ESRI UC 2017

THE UTILITY NETWORK FOR POWER GRIDS
- DONG ENERGY CASE STUDY PRESENTATION

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SIMILIX
Architecting Smart Energy

DONG energy

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Abstract

The Utility Network for Power Grids
– DONG Energy Case Study Presentation

DONG Energy experiences with:

- Defining a domain model - Migrating data from the existing data model
- Implementing the first applications managing designs covering all processes from the first idea to commissioning
- Integrations with operational and asset perspectives (ADMS, SAP)

After this session you will know how the Utility Network solves the demand for a more accurate and rich representation of the grid and support for planning, maintenance, and operation processes

DONG Energy develops energy systems that are green, independent and economically viable

- Revenue (2016): DKK 61bn[1]
- EBITDA (2016): DKK 19.1bn[1]
- ~6,200 employees
- Active in Scandinavia, United Kingdom, Germany, The Netherlands, USA and Taiwan

Wind Power

- EBITDA (2016): DKK 11.9 bn
- Global leader in offshore wind with 3.6GW installed
- Active in all parts of the value chain - develops, constructs, owns and operates offshore wind farms
- Robust and visible build-out plan of 3.8GW towards 2020
- Differentiated partnership model

Distribution & Customer Solutions

- EBITDA (2016): DKK 7.1 bn[2]
- Distributes power and sells energy solutions to our customers
- Largest power distributor in Denmark with 1 million customers
- Largest utility with 900,000 residential and industrial customers in Denmark

Bioenergy & Thermal Power

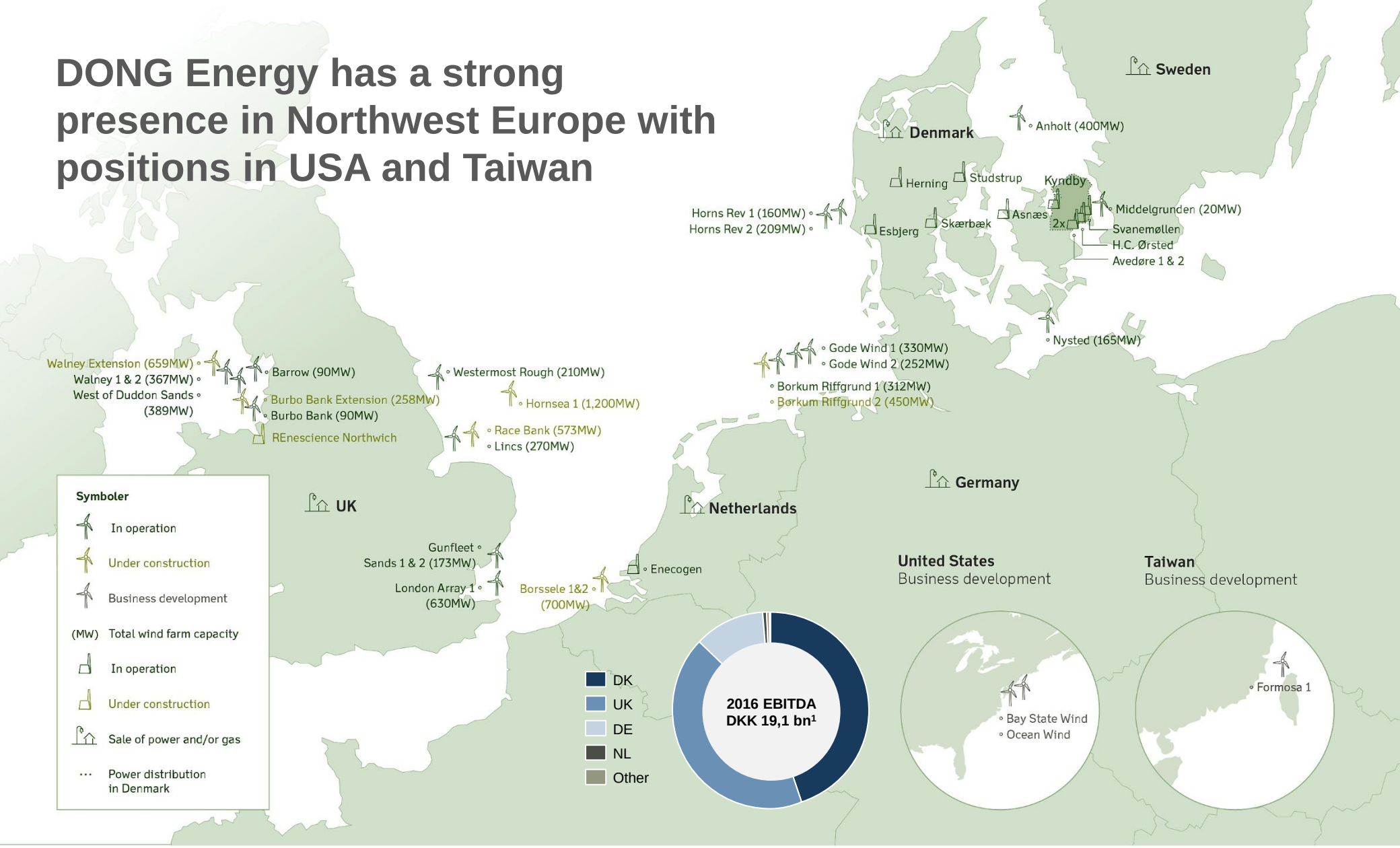
- EBITDA (2016): DKK 0.1 bn
- Generates heat and power at central heat and power stations
- #1 in Danish heat and power generation with a strong and increasing biomass position

Oil & Gas[3]

- EBITDA (2016): DKK 6.5 bn
- Exploration and production of oil and gas
- Focused position with activities in Norway, Denmark and UK
- High quality, low-cost core assets
- Process to exit Oil & Gas initiated

1. Continuing operations
2. One-offs from renegotiations of long-term gas contracts: DKK 4.3 bn
3. Discontinued operations

DONG Energy has a strong presence in Northwest Europe with positions in USA and Taiwan



1. Continuing operations

State of the climate 2016

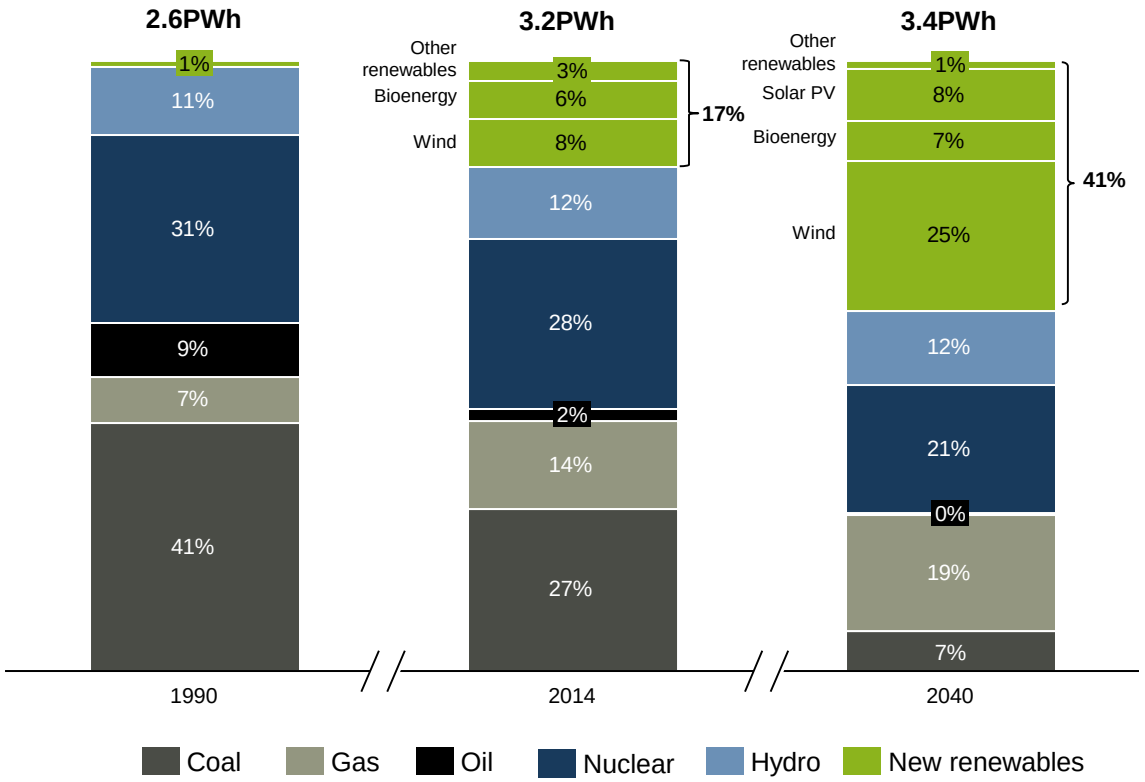
- The concentration of greenhouse gas emissions in the atmosphere has never been higher
- Warmest year ever recorded
- The extent arctic sea ice is lowest ever recorded
- Water levels in the oceans are the highest ever recorded
- Areas in ‘severe’ drought rose dramatically

Source: The World Meteorological Organization

Structural transformation of European power

Production from renewables forecasted to more than double in the European power mix by 2040

%



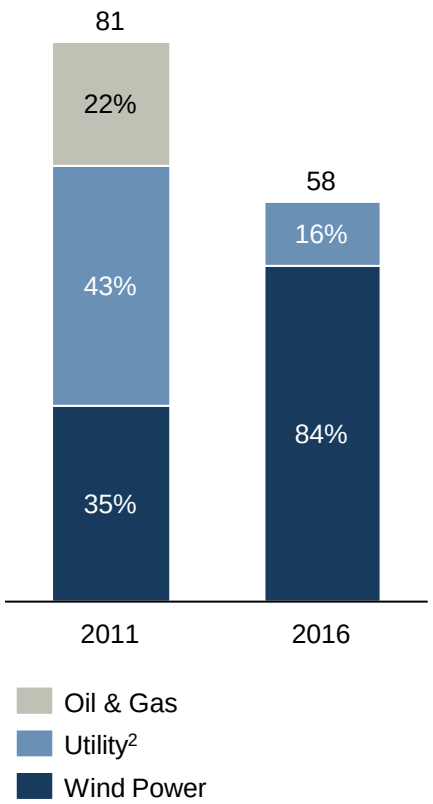
Source: IEA 2016, World Energy Outlook; European Union, New Policies Scenario

Multiple factors driving European transition away from fossil fuels

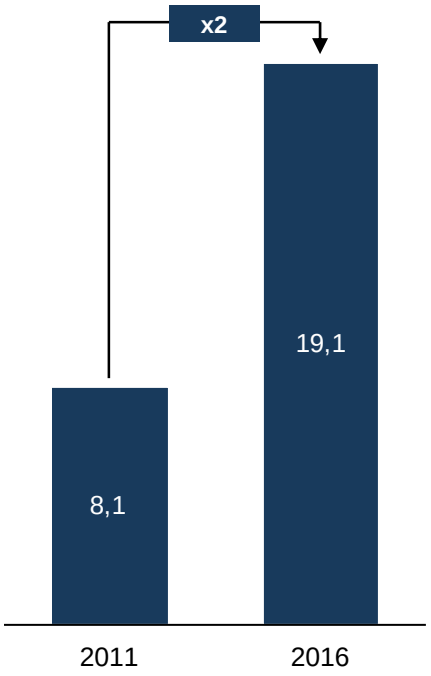
- **De-carbonisation**
- **Replacement of aging capacity**
- **Security of supply**
- **Local job creation**

DONG Energy is transforming its business model

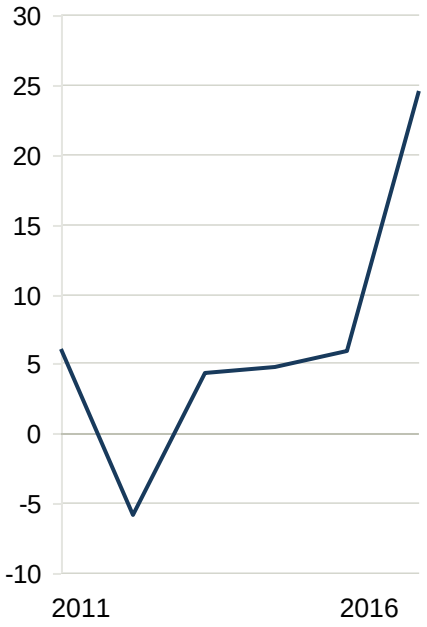
Business mix transformed
Share of capital employed
DKK billion[1]



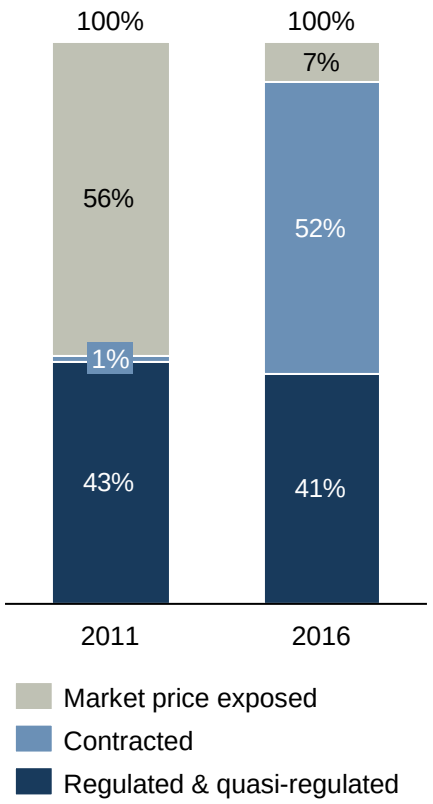
Operating profit doubled
EBITDA, DKK billion[1]



Increasing return
Adjusted ROCE, %[1]



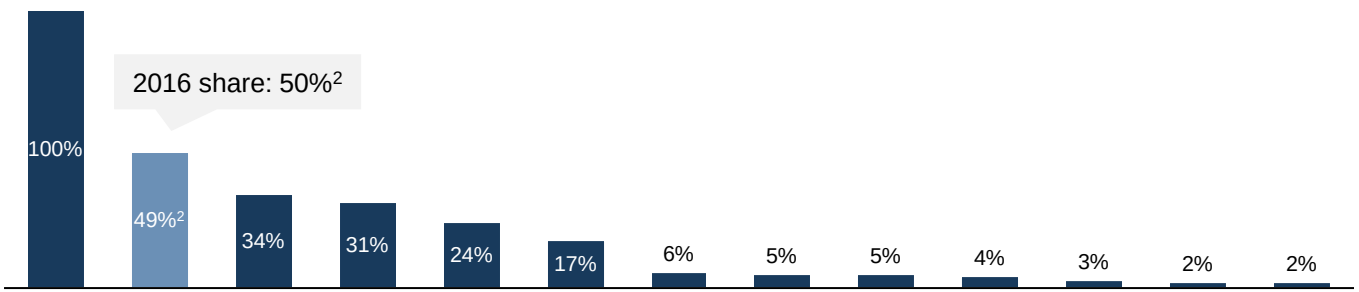
Earnings quality increasing
Share of regulated EBITDA, %[1,3]



