SP Energy Networks

Future Networks

D-Suite Discovery Show and Tell

13/06/2023

Content

01 Introduction

Introduction

Drivers and Solutions

Government incentives:

- Planned rollout of 600,000 heat pumps a year from 2028,
- The ban on new ICE vehicles by 2030 and, ultimately,
- The net zero target for 2050.

The LV network is expecting a large uptake of:

- Heat pumps
- EV chargers 3.5 & 7 kW
- DER

The problems LV networks will experience

- Voltage rise
- High circuit and transformer utilisation
- Large phase imbalance due to single phase connections of most customers.

These issues can be mitigated by:

– LV Distributed STATCOM (D-STATCOM). This technology has never been deployed in UK network.

– Distributed Soft Open Point (D-SOP) – D-Suite aims to build up on the technology developed by UKPN to trial a more flexible and controllable solution.

– Distributed Smart Transformer (D-ST) -- D-Suite will build up on learning from LV Engine project to fit a partially rated power electronics within slim design distribution transformer; and

– Distributed Harmonic Filter (D-HF) -- There are number of solutions in the market that need further development for LV applications.

01 Work Package 1

Customer Requirements and Core LV Network Functions

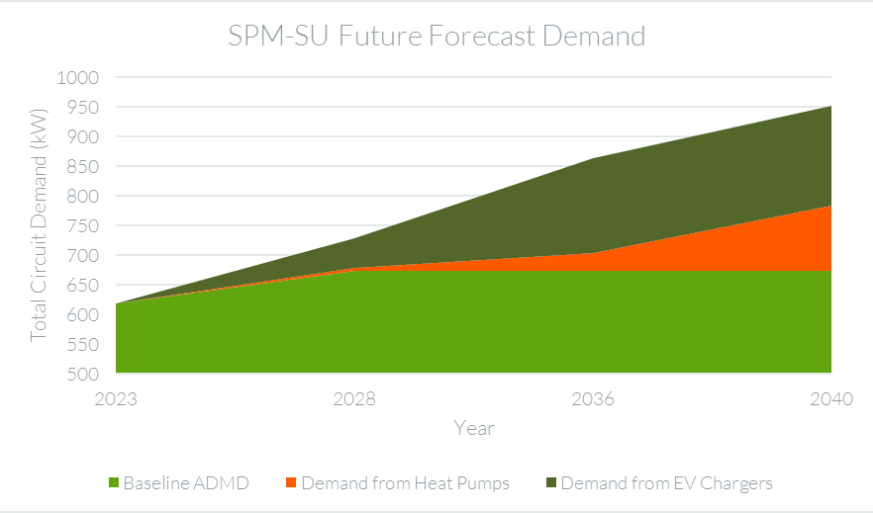
Use Case

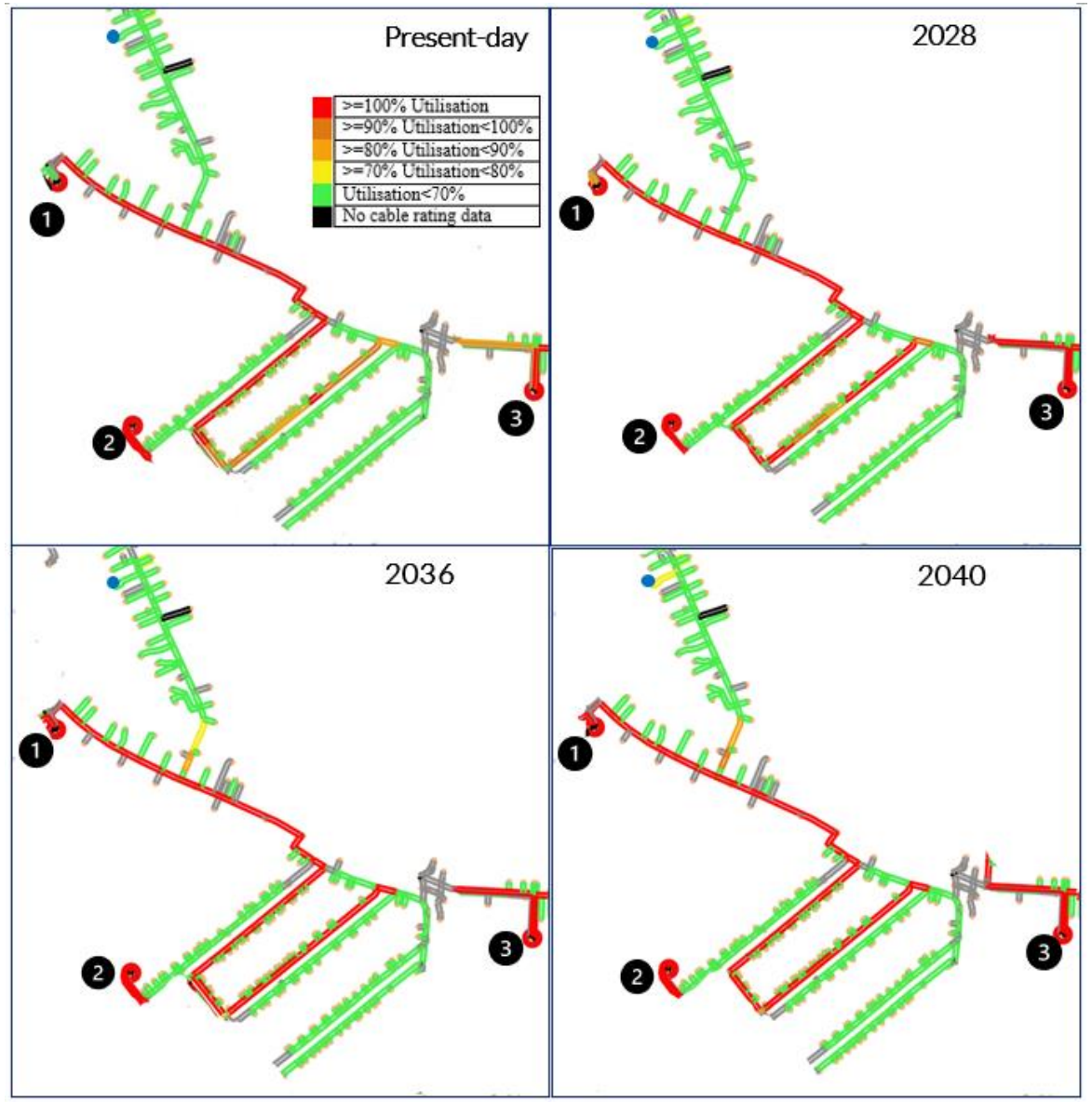
Examples:

- Voltage Profile Improvement – D-STATCOM
- Phase Balance Improvement – DSTATCOM, D-SOP & D-ST
- Balanced Transformer Utilisation – D-SOP
- Harmonic Mitigation- D-HF

Networks Modelled

- SP Distribution- Radial: Urban, Suburban, and Rural.
- SP Manweb - Interconnected: Urban, Suburban, and Rural.
- LCT Levels: Present, 2028, 2036, 2040.





02 Work Package 2

WP2: Literature Review and Supplier Engagement

Goal: holistic literature review and supplier engagements to identify research gaps and inform technology development

Three D-Suite unique aspects considered:

- **LV distribution** (rather than MV or HV distribution),
- **grid-connected systems** (rather than islanded microgrids),
- and **conventional AC systems** (rather than mixed AC/DC or DC distribution systems).

