendor solution rather than vendor product – understand where the line is.
- The system must have paralleling capabilities with the existing system such as dual connections, listen mode or monitor mode.
- Local presence of vendor expertise relative to your situation with good after sales support

✓**A right system selection is the first and the most important step towards building a safe system!**

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2 – Design and Engineering Phase

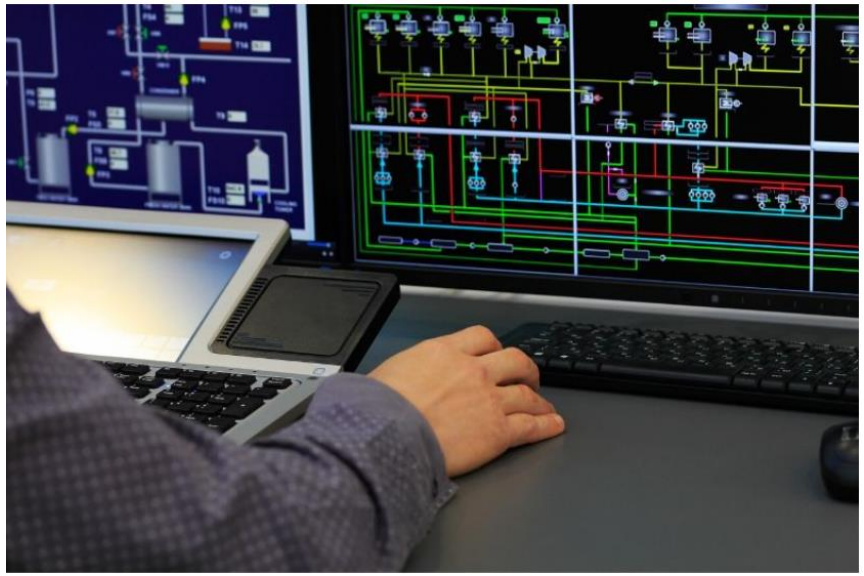
2.1 – Design Engineering Workshops

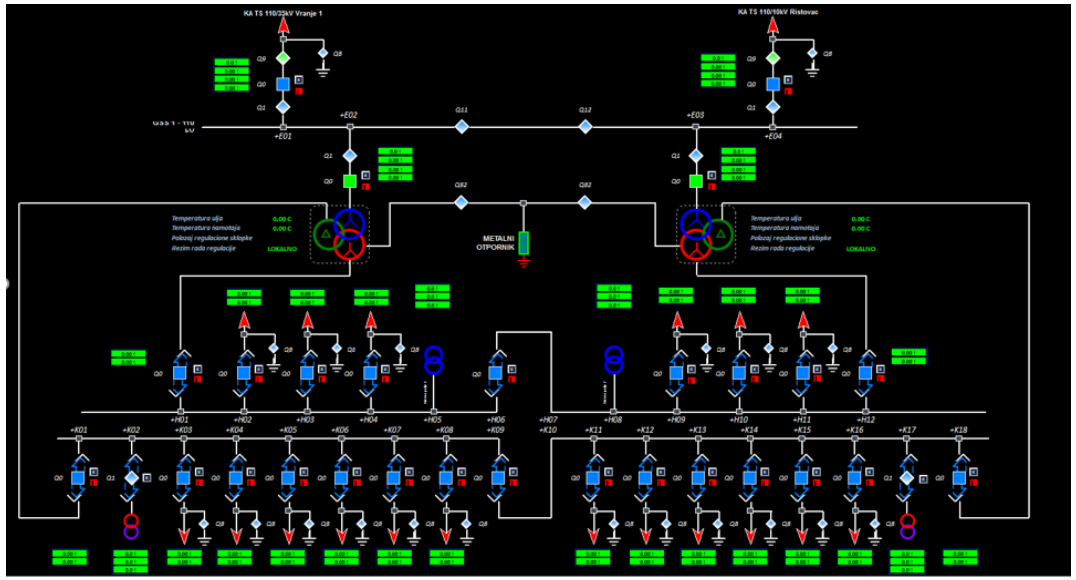
- Play a vital role in shaping of the new SCADA system
- Sets the road map for the overall architecture of the SCADA system
- Define the conversion methodology of the databases, displays and calculations
- Develop and agree on the conversion acceptance criteria with the Vendor
- Checks of the design against the relevant standards and regulatory compliances
- Risk workshops including safety in design must not be missed!
- Complex architecture and large no. of functions run and control by SCADA, a correct method of risk assessment is important (SiD, HAZOP, CHAZOP, FMEDA)