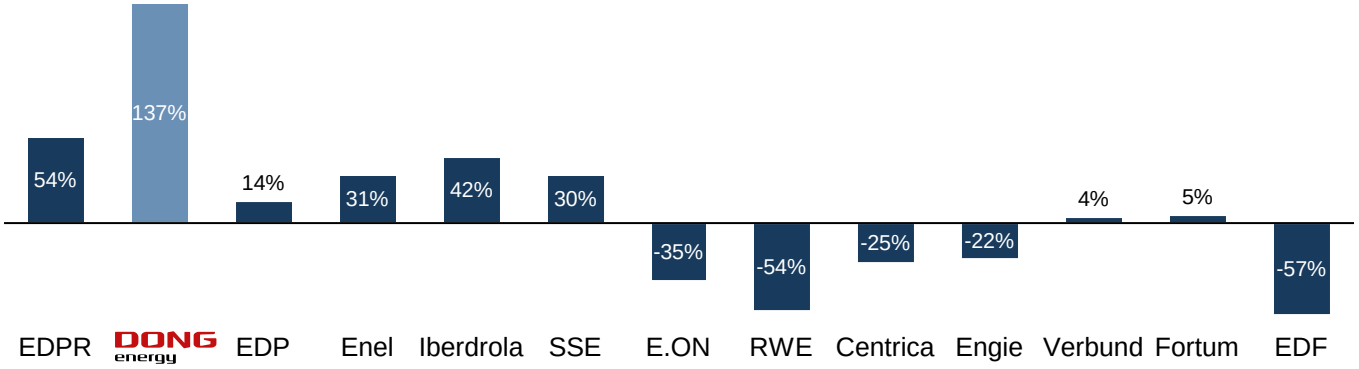
1. Continuing operations
2. Includes Bioenergy & Thermal Power and Distribution & Customer Solutions
3. Excluding one-offs and Gas Distribution EBITDA

Early shift towards renewables has driven strong shareholder returns

2015 generation from new renewables in % of total power generation[1]



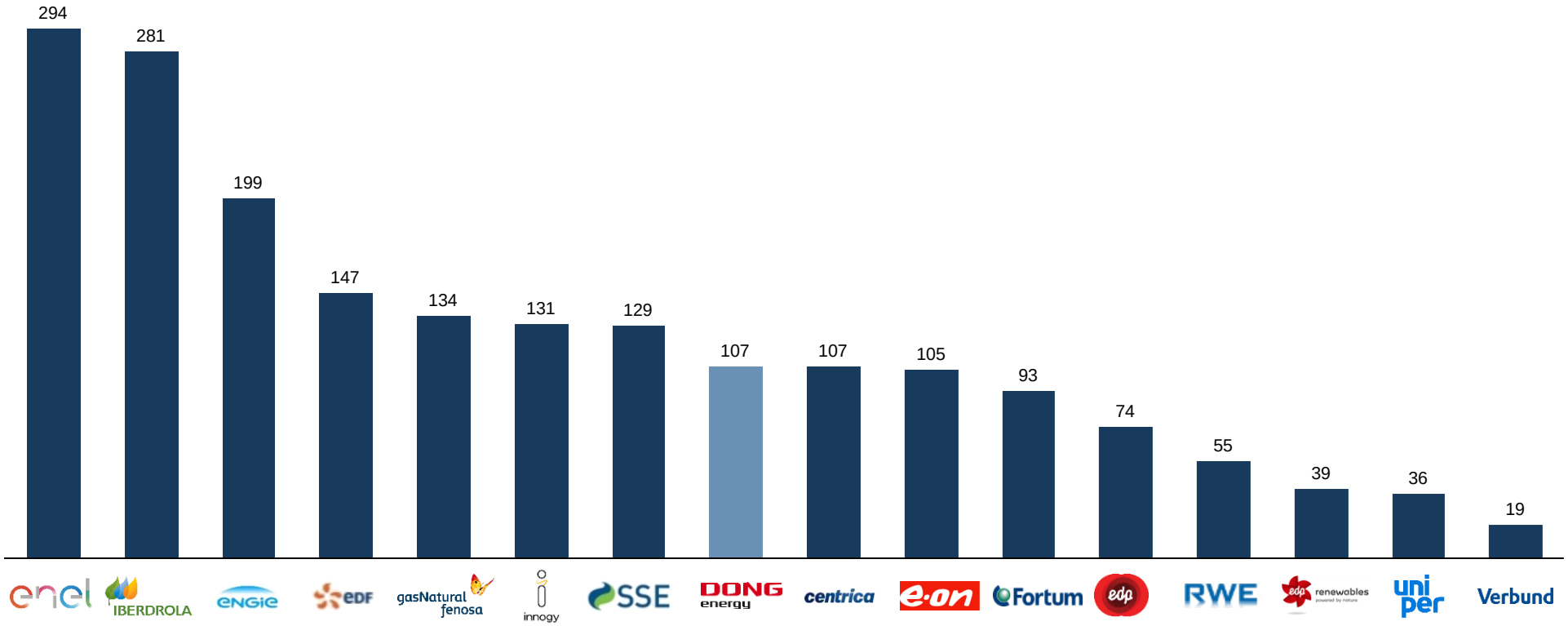
Total shareholder return (29 Nov 2013 to 2 Feb 2017)



Source: FactSet, Company reports and other publicly available information. Peer group is composed of the largest listed European energy companies
1. New renewables include onshore wind, offshore wind, solar PV, and bioenergy
2. Renewables as share of total generated heat and power

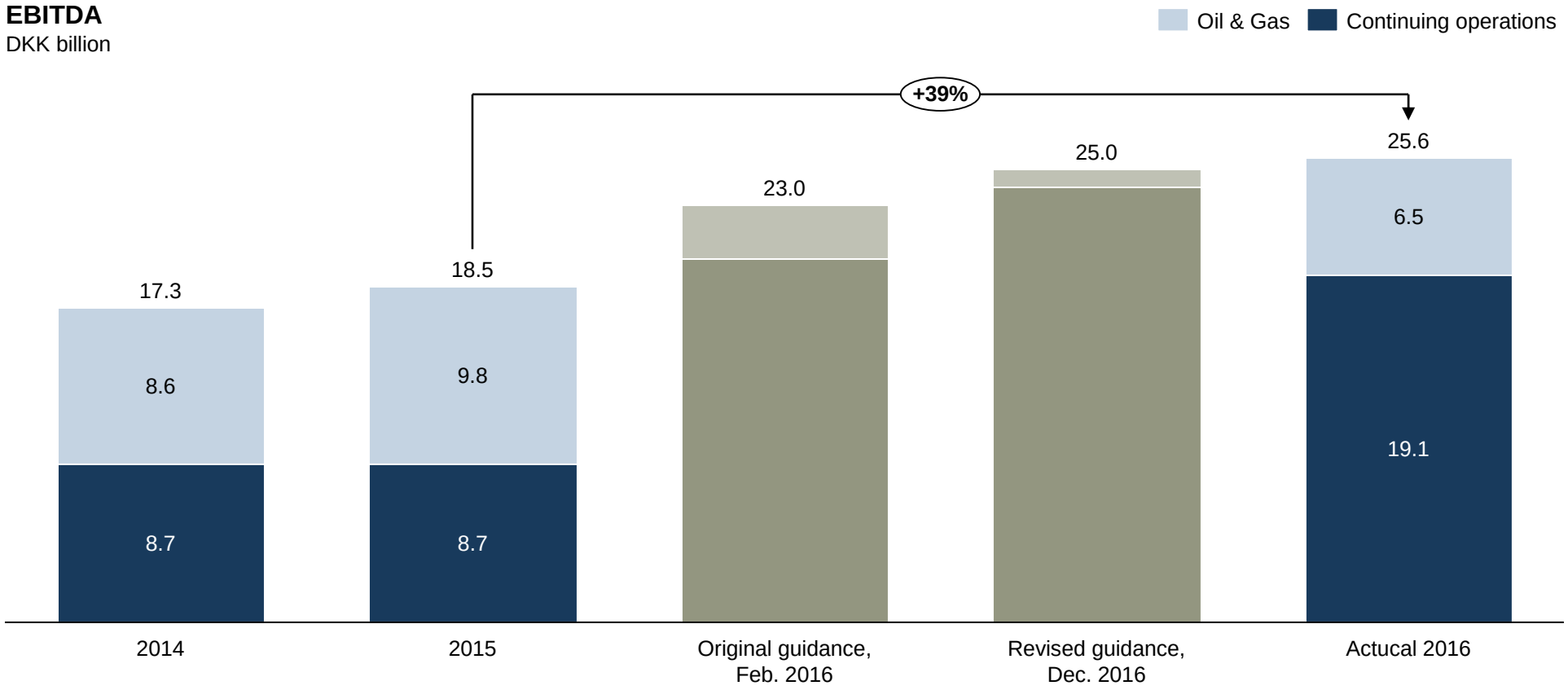
DONG Energy has emerged as a mid-sized European energy player

Market cap of largest European energy groups
DKK billion



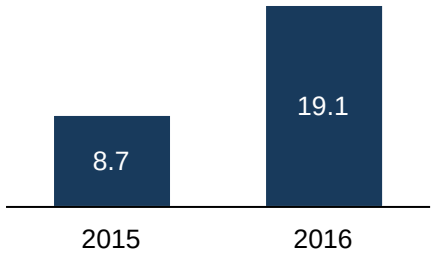
Source: FactSet, 2 Feb, 2017

Strong performance in 2016

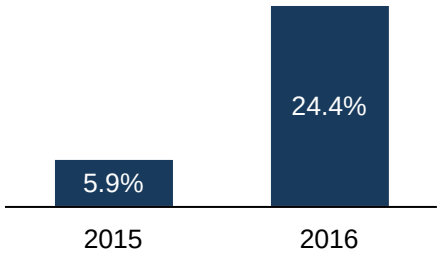


2016 was a very good year

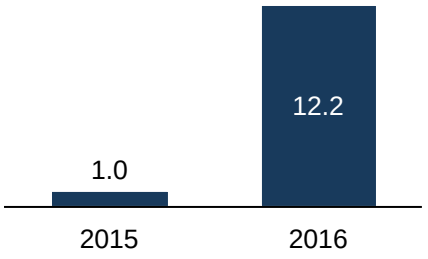
EBITDA
DKK billion[1]



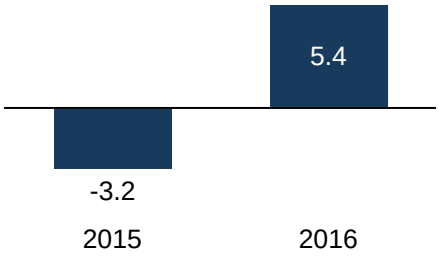
Adjusted ROCE
%[1]



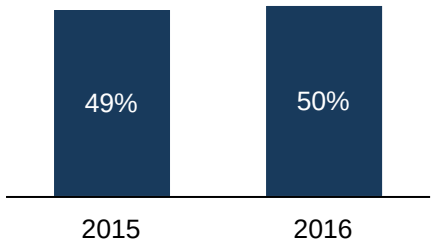
Net profit
DKK billion[1]



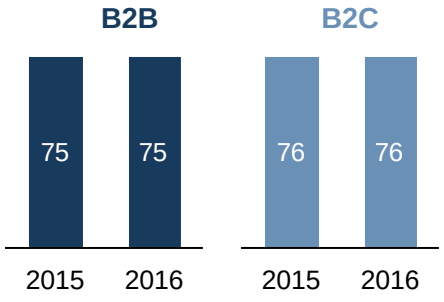
Free cash flow
DKK billion[1]



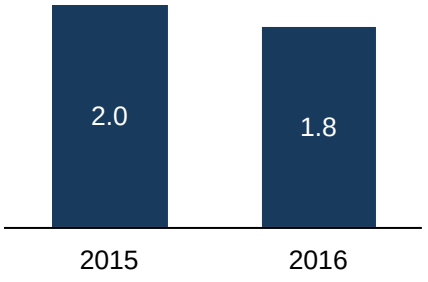
Renewable share of generation
%[2]



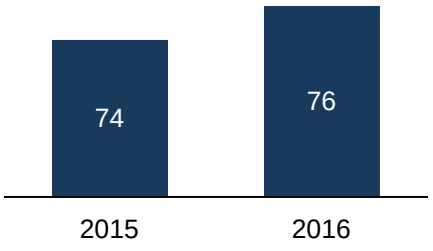
Customer satisfaction
Scale (1-100)



Safety performance
LTIF[1,3]



Employee satisfaction
Scale (1-100)[1]



1. Continuing operations
2. Renewables as share of total generated power and heat
3. # of lost-time injuries within a given accounting period relative to the total # of million hours worked in the same accounting period

DONG Energy's strategic direction remains clear

Group

- Lead the market in the transition to sustainable energy
- Compete from market-leading positions and grow through innovation
- Leverage existing strongholds and build long-term growth options

WP

Fuel global market leadership and profitable growth – ambition of 11-12GW capacity by end of 2025

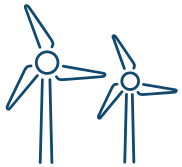
BTP & DCS

Transform BTP and DCS to smart, green and growing businesses

O&G

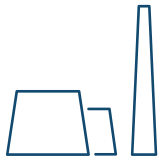
Drive value and strength of Oil & Gas and prepare for new ownership

Business Units' objectives support strategic direction



Wind Power

- Maintain the position as global market leader
- Support profitable growth by realising our current build-out plan for the period towards 2020
- Expand installed capacity to 11-12GW (ambition) by 2025 provided that the risk and return profile is sound
- Continue to reduce the cost of electricity for offshore wind through industrialisation, economies of scale and innovation



Bioenergy & Thermal Power

- Continuously strengthen operational excellence
- Continue the conversion of Danish CHP plants to sustainable biomass
- Phase out the use of coal and stop using coal from 2023
- Continue the commercial development of our enzymatic waste technology REnescience

Distribution & Customer Solutions

- Maintain a high level of security of supply and customer satisfaction in our distribution business
- Further strengthen competitiveness and customer satisfaction among residential and business customers in our sales business
- Optimise our energy portfolio and provide competitive market access

Oil & Gas

- Adapt to new market realities
- Transform Oil & Gas into a lean cash-generating business to fund investments in renewables
- Prepare for new ownership

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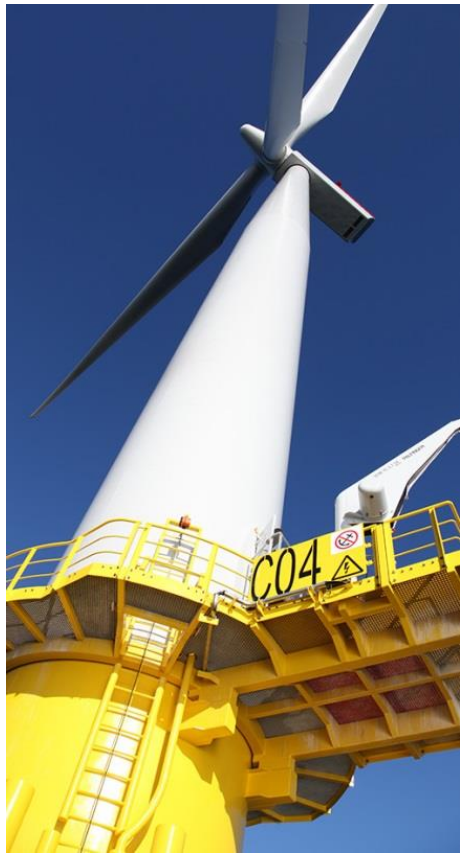
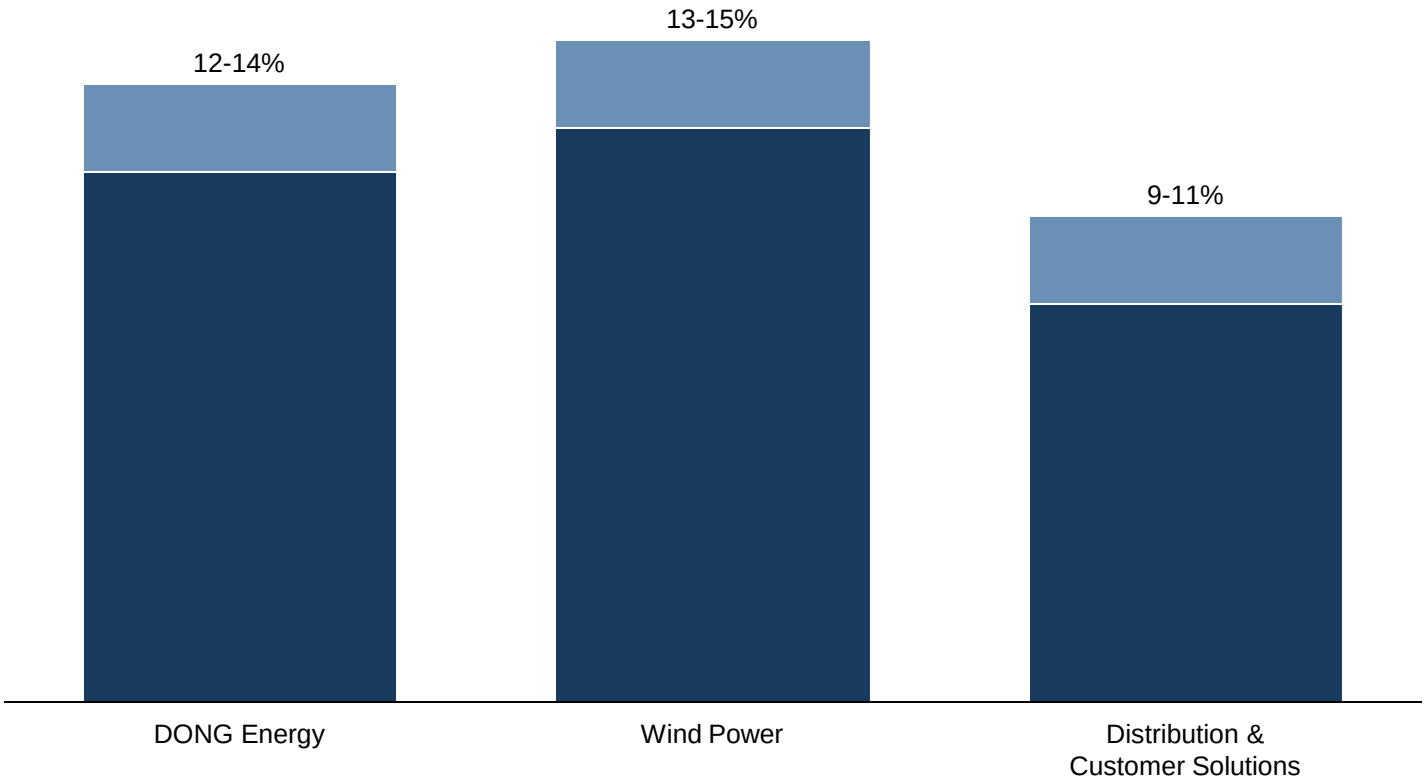
Return targets extended towards 2023