Threefold approach considered:

- Holistic review of historic and ongoing power electronics projects, to **identify challenges to uptake and potential technology innovation** classes
- Assessment of the **potential of each technology class to address challenges**
- **Identification and discussions with potential suppliers** of D-Suite technologies

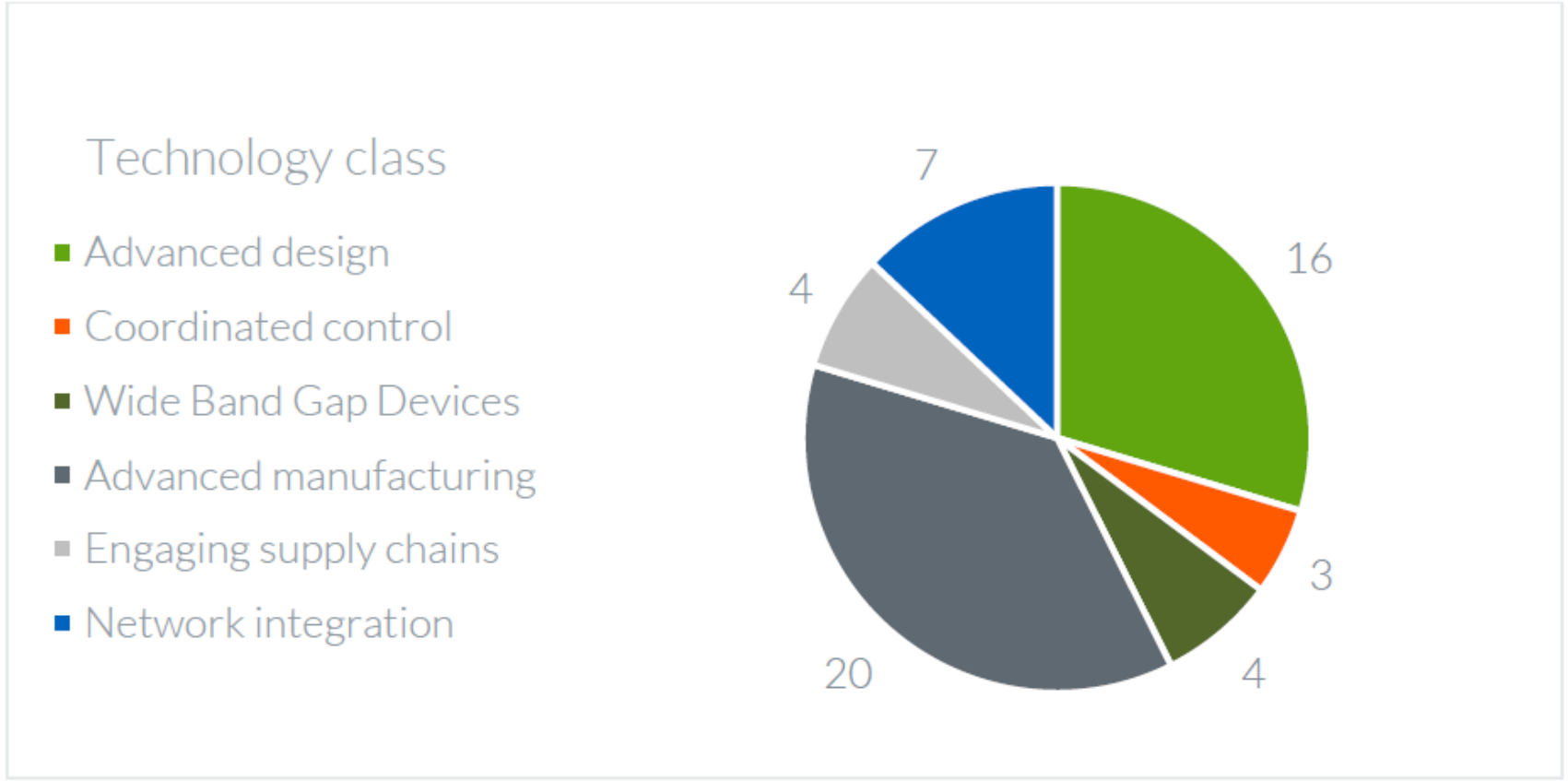


Figure 2.1. The primary technology class of the 54 EU-based Horizon projects and US-based ARPA-E projects

WP2: Literature Review and Supplier Engagement

Project review

- Project review explored projects on Smarter Networks Portal, Horizon Europe CORDIS database, ARPA-E project database
- Nine challenges to uptake identified
- Innovations fall into six technology classes

Literature analysis

- Projects reviewed and categorized for D-Suite relevance
- Potential benefits of innovations assessed against challenges
- D-Suite relevant project findings collated for challenges and in terms of LCA

Resources developed

- 6×9 challenge-technology innovation matrix developed
- International project database (54 projects, 9 challenges, 6 technologies)
- Potential suppliers database (18 suppliers)

Table 2.1. List of challenges identified in projects surveyed.