2 – Design and Engineering Phase

2.2 – Accuracy of the Existing Databases and Display – clean your data first

- All utilities grow naturally with time, means more front-end devices are added and removed each year as a part of upgrade, on local and remote interfaces, in house and third-party systems
- Addition and deletion of points and of functionality is not always perfect. As a result, over a period it ends up with considerable amount of data points and unused functionality.





2 – Design and Engineering Phase

2.2 – Accuracy of the Existing Databases and Display – clean your data first

- **Data Conversion** - Some of the functionality can be extremely complex and can take significant amount of time and efforts to work out if to be translated and how much in the new system
- **Design -** A well worked and a conscious decision at the beginning is a must!
- **Clean your data** - Perform a database and display cleansing before start of migration / conversion process.
- **If data cleansing in parallel** to the upgrade project then ensure that it is performed in the in-service production first and then periodically transported to the new upgrade system (under testing) through iterative conversion process.
- Where possible, **avoid** performing data cleansing only in the new system and not in the existing in-service system (i.e. could be for cost savings). Dissimilarity between the existing and new system can lead to significant issues in data integrity, comparison of functionality and can add risk in the cutover.

Project risk increases and system safety is impacted with the increase in number of changes

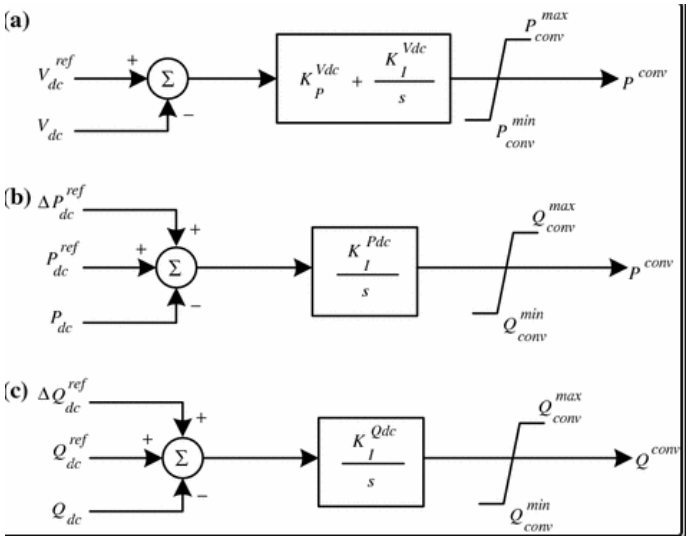
2 – Design and Engineering Phase

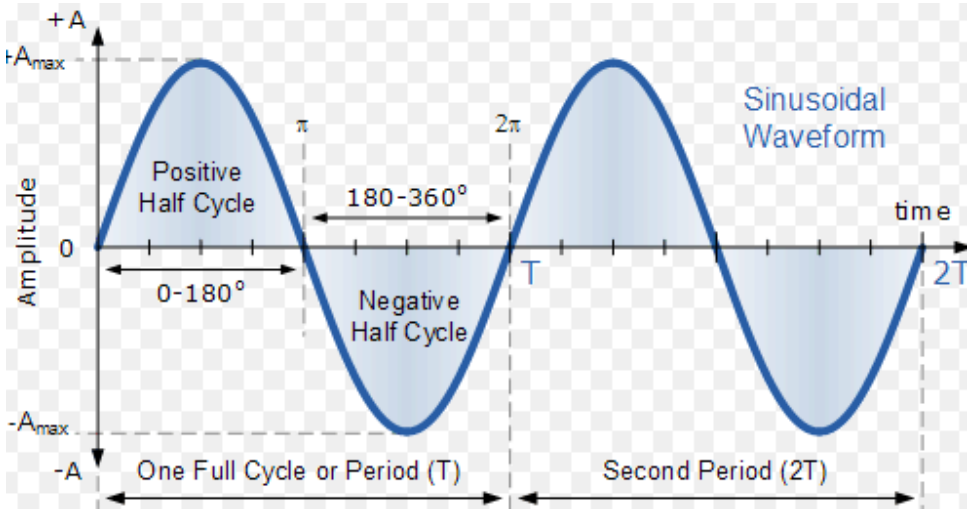
2.3 – Power Systems Applications

- Finish to start relation with SCADA works, hence extra time
- Dedicated resources will be required, knowledge of past customization, not just the skill set