Average ROCE target 2017-2023

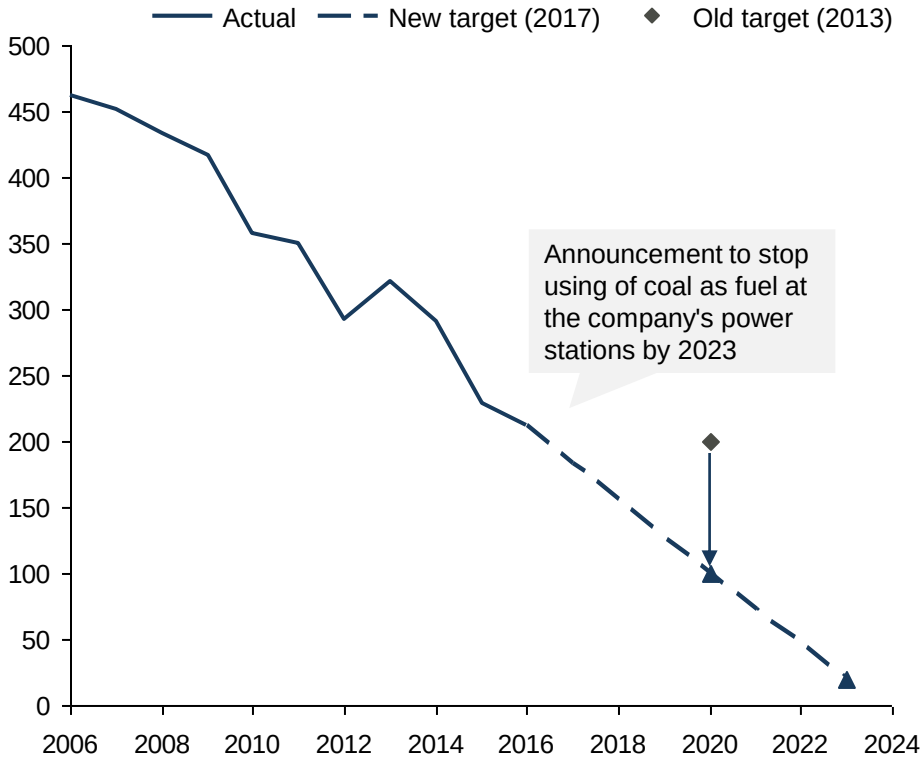
%

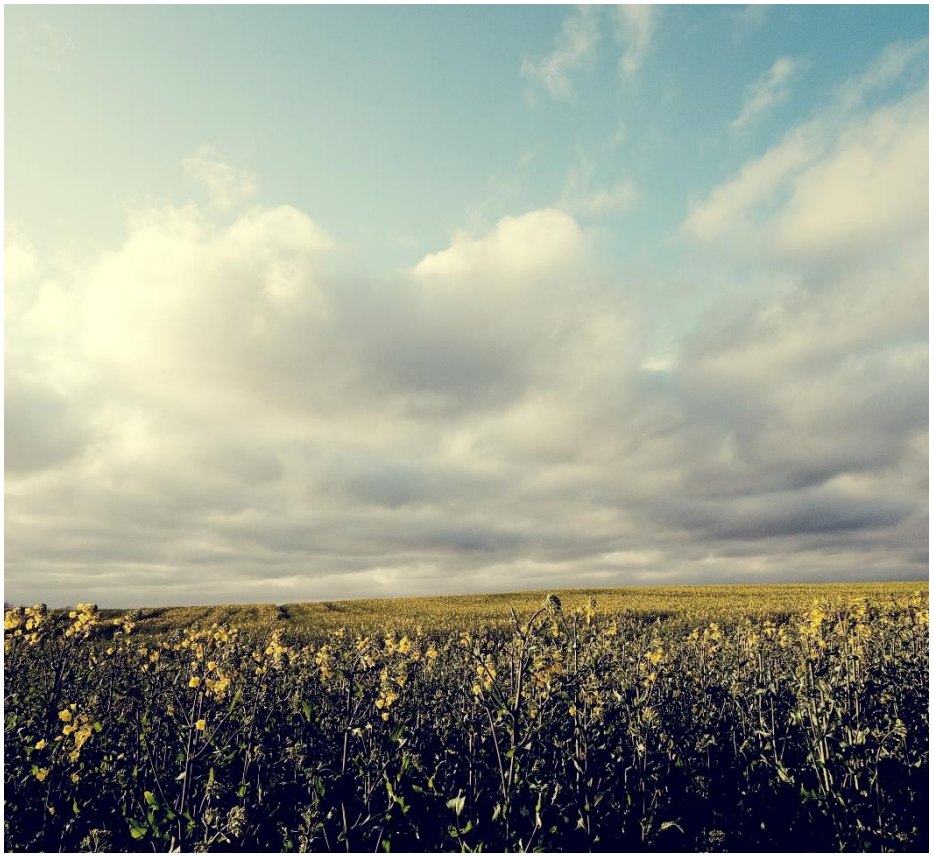


Significant decarbonisation of heat and power production – ambition to be coal-free by 2023

DONG Energy's reduced emissions of greenhouse gasses

g CO_2 equivalents[1] / kWh

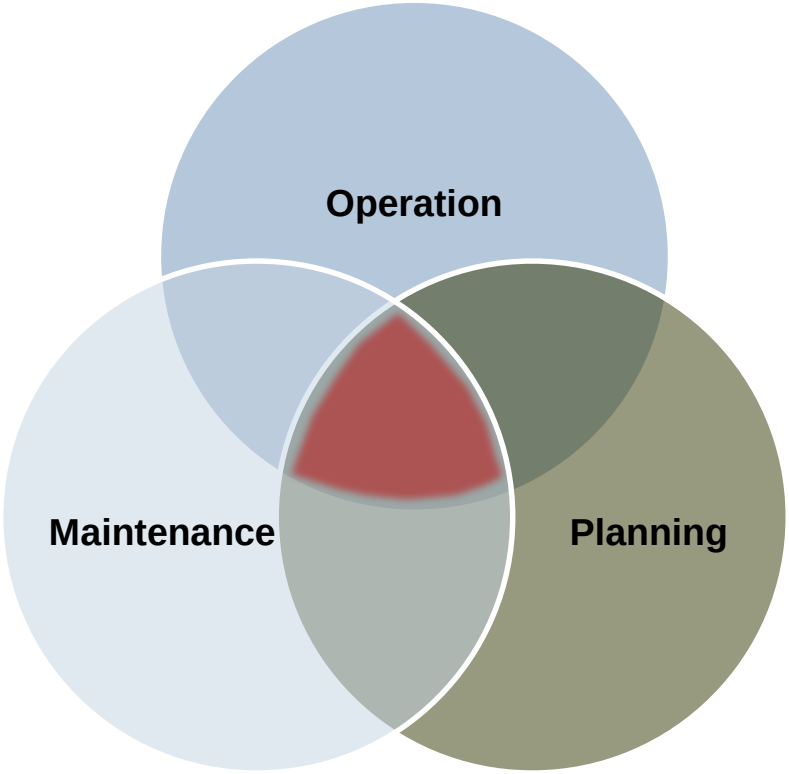




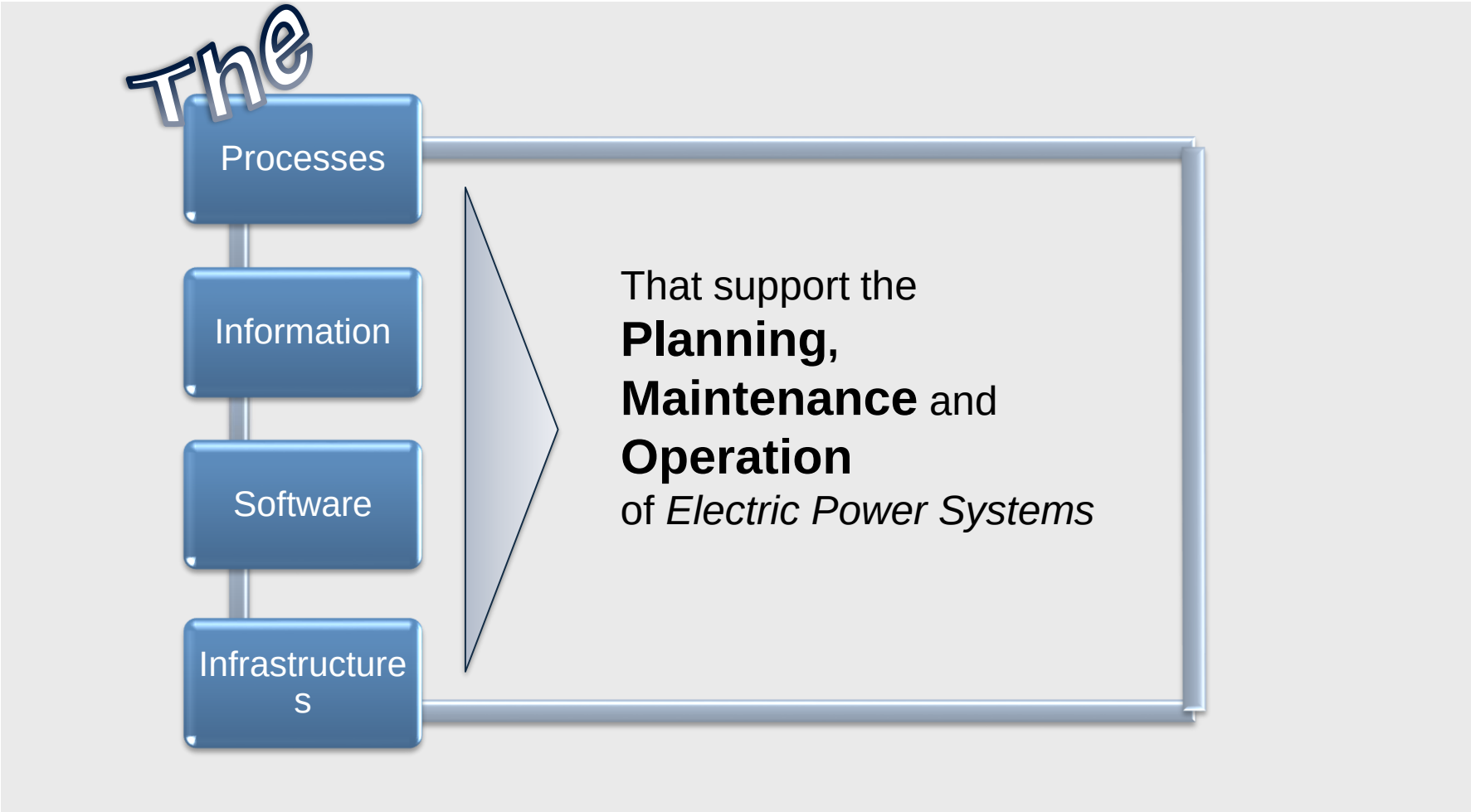
1. CO_2 equivalents is the standard unit for greenhouse gas emissions. The new definition includes all greenhouse gasses from thermal production, ie CO_2, N_2O and CH_4 in accordance with the Green House Gas Protocol. This means that for example the CH_4 emissions are converted into similar CO_2 emissions based on the green house gas potential of CH_4 and added to the CO_2 emissions.

Smart Energy is about implementing a data and process centric strategy.