Challenge	Abrv.
Cost	Co
Maintenance & reliability	M&R
Maintaining power quality	PQ
Thermal management	ThM
Cyber security	CS
Stability and controllability	S&C
Sustainability	Su
Protection	Po
Personnel	Pe

Nine challenges

Table 2.2. List of technology classes identified in projects surveyed and abbreviations.

Technology class	Abrv.
Advanced design	AD
Coordinated control	CC
Wide bandgap devices	WBG
Advanced manufacturing	AM
Engaging supply chains	ESC
Network integration	NI

Six technologies

Table 2.3. Challenge-technology matrix for power electronics-based solutions.

Technology or innovation class	Challenge to PED uptake at LV by DNOs								
	Co	M&R	PQ	ThM	CS	S&C	Su	Po	Pe
AD	2	1	1	2	1	1	2	1	1
CC	1	1	1	2	2	3	2	1	1
WBG	1	1	1	2	1	2	1	1	1
AM	2	2	1	3	1	1	1	2	1
ESC	2	2	1	1	1	1	2	1	2
NI	1	2	2	1	1	1	2	2	1

Key	
Neutral / ineffective	1
Effective	2
Highly effective	3

Challenge-technology matrix

03 Work Package 3

WP3: Design Specifications of Hardware and Control Algorithms

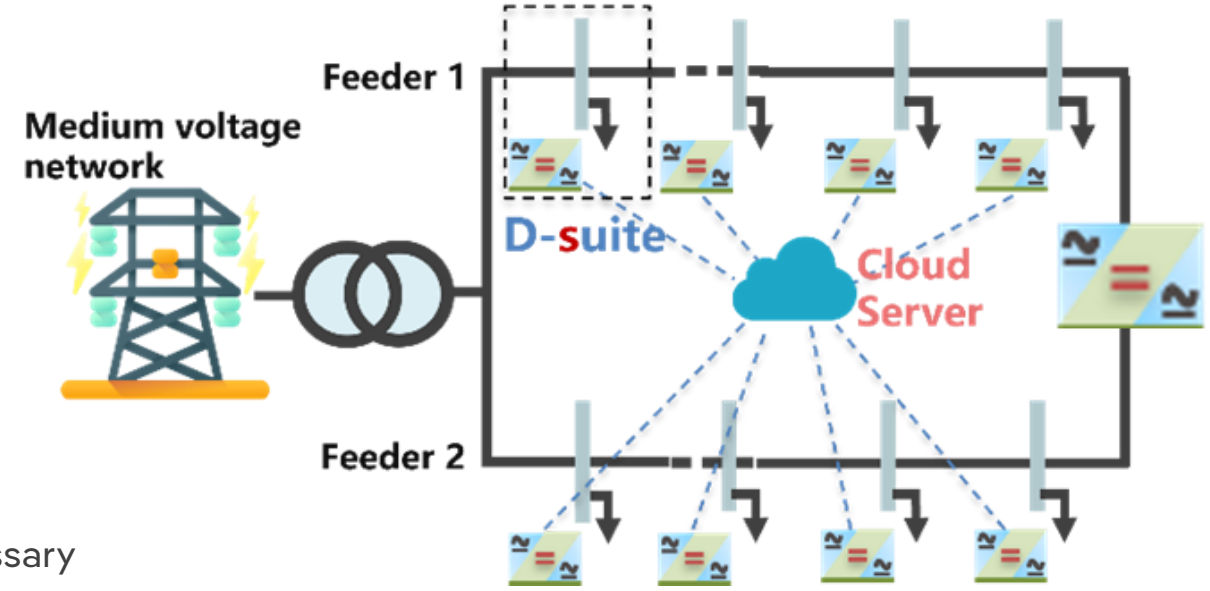
Goal: To identify design specifications of suitable PED solutions for **various types of D-Suite devices** to enhance power quality and promote the adoption of low-carbon technologies in LV distribution networks.