SCADA displays can be different from advanced power displays

- Dynamic / Static Ratings
- Estate estimation
- Contingency analysis
- Power flow
- Short circuit
- Transient analysis
- Power quality





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3 – Conversion Verification and Validation Phase

Phases/Layers of Conversion Verification

Testing Regime, test harness and full featured simulation environment is a must!

Investment in testing kits including;

3.1 - Comparison scripts (application specific)

3.2 - Software based simulators (e.g. IOServer for DNP3, ICCP) and Diagnostic Tools

3.3 - Test and Legacy Hardware

3.4 – Deployment of listener (read only) hardware / applications

✓ **A robust and multilayered verification process significantly reduces testing effort and overall project risks.**

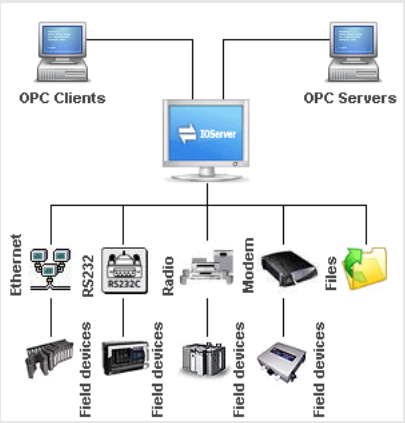
3 – Conversion Verification and Validation Phase

3.2 – Software based simulators and diagnostic tools

Invest in testing kits comprising simulators for each type of device / interface existing in your system.

Various SCADA protocols

Protocol analyzers

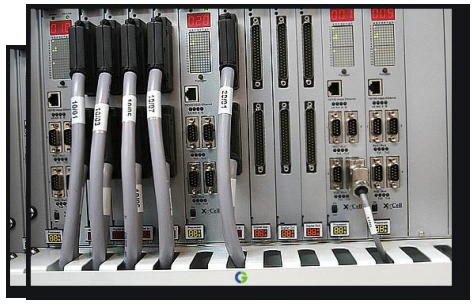


Multiprotocol Simulators

3 – Conversion Verification and Validation Phase

3.3 – Test and Legacy Hardware

- Must be capable of **interfacing** with the legacy RTUs and legacy protocols
- Utilities can have a range of legacy devices and protocols requiring interoperability tested with the new system
- **Interoperability testing** can take months to a year to complete if performed without planning
- For different RTUs, perform **compare device profiles** of similar devices to come up with testing based on exception scenario
- **Exception based testing** can easily reduce the total effort by as much as five times
- **Allocate sufficient time** and funds in the project to allow for testing and issue resolution



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3 – Conversion Verification and Testing Phase

3.4 – Deployment of Listener Hardware and Applications

The Listen mode setup to be placed across all the real time field devices and interfaces for the comparison of two systems.

Typical Interfaces are;

3.4.1 – Serial RTUs (to old equipment)