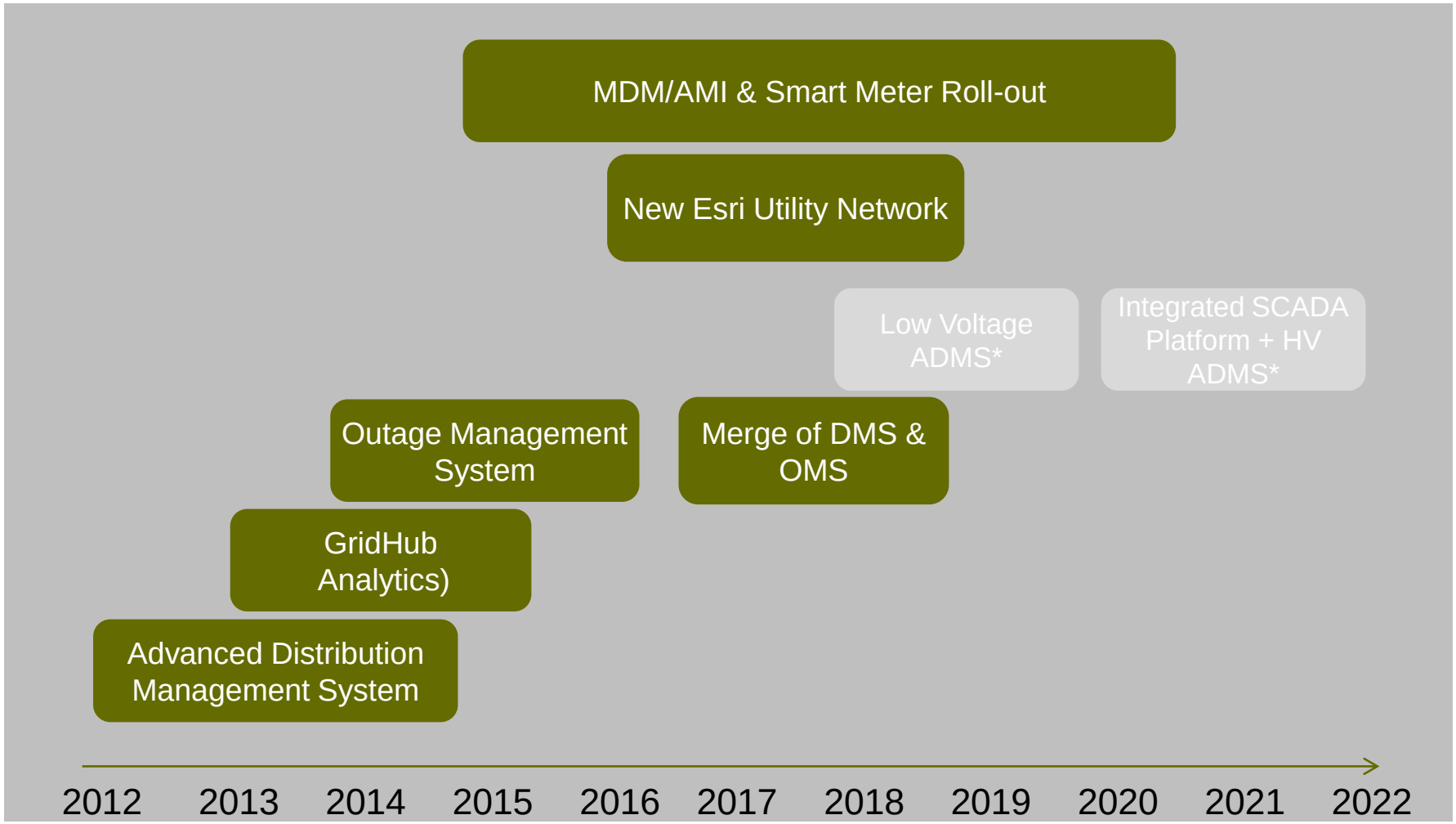
- Defining a transparent and communicated **master data management strategy**, delegating the responsibility of data ownership for each data component.
- Having aligned **business processes** across business units, integrating the Planning, Maintenance and Operation of the Critical Infrastructures into unified processes
- Implementing a **seamless integration** between software platforms ensuring process support and maintaining high data quality



Smart Grid Architecture – From an IT-perspective



DONG Energy Smart Grid Projects



* Future possible projects - Not decided

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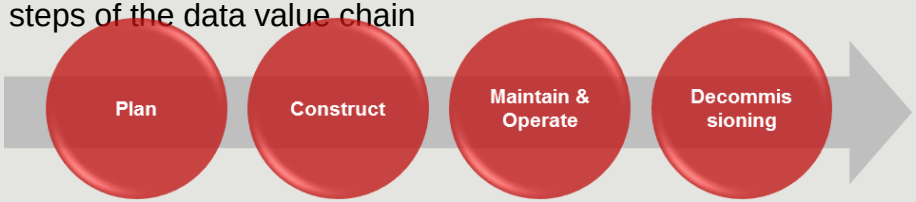
The Utility Network Project: Objective & Scope

Objectives & Goals:

- Cost Reduction
- Low cost maintenance and agile development
- The data model is the best possible representation of reality
- The data model supports all relevant business processes
- Data is collected as close to the origin as possible
- GIS data is easy available across processes and applications
- GIS supports enrichment and quality assurance of data in all steps of the data value chain



Implementing the Utility Network

- **Creating a Utility Network Data Model**
- **Migration Tool & Migration**
- **Design Tool & QA**
- **Task List**
- **Editing Tools**
- **Reporting Tool**
- **Integration to DMS and OMS**
- **Integration to SAP**
- **Integration to Work Manager & Geo.e**

Project Scope – supporting more business processes

Phase 1: Implementing the Utility Network

- Creating a Utility Network Data Model
- Migration Tool & Migration
- Design Tool & QA
- Task List
- Editing Tools
- Reporting Tool
- Integration to DMS and OMS
- Integration to SAP
- Integration to Work Manager & Geo.e

Later phases: Possible Projects

- Automating import of as-build information
- Supporting Design Sketches
- Adding simple load estimation to designs
- Adding Price Calculations to designs
- Evaluate Contractor Invoices
- Managing Estimates to Contractors
- Support Condition Based Maintenance
- Support Grid Value Estimation
- Support full Project Life Cycle
- Support for future LER requirements
- Support field crews with schematics information

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Work Items – Topics to be addressed

1 Data Models

- Domain models ability to represent the needed grid configurations
- Will the expressiveness of rules meet the requirement form
- How can versioning and temporal aspects of the model cover the grid change processes?

2 Business Process Support

- What constructs for modelling business processes will be available?
- How can these be customized and extended?
- Will where be Utility Specific workflow supported natively, e.g. will end to end construction projects be supported?
- How is install and un-install processes supported?

3 User Experience

- What can we expect from Esri in term of user interfaces covering typically utility production processes?
- How can we extend and combine delivered UI's to cover specific needs?

4 Programming Interfaces

- How can be build applications on top of the Utility Model?
- Which strategy should we use to deploy the same or similar functionality on several platforms?
- What part of the SDK and API's would should we start out with?

5 Integrations

- How will the overall system architecture be?
- Which data should be distributed across multiple platforms, and
- How will we do this?
- Which tools will be included to exchange data with 3rd party systems

6 Migration

- What tools will be available to support the migration?
- How can we keep up with model changes in the mapping to the Utility Model?
- What is the recommended migration strategy and process?

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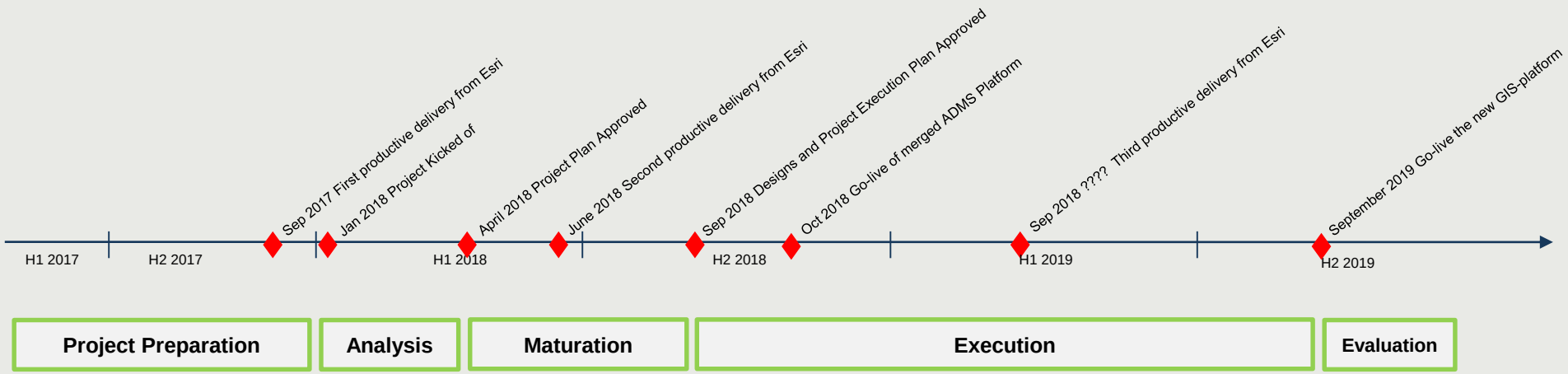
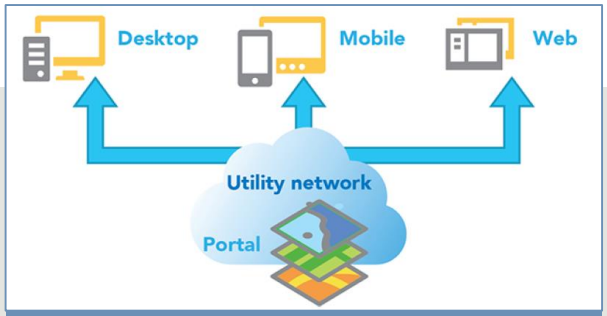
Project Milestone Plan



The Utility Network….



- Implements the next generation geospatial platform for Utilities
- With a responsive data model capturing both Asset and Operational aspects of the infrastructure
- Using a completely new multi-threaded, 64bit, service based architecture
- And leveraging the advanced technologies to all part of the Esri Technology Stack, including desktop, web, cloud, and mobile technologies.

Technology

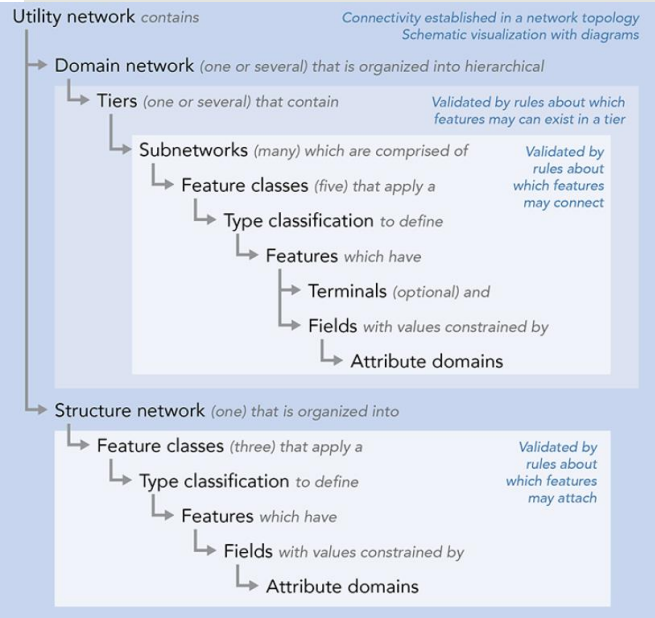
- Is optimized for high-performance and is scalable to very large utilities
- Models how every component of the grid is connected
- Represents dense area of the grid without map clutter
- Enforce data integrity and reduce data entry errors
- Enables advanced analytics on the grid
- Gives a comprehensive view of the grid

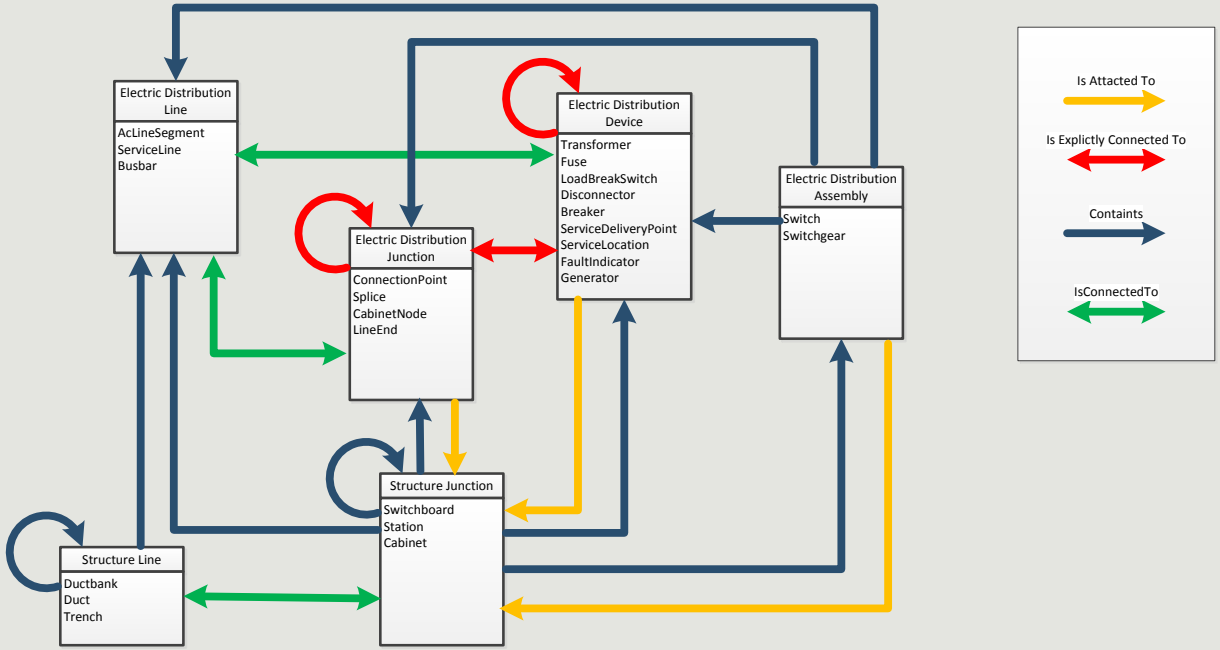
Functionality

- Supports end-to-end business processes
- Reduces the cost and increase the quality of documentation processes
- Contributes to the operational efficiency of the grid
- Optimizes the maintenance processes reducing the overall cost
- Supports long term planning