Four D-Suite devices include:

- **Distributed STATCOM (D-STATCOM)**
- **Distributed Soft Open Point (D-SOP)**
- **Distributed Smart Transformer (D-ST)**
- **Distributed Harmonic Filter (D-HF)**

Threefold approach considered:

- Propose **tailored hardware solutions** to effectively achieve necessary network functions
- Conduct **comprehensive hardware design** to meet operation, protection and overall network interface requirements
- Develop **effective control methods** to ensure voltage support, reactive power compensation, active power flow management, and harmonic elimination



The overall structure of D-Suite.

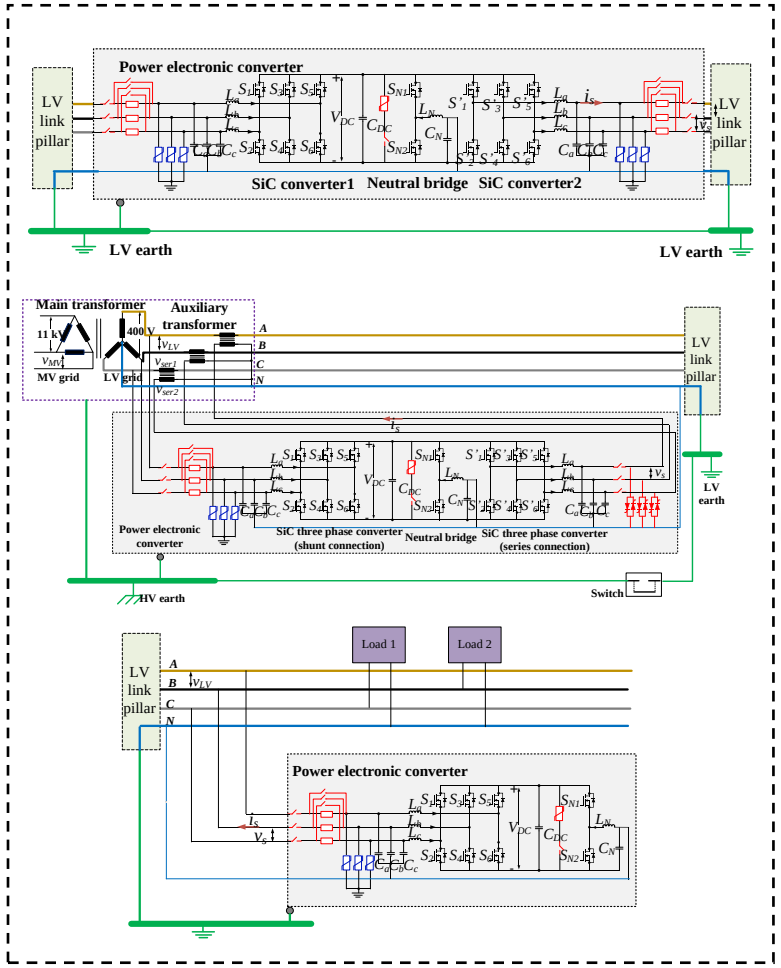
WP3: Design Specifications of Hardware and Control Algorithms