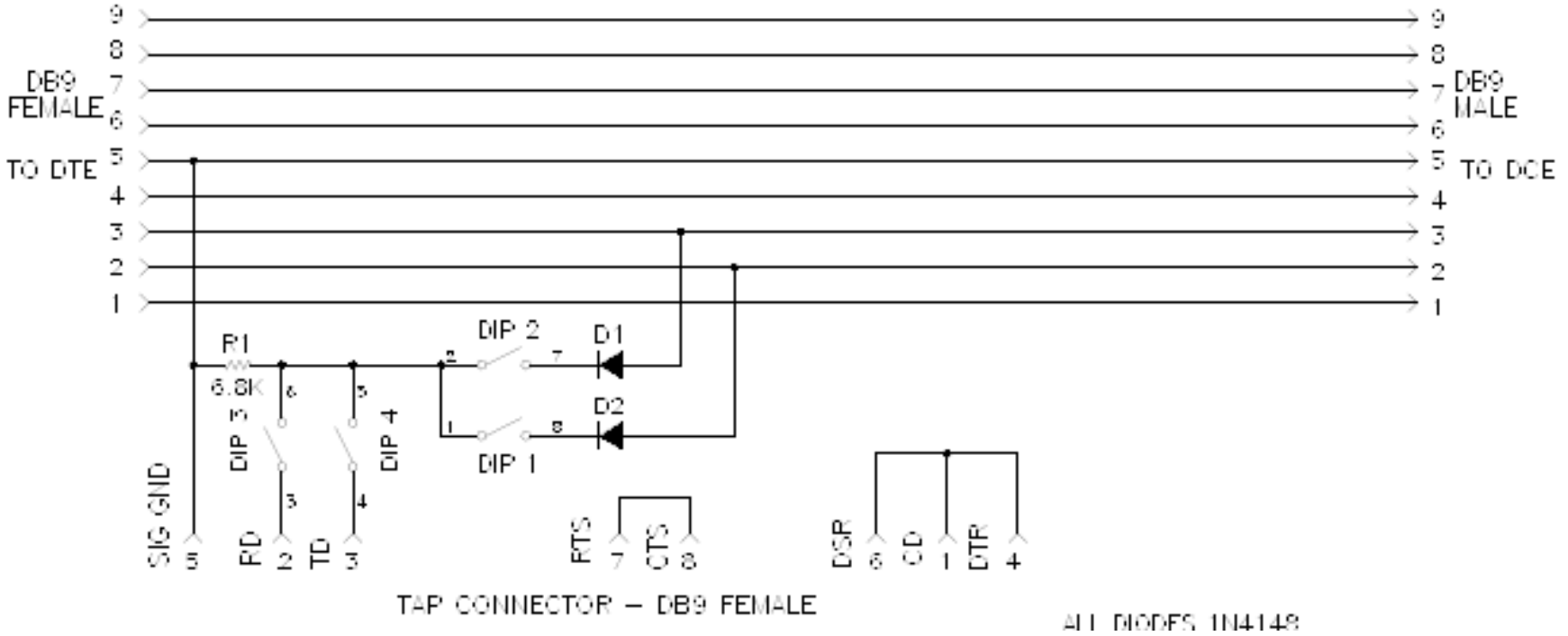
3.4.2 – IP RTUs (to new equipment)

3.4.3 – ICCP Interfaces (to other systems or parties like AEMO)

3 – Conversion Verification and Validation Phase

3.4.1 – Listen Mode Setup – Serial RTUs

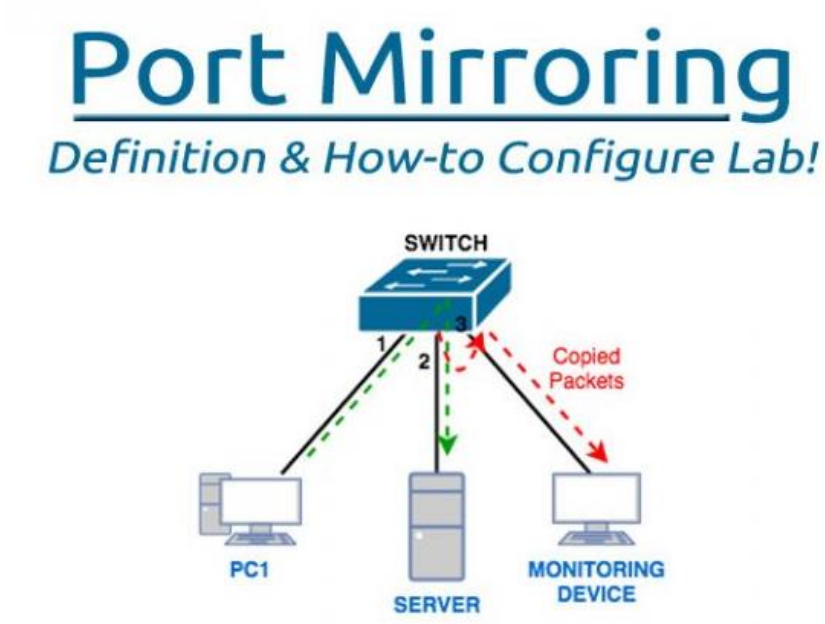
Used data tappers or adopters which can listen the data from old legacy RS232, RS485 and other protocols