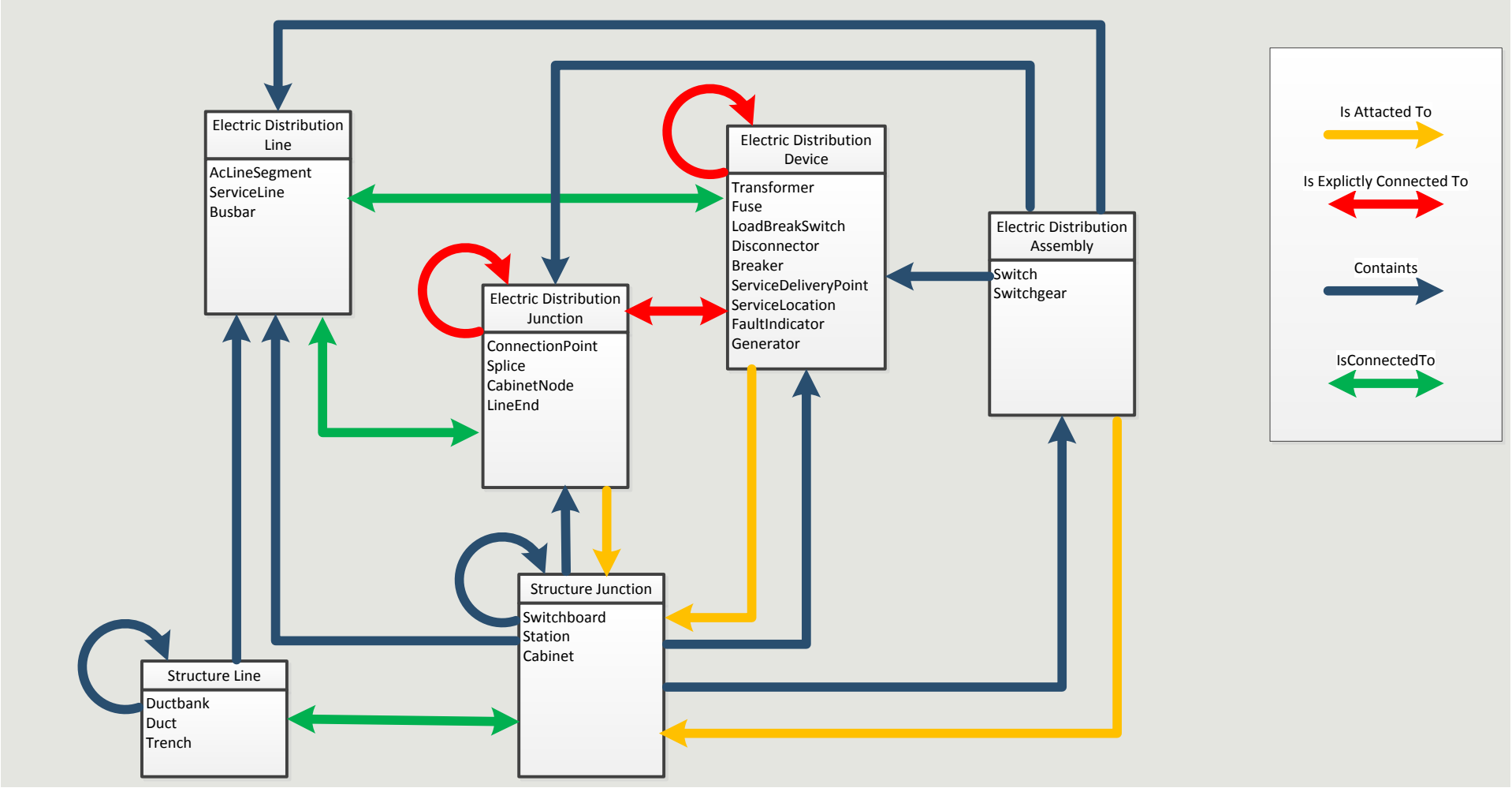
Business Value

The Utility Network – the model

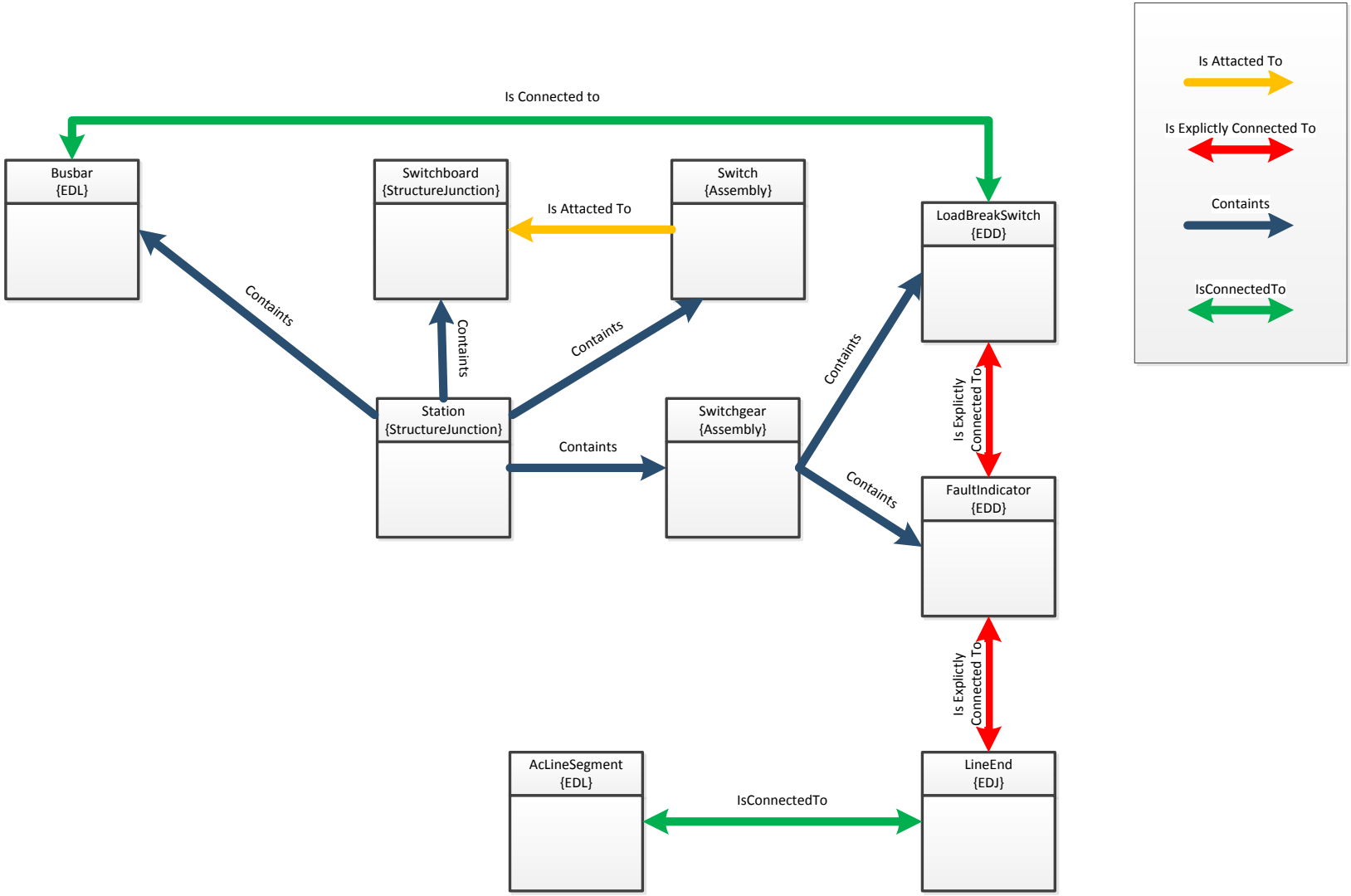




Feature Classes, Asset Groups & Relationship Types



Asset Groups, Asset Types and Relations ships – An example



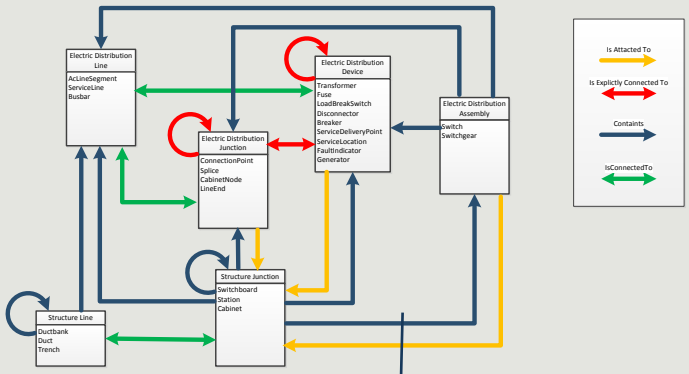
Data migration

Mapping configuration

	A	B	C	D	E	F	G	H	I
1	OriginFeatureClass	OriginSubtype	OriginWhere	DestinationFeatureClass	DestinationSubtype	DestinationAssetType	OriginAttribute	DestinationAttribute	Format
570	GEOADM.LowVoltageDistributionBo	Kabelskab - radialnet		StructureJunction	Cabinet	Servicecabinet		CREATOR	
571	GEOADM.LowVoltageDistributionBo	Kabelskab - radialnet		StructureJunction	Cabinet	Servicecabinet		CREATIONDATE	
572	GEOADM.LowVoltageDistributionBo	Kabelskab - radialnet		StructureJunction	Cabinet	Servicecabinet		UPDATEDBY	
573	GEOADM.LowVoltageDistributionBo	Kabelskab - radialnet		StructureJunction	Cabinet	Servicecabinet		LASTUPDATE	
574	GEOADM.LowVoltageDistributionBo	Kabelskab - radialnet		StructureJunction	Cabinet	Servicecabinet	StationNumber;Cabinetnumb	LabelText	{0}-{1}
575	GEOADM.LowVoltageDistributionBo	Kabelskab - radialnet		StructureJunction	Cabinet	Servicecabinet	GLOBALID	GlobalIdTxt	{0}
576									
577									
578	GEOADM.LowVoltageDistributionBo	Kabelskab u. deling - ø-/maskenet	Kabelskab m. deli	StructureJunction	Cabinet	Servicecabinet		Shape	MoveByVector:offset=0.10,
579	GEOADM.LowVoltageDistributionBo	Kabelskab u. deling - ø-/maskenet	Kabelskab m. deli	StructureJunction	Cabinet	Servicecabinet		Assettype	servicecabinet
580	GEOADM.LowVoltageDistributionBo	Kabelskab u. deling - ø-/maskenet	Kabelskab m. deli	StructureJunction	Cabinet	Servicecabinet		CREATOR	
581	GEOADM.LowVoltageDistributionBo	Kabelskab u. deling - ø-/maskenet	Kabelskab m. deli	StructureJunction	Cabinet	Servicecabinet		CREATIONDATE	
582	GEOADM.LowVoltageDistributionBo	Kabelskab u. deling - ø-/maskenet	Kabelskab m. deli	StructureJunction	Cabinet	Servicecabinet		UPDATEDBY	
583	GEOADM.LowVoltageDistributionBo	Kabelskab u. deling - ø-/maskenet	Kabelskab m. deli	StructureJunction	Cabinet	Servicecabinet		LASTUPDATE	
584	GEOADM.LowVoltageDistributionBo	Kabelskab u. deling - ø-/maskenet	Kabelskab m. deli	StructureJunction	Cabinet	Servicecabinet	Cabinetnumber	LabelText	{0}
585	GEOADM.LowVoltageDistributionBo	Kabelskab u. deling - ø-/maskenet	Kabelskab m. deli	StructureJunction	Cabinet	Servicecabinet	GLOBALID	GlobalIdTxt	{0}
586									
587									
588	GEOADM.LowVoltageDistributionBo	Forsyningsskab - ø-/maskenet		StructureJunction	Cabinet	Supplycabinet		Shape	
589	GEOADM.LowVoltageDistributionBo	Forsyningsskab - ø-/maskenet		StructureJunction	Cabinet	Supplycabinet		Assettype	SupplyCabinet
590	GEOADM.LowVoltageDistributionBo	Forsyningsskab - ø-/maskenet		StructureJunction	Cabinet	Supplycabinet		CREATOR	
591	GEOADM.LowVoltageDistributionBo	Forsyningsskab - ø-/maskenet		StructureJunction	Cabinet	Supplycabinet		CREATIONDATE	
592	GEOADM.LowVoltageDistributionBo	Forsyningsskab - ø-/maskenet		StructureJunction	Cabinet	Supplycabinet		UPDATEDBY	
593	GEOADM.LowVoltageDistributionBo	Forsyningsskab - ø-/maskenet		StructureJunction	Cabinet	Supplycabinet		LASTUPDATE	
594	GEOADM.LowVoltageDistributionBo	Forsyningsskab - ø-/maskenet		StructureJunction	Cabinet	Supplycabinet	Cabinetnumber	LabelText	{0}
595	GEOADM.LowVoltageDistributionBo	Forsyningsskab - ø-/maskenet		StructureJunction	Cabinet	Supplycabinet	GLOBALID	GlobalIdTxt	{0}
596									
597									
598	GEOADM.LowVoltageDistributionBo	Forsyningsskab - ø-/maskenet		ElectricDistributionJunction	ConnectionPoint	Busnode		Shape	MoveByVector:offset=0.10,
599	GEOADM.LowVoltageDistributionBo	Forsyningsskab - ø-/maskenet		ElectricDistributionJunction	ConnectionPoint	Busnode		Assettype	Busnode
600	GEOADM.LowVoltageDistributionBo	Forsyningsskab - ø-/maskenet		ElectricDistributionJunction	ConnectionPoint	Busnode		CREATOR	

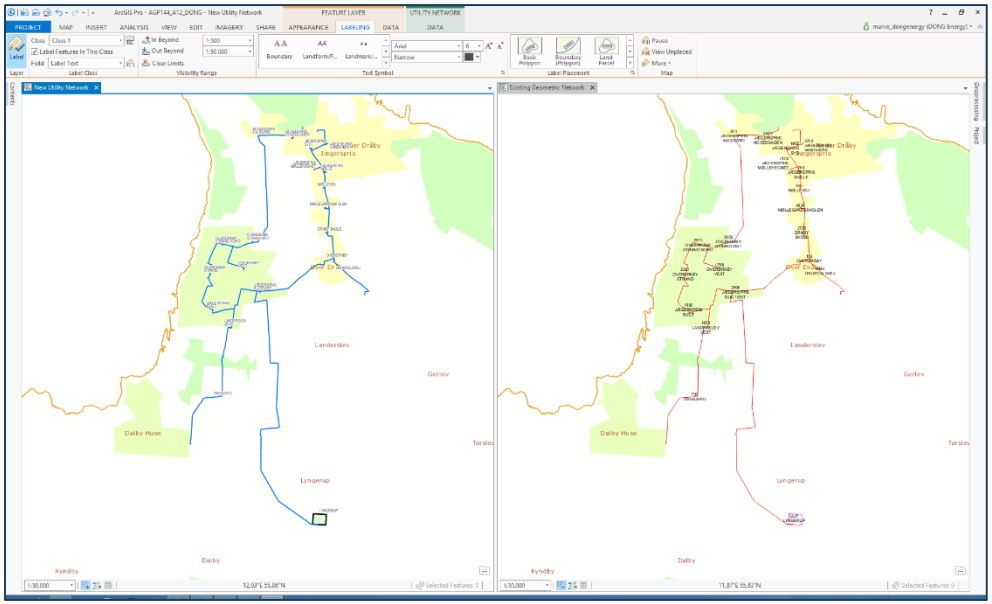
Mapping | Domain | Attachment | Containment | Connectivity | ObjectType Mapping | Subtypes | Noter

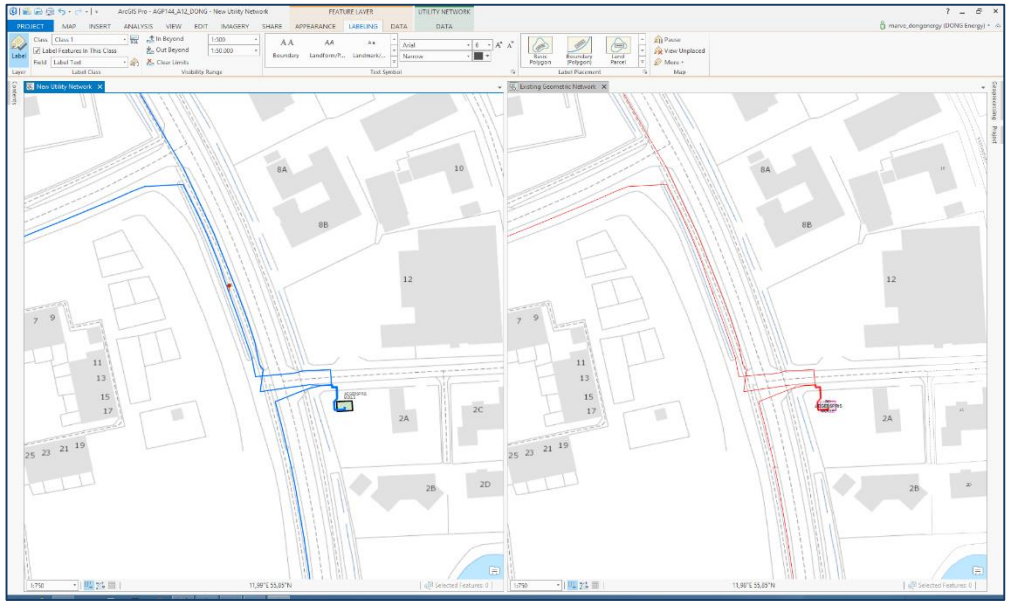
New Data model

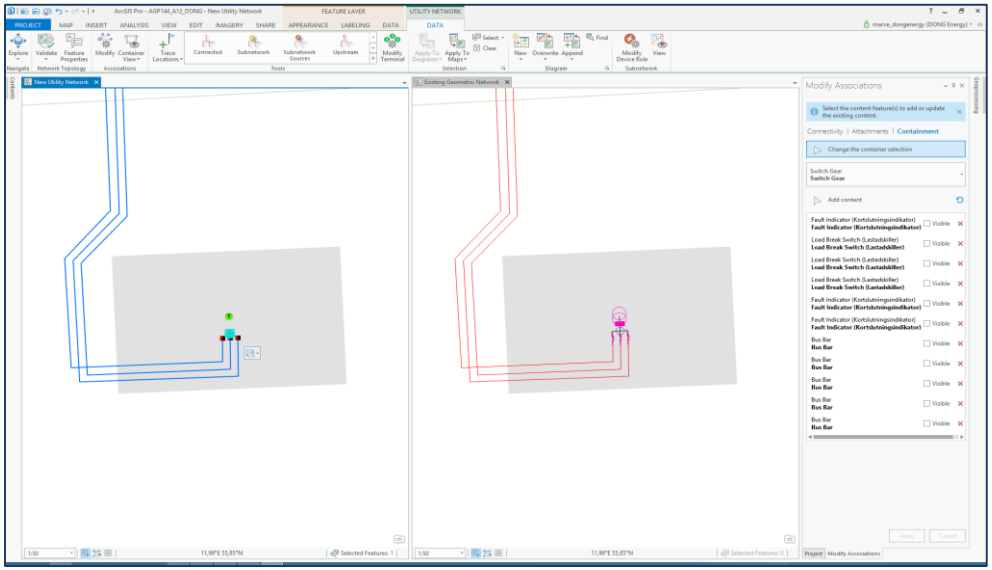


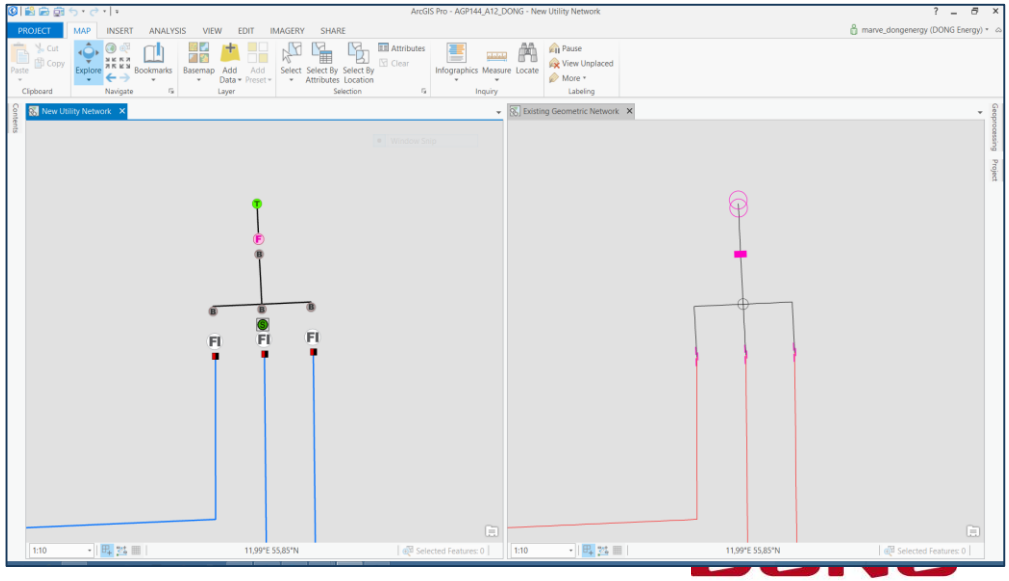
Existing GIS Database → **Migration Tool** → **New Database with the Utility Network**