Topology design

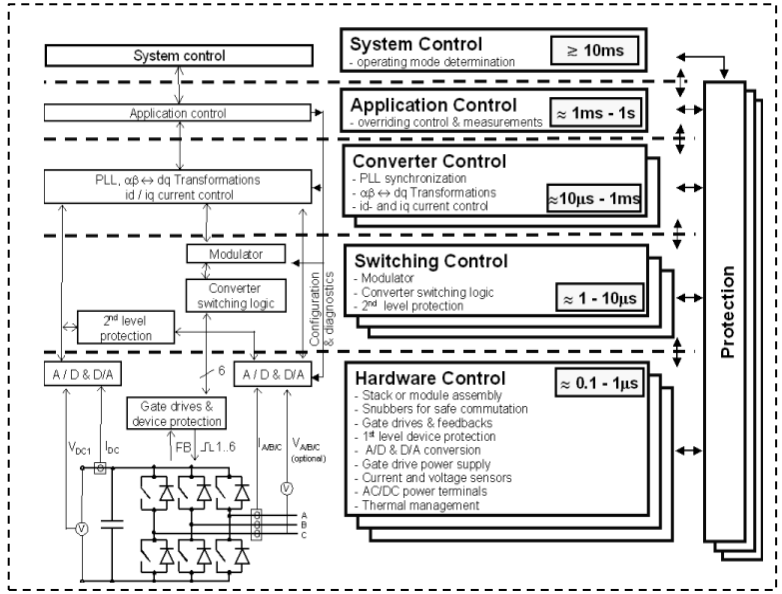
- Suitable topologies for four D-suite devices are identified
- Protection circuits are designed to meet the safety requirement
- Design specifications of power electronic devices are elaborated
- Modular and scalable designs are developed

Control design

- Functions offered by four D-suite devices are identified
- Control schematics are developed following hierarchical control structures (switching control layer, converter control layer, application control layer, and system control layer)



Topologies of D-suite devices



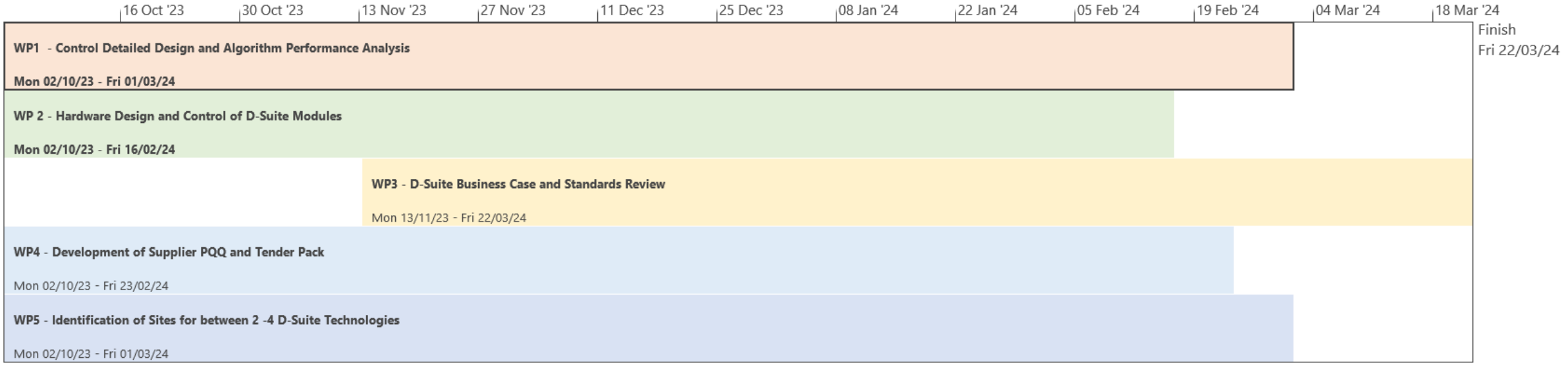
Control methods of D-suite devices

WP3: Summary of Findings

- The low voltage network will face the most strain as the uptake of Low Carbon Technologies increases.
- D-Suite technologies can enhance low voltage networks by providing coordinated functionalities such as voltage, power, and harmonic compensation.
- Topologies and control strategies of D-suite devices have been designed to achieve desired voltage stability, system reliability and harmonic performance.
- To advance the Technology Readiness Level of D-Suite devices, further development will involve the creation of control units for the PEDs, prototyping and demonstration of different topologies.

04 Work Package 4

Roadmap to Commercialisation



05 Q&A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