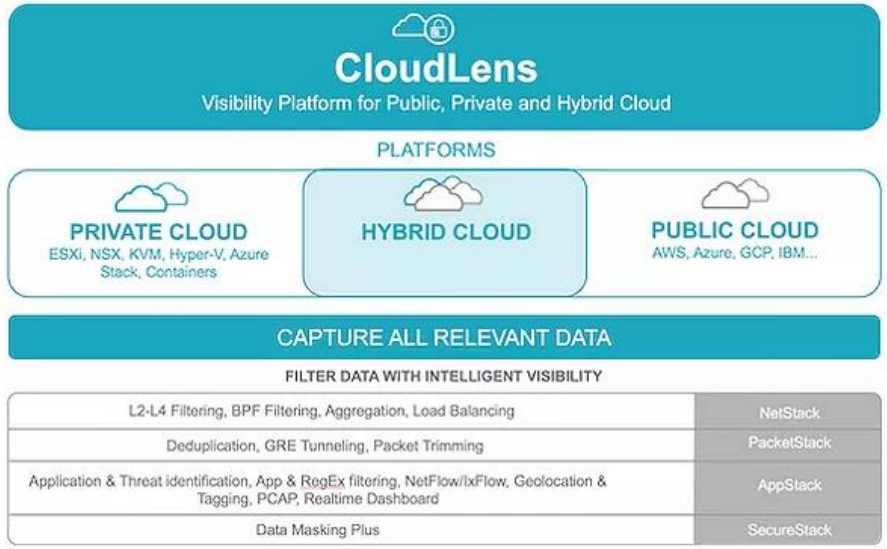


3 – Conversion Verification and Testing Phase

3.4.2 – Listen Mode Setup – IP RTUs

Used Port Mirroring to forward the realtime duplicated DNP3 RTU data from GE Production domain to OSI Production (under testing) domain.





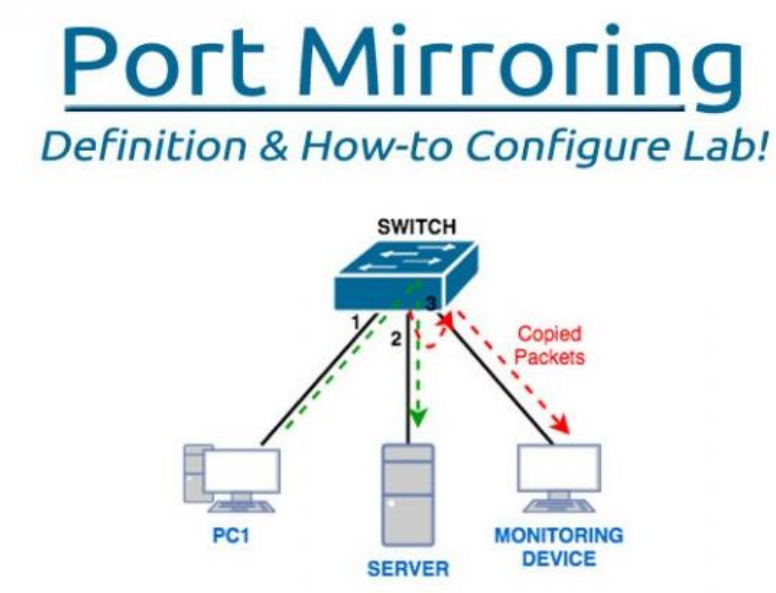
3 – Conversion Verification and Testing Phase