Migrated data – examples

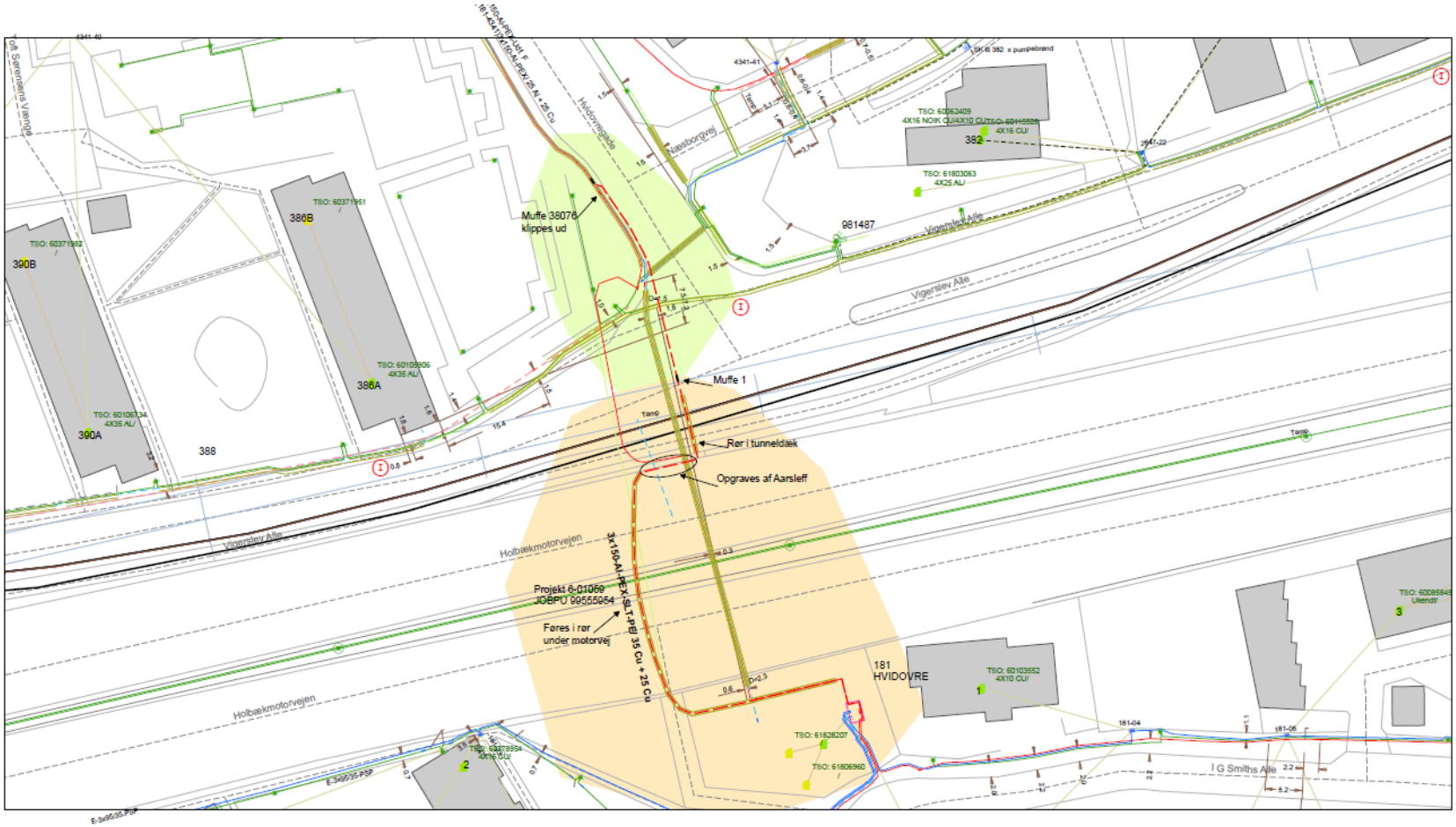








Supporting complex projects



Etape 1 - Nyt kabel fremføres i rør fra Stat. 181 til ny muffe 1

Etape 2 - Laves når byggeplads er ryddet

METER 0 10 20 30 40

Målforhold 1:500

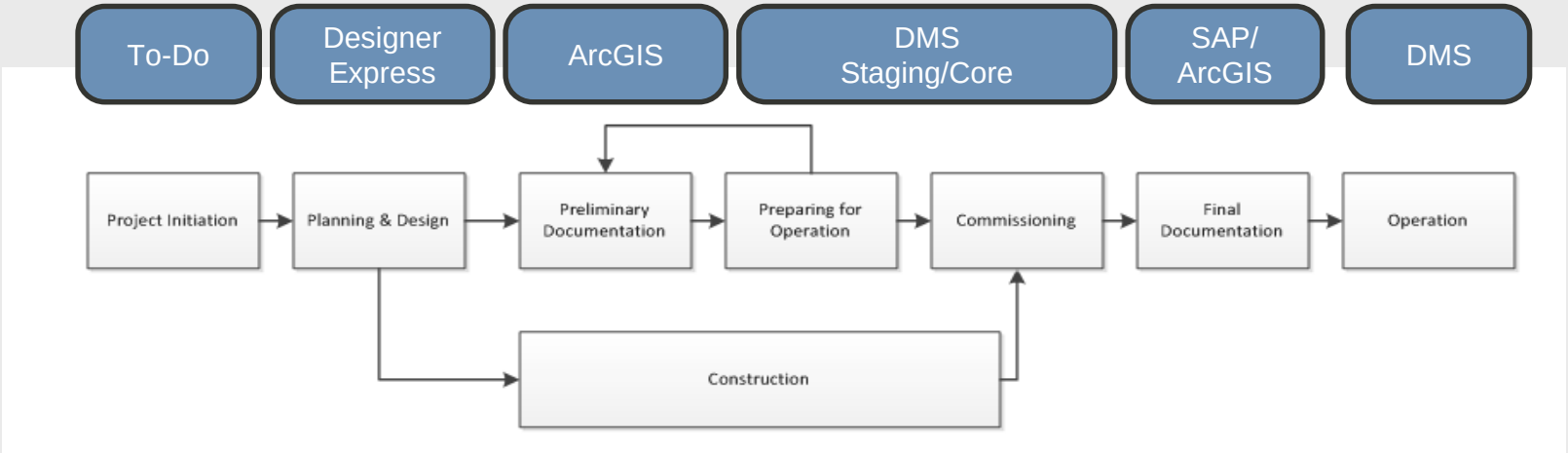
Rød
Gul
Blå

OBS!
På denne projektplan er alle oplysninger ikke nødvendigvis opdateret.
Inden der graves, skal der derfor rekvireres opdaterede ledningsplaner på
www.radiuselnet.dk/ledningsoplysninger.
Ledningsoplysninger: Telefon 70 20 58 00.

Radius	Ringstedsbanen LBL Hvidovrevej Endelig oml. af Ed0206		Projektleder: JOBPU Telefonnr.: 99555954 Projektnr.: 6-01059-07
Oprettet Dato: 12.08.2016	Rev. Dato: -	Initialer: SUSSL	Udgave: 1 Bladnr.: B05
Radius, Teknikerbyen 25, 2830 Virum, Tlf. 70 20 48 00			

DONG energy

Integrating GIS and DMS



Patch or incremental exports

- To support the life-cycle of projects, incremental changes or patches are used to describe added or removed components, that will be energized in one operation.

Full Feeder Export

- Full feeder export from GIS and SAP supports migration of data to DMS and will also be used for initial export of new feeders and to validate GIS and DMS model against each other.

Managing Long Transactions between multiple loosely coupled systems

Project manager
- Plans the work to be carried out
- Delivers plans to GIS documentation department
- Delivers finial documentation when the job is carried out.

Plan

GIS documentation
- Documents the plans for the project in GIS.
- Creates patch exports for DMS.
- Post changes in GIS when project is in production in DMS.
- Documents final implementation once information is received from project manger.

Document

DMS Model Manager
- Evaluates patches and approve them for later energization or reject them and return them to GIS for corrections.
- Draws schematic layout in DMS.
- Ensures that new data sent to DMS is correct.
- Handles full feeders containing final documentation of the network.

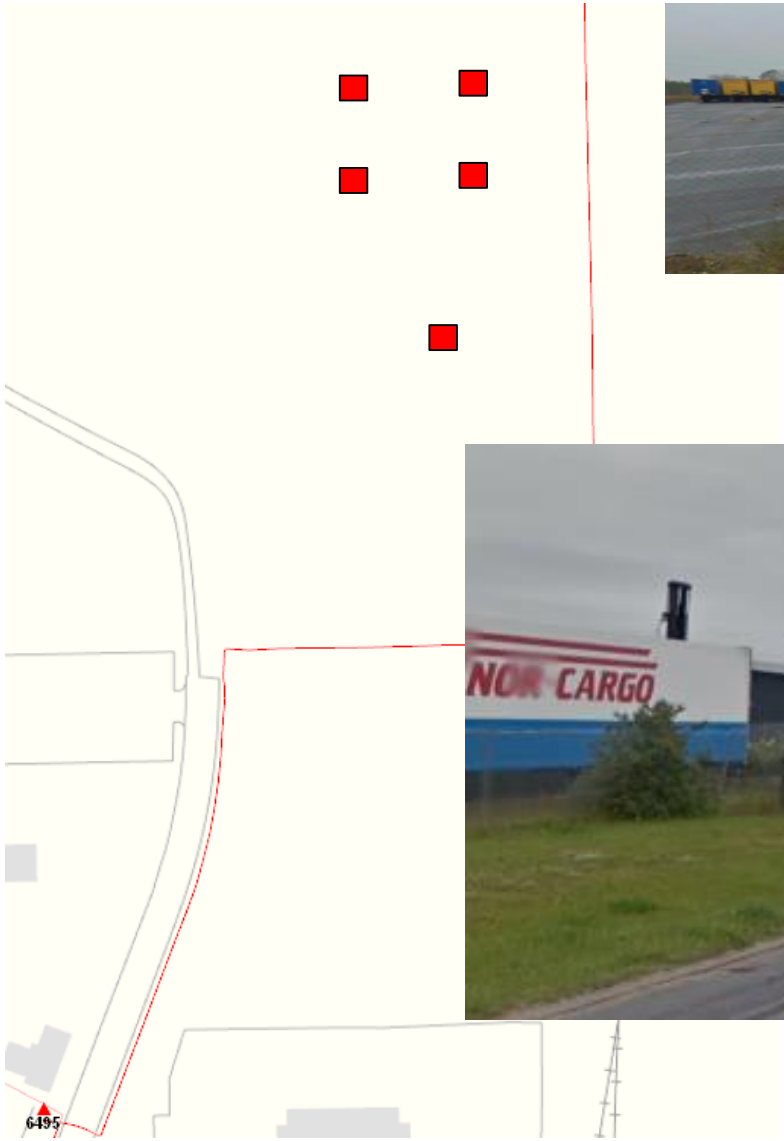
Prepare

Grid operator
- Controls the switching state of the network
- Communicates with the field crew during commissioning or decommissioning of equipment.
- Energize patches in DMS which updates the electric model and triggers feedback to GIS.

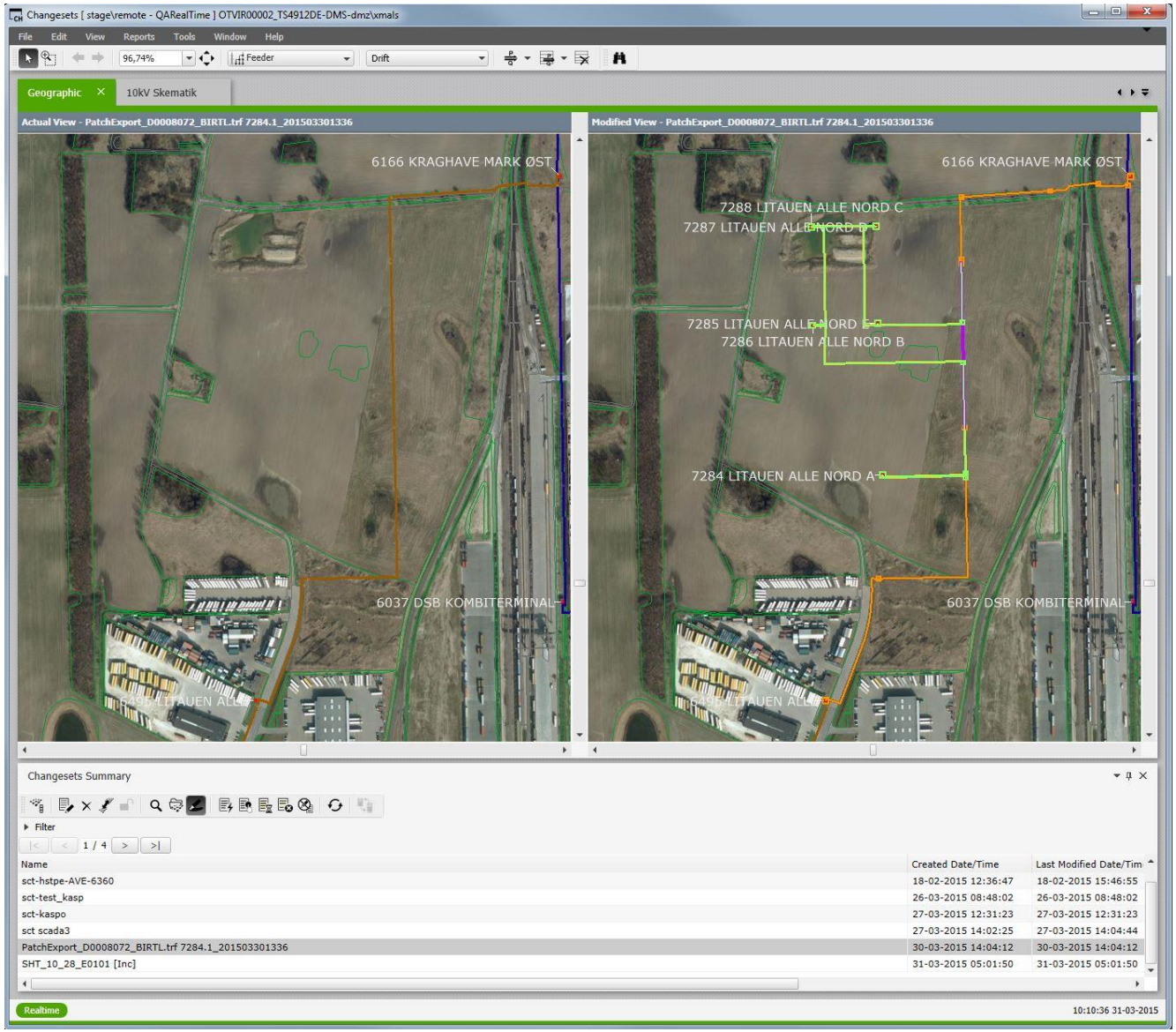
Commissio
ning

Field crew
- Follows the orders of the grid operator.
- Carries out the work planned by the project manager.
- Delivers information for final documentation of the finished project to the project manager

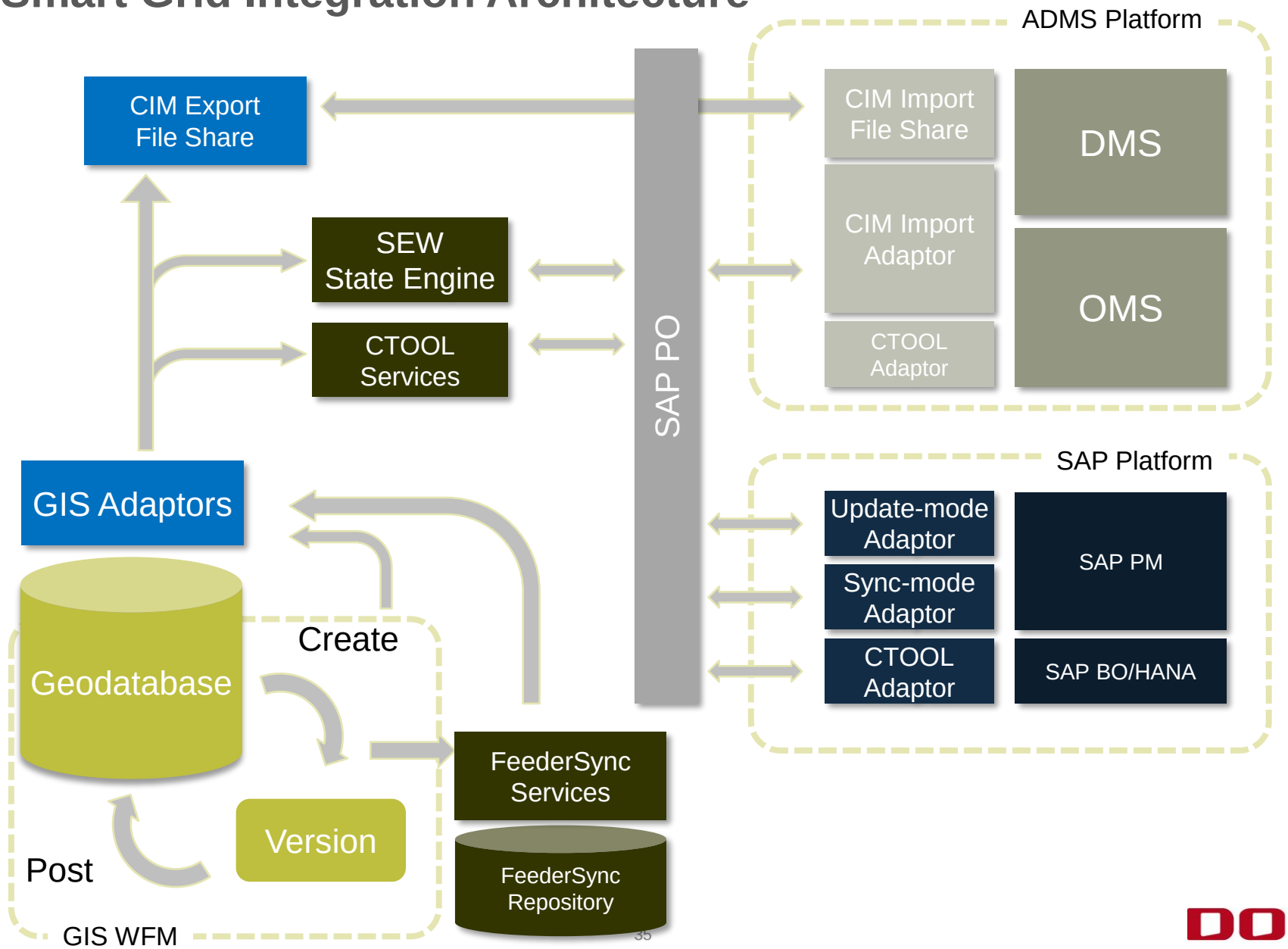
Case: New Transport Hub in Høje Taastrup



Network patch introducing new substations to the network

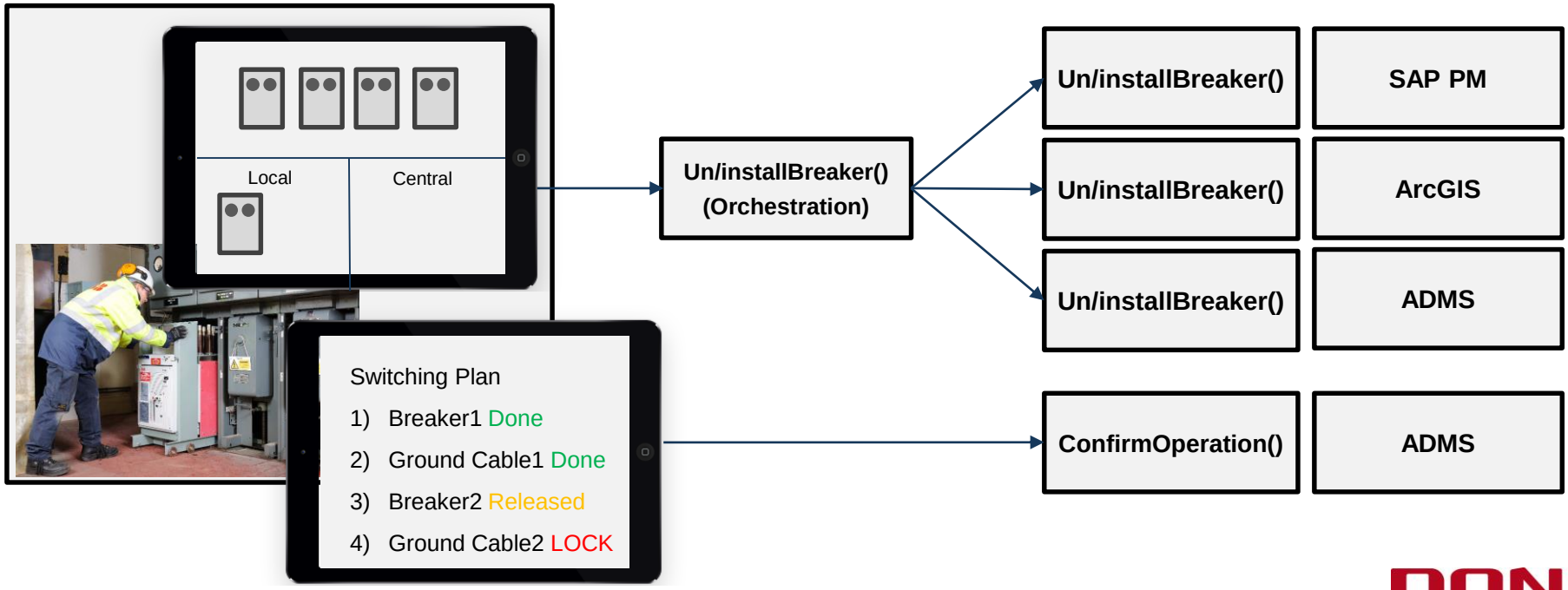


Smart Grid Integration Architecture



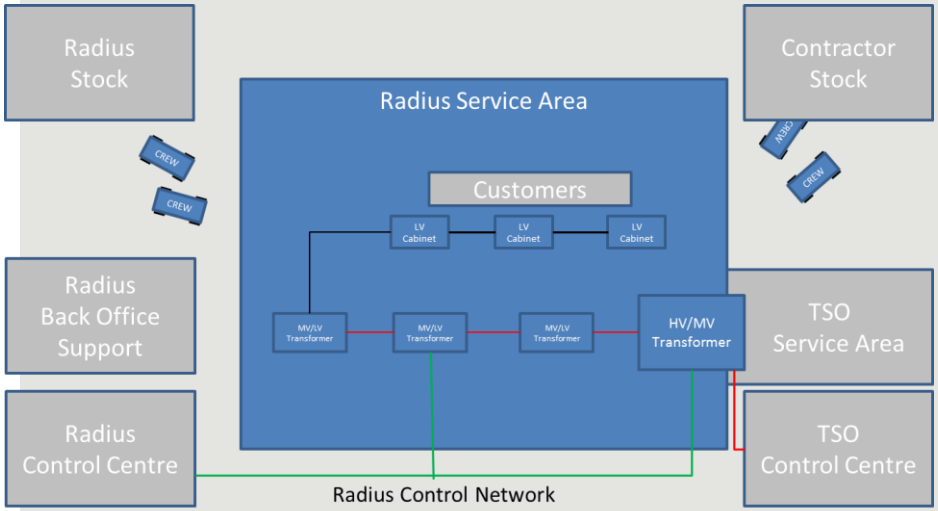
Supporting future field crew

Further integration of maintenance processes across technology platforms
Extend the use of GIS to analyze, explorer and visualize data
Streamline the current integration and dataflow
Support new business process for asset management and “Smart” Maintenance