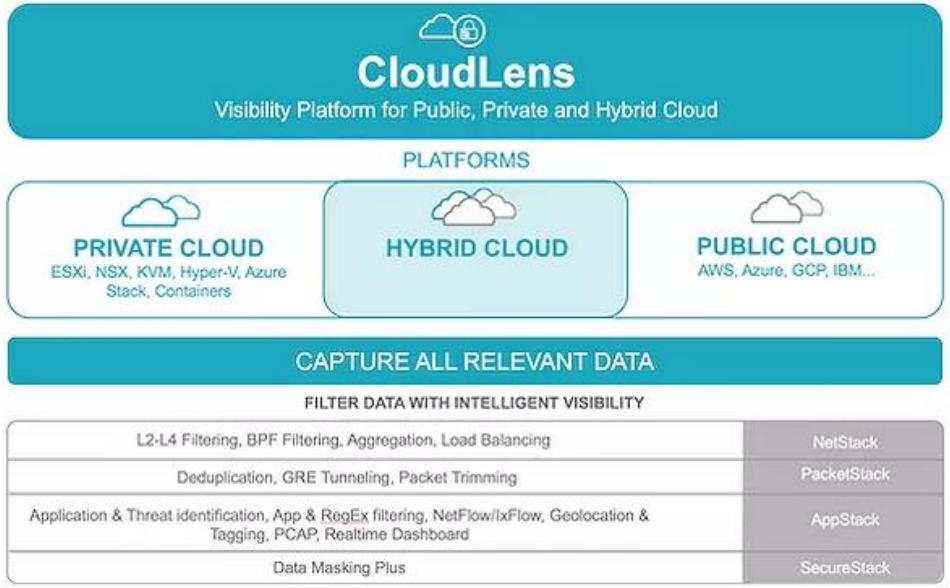
3.4.3 – Listen Mode Setup – ICCP Interfaces

ICCP Listener application for full matching datasets

If import data sets are matching on both local and remote servers then OSI's ICCP listener application is the easiest way to listen the incoming ICCP data by just port mirroring and configuration of the app.

Limitations: Inbound controls may not be routed through this app.

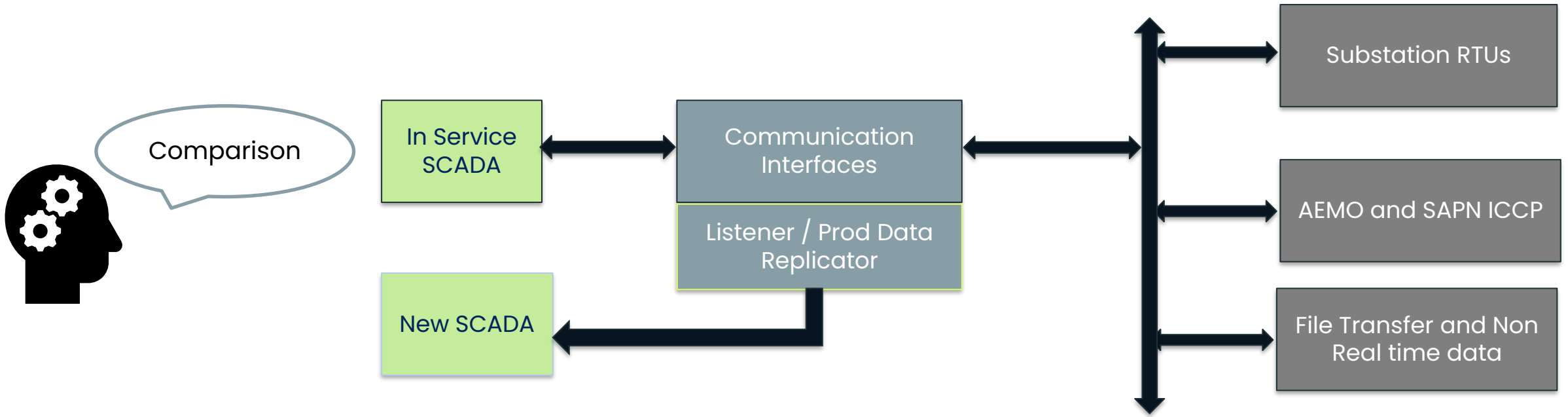




3 – Conversion Verification and Validation Phase

Listen Mode Setup – Full System

- The best approach for conversion validation is to connect the new system in Listen Mode with the existing system
  - Listening allows visual and script based comparisons (where possible) of tabulars



3 – Conversion Verification and Validation Phase

Live Testing with Third Parties

- Weather factors
- Generation gaps
- Other market constraints
- Resourcing constraints
- Peoples with the right knowledge of the times when these systems were put in service

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4 – Maintaining Old & New Systems in Parallel

How Parallelling is Different from Listening

- Parallelling is effectively connecting the two systems in in a way that both becomes identical for monitoring and control of the entire network.