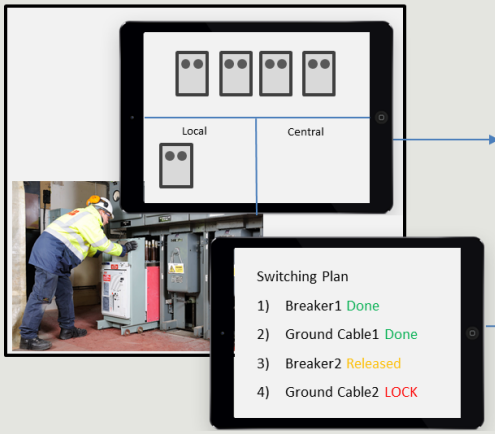


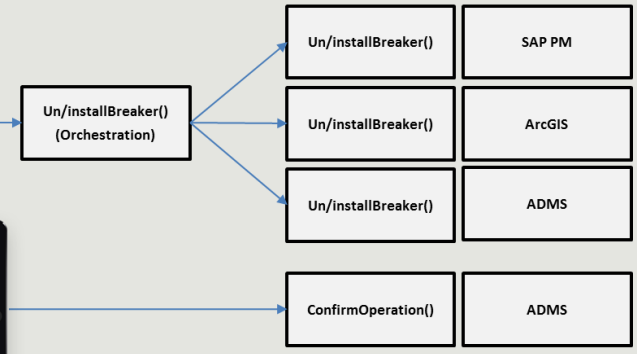
DONG energy

Supporting future asset management

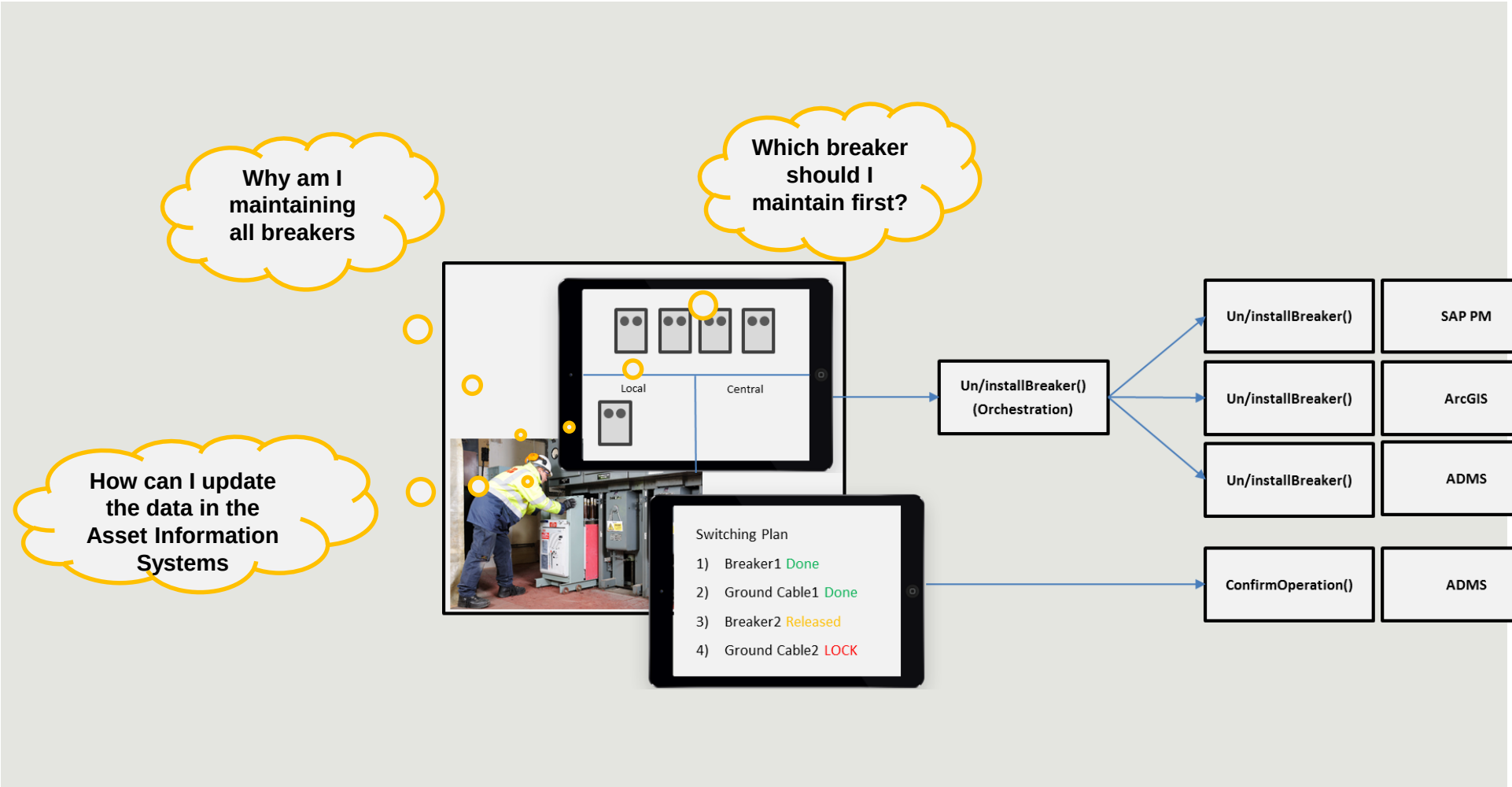


System Support for Asset Management

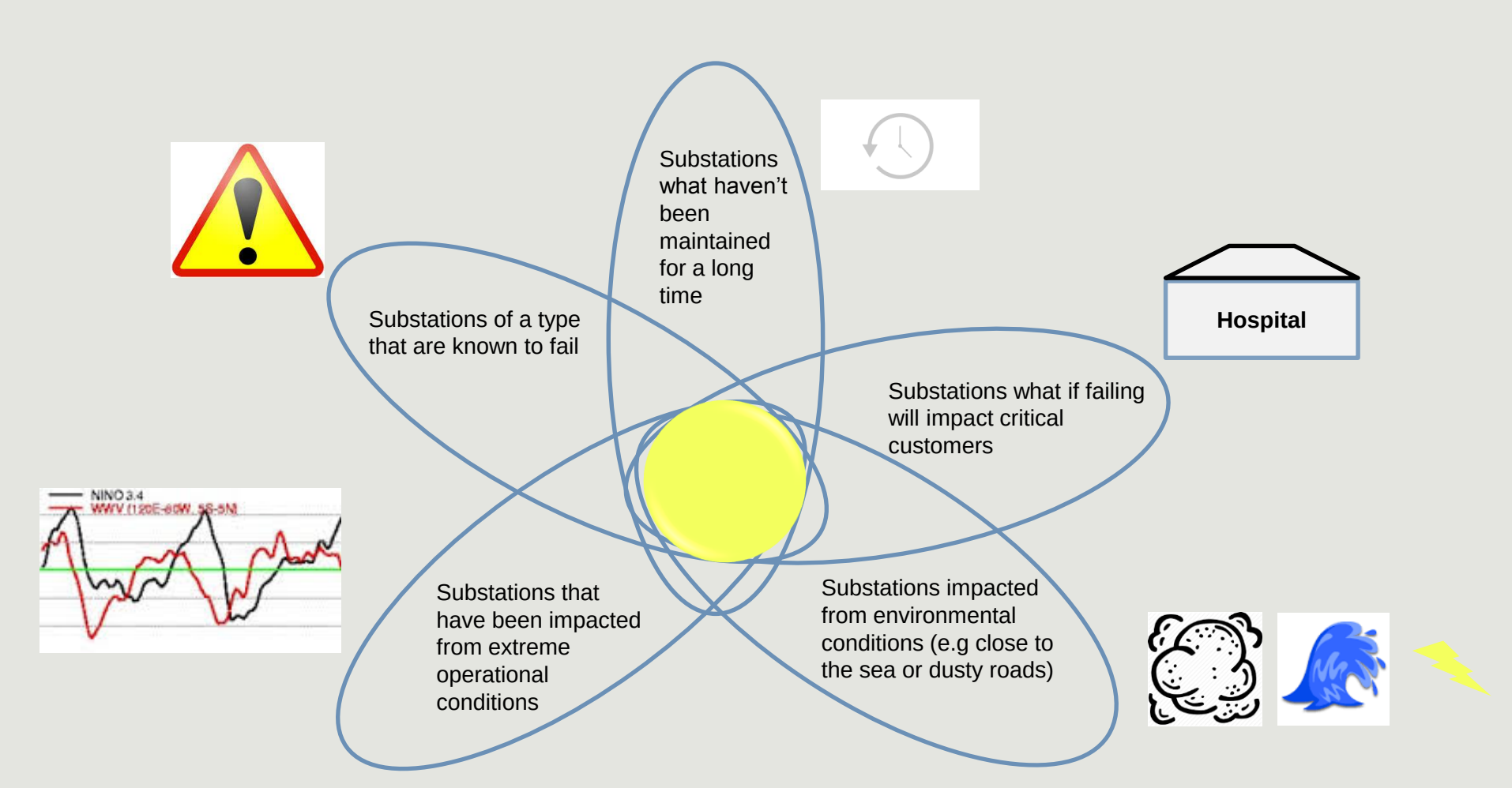




Asset Management Optimization involves all processes



Can we half the number of the substations inspected each year?



MAINTENANCE STRATEGIES

Time-based maintenance (TBM):

TBM is performed at regular and scheduled intervals, loosely based on the service history of a component and/or the experience of service personnel. This maintenance policy can be *expensive* and may not minimize the annualized cost of equipment.

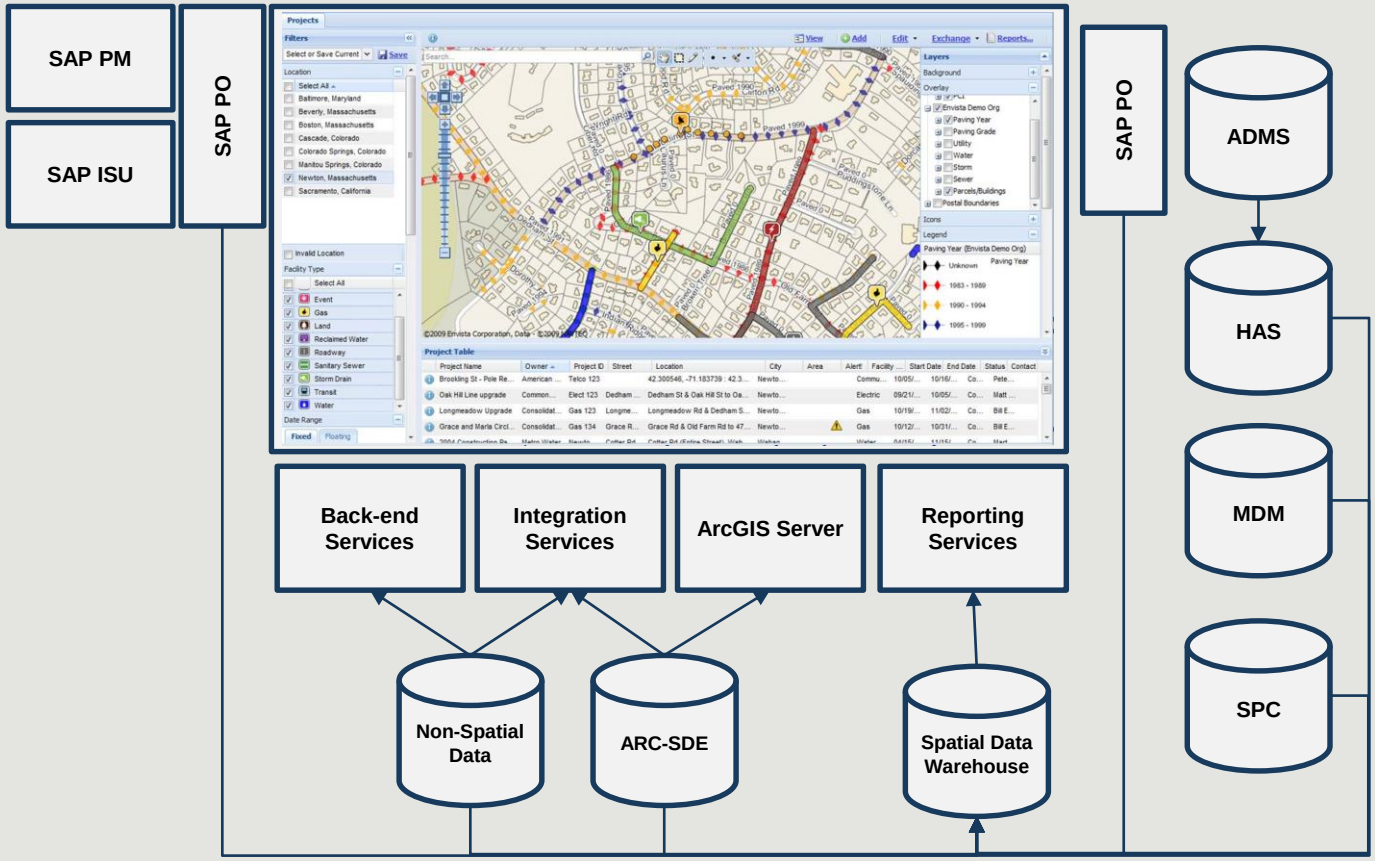
Condition-based maintenance (CBM):

CBM periodically evaluates the *state of equipment deterioration* expressed quantitatively as a *score or failure risk*, and maintains equipment when the condition falls below acceptable thresholds. Additionally, CBM approaches rank assets within a given asset group with respect to each other, thereby enabling a prioritization of investments.

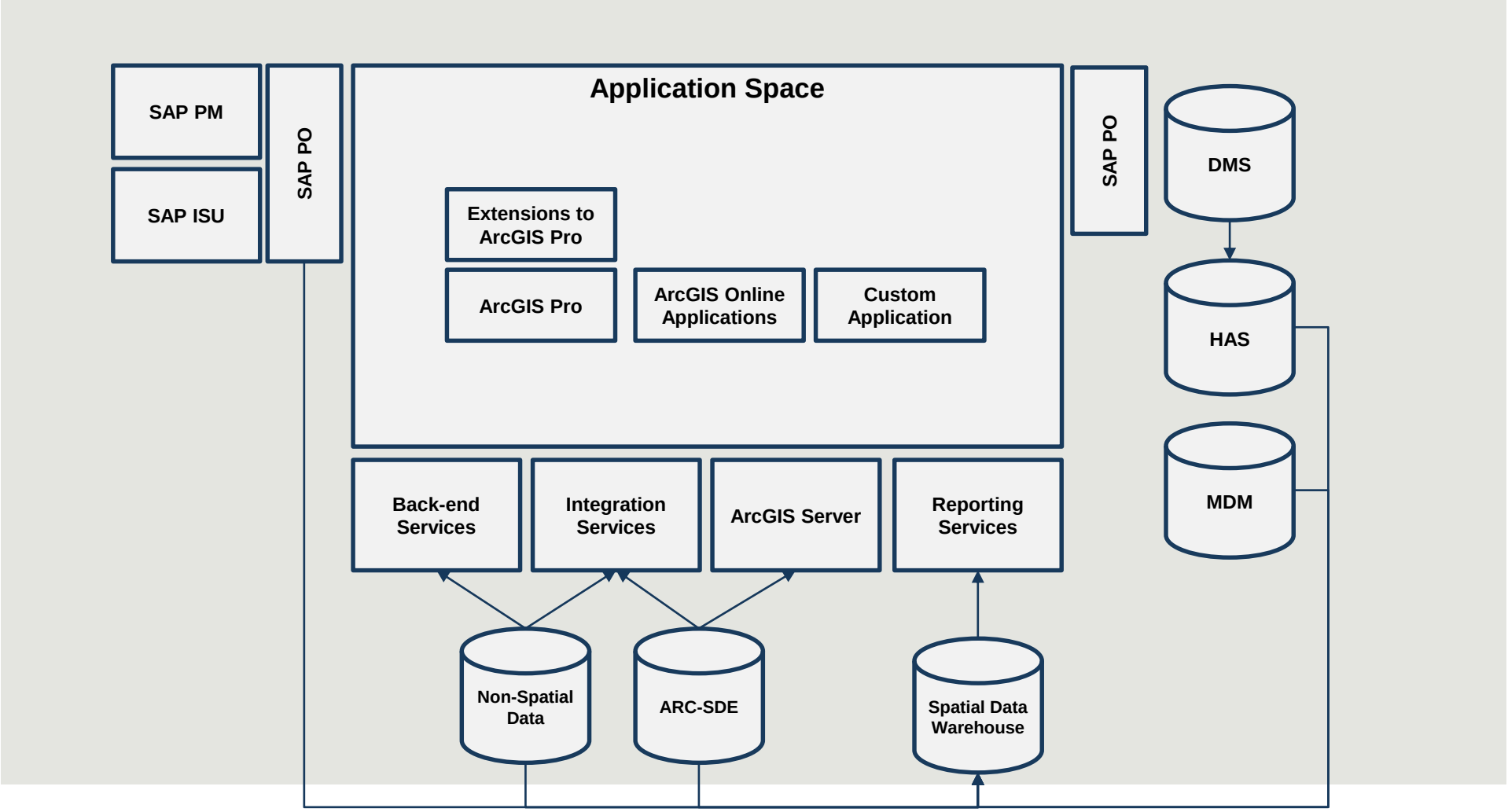
Reliability-centered maintenance (RCM):

RCM considers *both the probability of equipment failure and the system impact should a failure occur*. RCM approaches rely on frameworks for estimating network reliability indices based on the failure rates of the different components. Most commonly, such frameworks operate at the level of individual feeders and can be divided into *analytical* and *simulation* approaches.

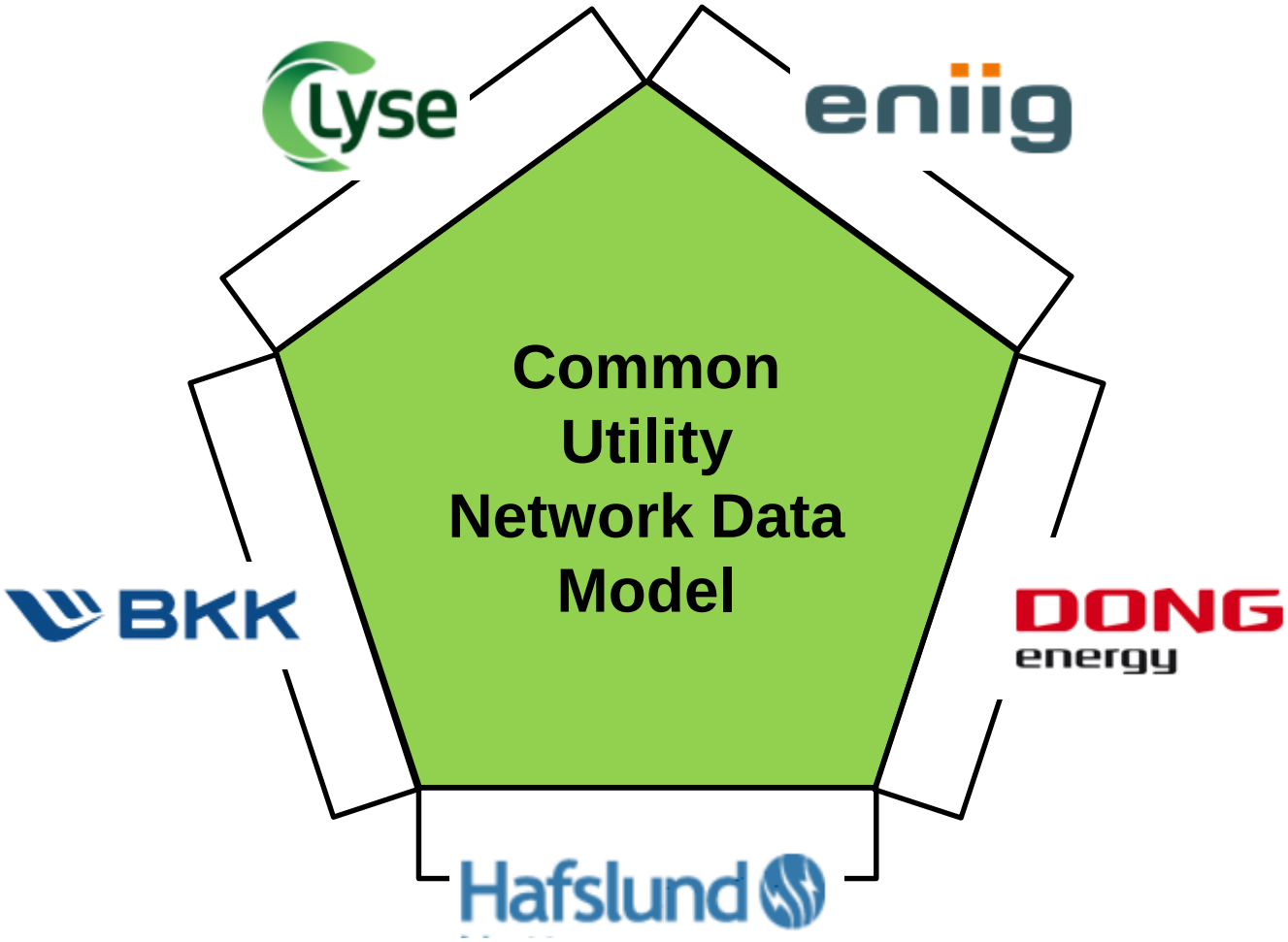
High Level System Architecture – Some Ideas



High Level System Architecture



Credits goes to….



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Jesper is currently working as partner/advisor onin UN implementations on the DONG Energy as well as other customers and as architect on several projects.

Jesper holds a Ph.D. in GeoScience & Computing Science and has 20 years of experience with IT-projects, especially with System Integration, Enterprise Architecture and Geographic Information Systems.
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