Once this setup is achieved, the system cutover becomes completely seamless.

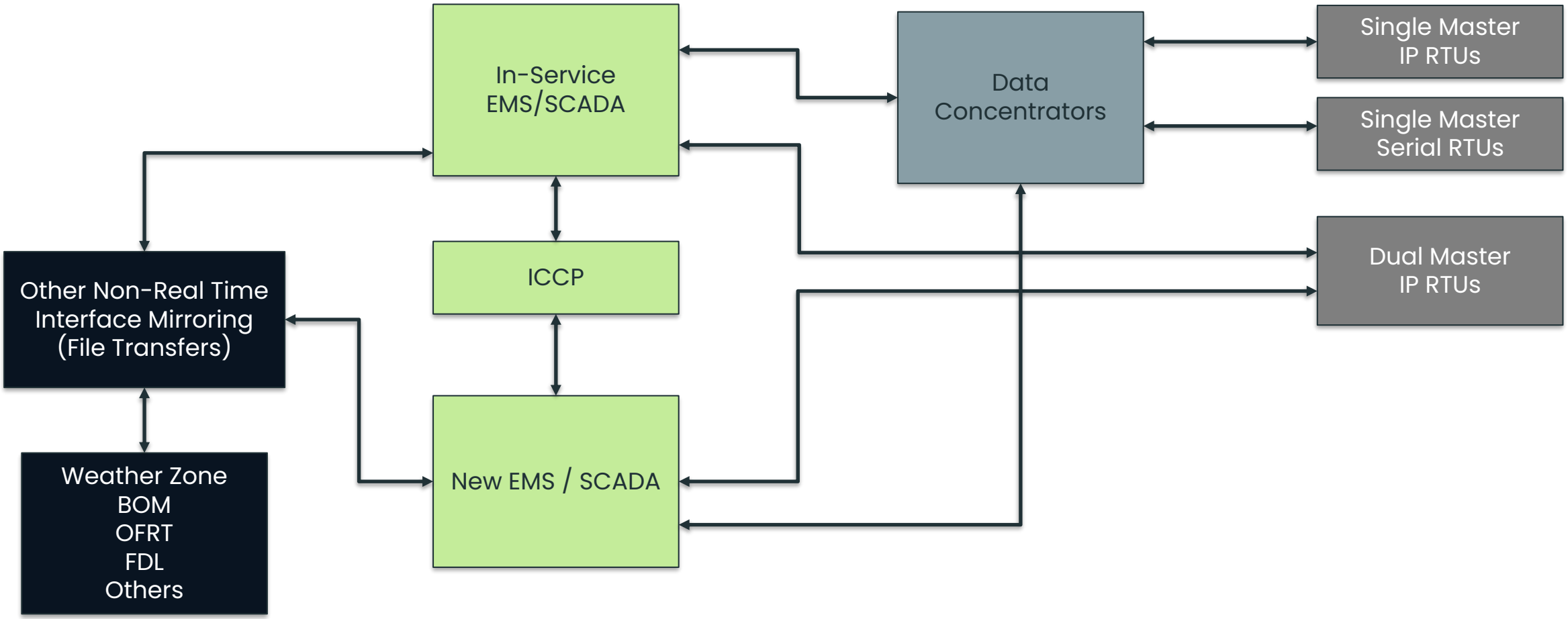
Paralleling of the new EMS with the existing Production System

- RTUs Parallelling – By the introduction of Data Concentrators for single master RTUs
- ICCP – By a duplicated feed
- ICCP – By periodically connecting the new SCADA on the second link of AEMO system
- Non Realtime Interfaces (file transfers) – by duplicated link

4 – Maintaining Old & New Systems in Parallel

Parallel Mode Setup – Full System High Level Connection Diagram

The best approach for go live is to connect the new system in parallel with the existing system with the full control and monitoring capability



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4 – Maintaining Old & New Systems in Parallel

Dual Maintenance of Parallel Systems

- Data changes, and hence the databases, displays and calc, power modelling, advanced applications, other external interfaces etc.
- While the conversion process of existing system's database, displays and calcs will be happening at the vendor facility, existing systems databases keep changing.
- Extra resources and time and budget to be allocated for this activity

✓**One of the most difficult to keep track of and has high potential to cause safety related issues**

5 – Cutover Phase – Types of cutover

Hard Cutover

Old system is physically removed (e.g. serial cables, data feeds from other interfaces etc.) and new system is put in place

- Less costly but higher risk
- Rollback to the old system may not be easy
- Old system goes blind so no possibility of any comparison of new system values
- Requires extensive testing and above the mark QA/QC system
- Network level outage and serious issue can surface after change over
- Option looks cheaper on the surface but can be quite expensive and risky in reality

Hard cutover is not an option for large critical infrastructure utilities

Soft Cutover

New SCADA system is connected in parallel to the existing SCADA system for both read and write operations, in one of two ways:

- Directly where field RTUs /devices supports dual read / write connection
- Through an externally developed paralleling solution where the field RTUs / devices do not support dual read / write connection

Achieving a parallel connection will require additional engineering effort in most of the cases which should be accounted in the project schedule

Soft cutover is worth the investment for medium to large scada systems to lower risk

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5 – Operational Phase Considerations

5.1 – Factors to Consider

- Handover of the documentation
- Support model
- Operational Usage readiness
- OT Maintenance readiness
- Business processes are finalised and accepted
- Transition from Project mode to BAU mode
- Training of resources
- Configuration management

5 – Operational Phase Considerations

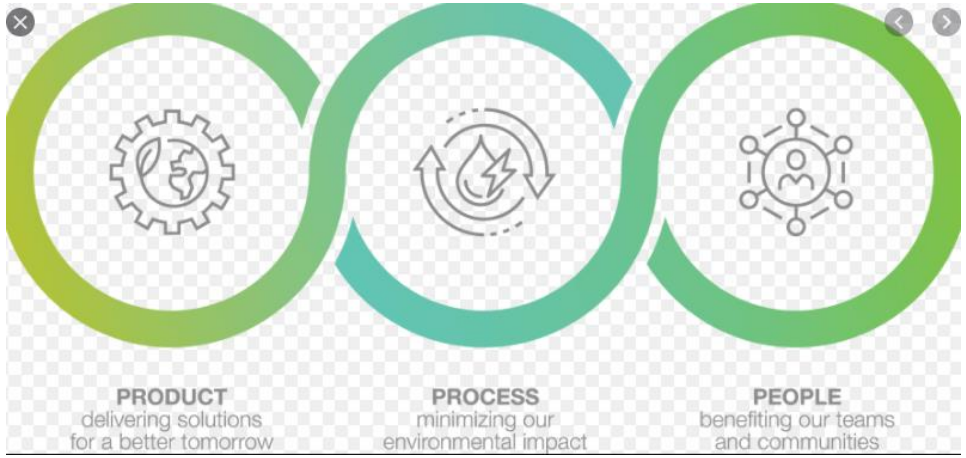
5.2 – Life Span, Sustainability and Expandability

- Life span of these systems is usually 10 to 15 years
- During life span, the system regularly goes through patching process therefore understanding of Vendor's support service and culture are vital
- Complex and Time Consuming
  - Large no. of servers, typically 50 + but can easily exceed 100+. Virtual is best.
  - Require ongoing planning, resources
  - Require redundancy in system architecture to support online patching process
- Higher Risk Activity
  - To be done online
  - Can cause disturbance / outage to infrastructure
- Patching Types
  - Hardware patching (firmware), OS patching, Application patching

5 – Operational Phase Considerations

5.2 – Life Span, Sustainability and Expandability

- What type of services vendor provide for patching?
  - Local resources
  - Active help or just providing notes / instruction list
- Regression testing
  - Impact on the project's existing timelines
  - Resources available?
  - Budgets available?
- Compatibility and Expandability
  - Most utilities grow significantly - the selected system to be modular and expandable to cater for future expansion
  - The selected system should provide easily configurable and standard interfacing options to connect it with other data systems
- Licensing and SLA Costs
  - Understanding of licensing costs and licensing model including SLA levels



Questions?

For more information please contact:

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