The University Of Queensland AUSTRALIA

ES Cornwall Memorial Scholarship

FIRST QUARTER REPORT

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TenneT

Acknowledgements

The first quarter of my experience undertaking the ES Cornwall Memorial Scholarship would not have been possible without the help of a number of people whose support I would like to acknowledge and thank here.

Firstly, I would like to express my gratitude to TenneT TSO for being open to and enabling my first placement. I would like to specifically thank my manager Axel Kieβling and also Len Wismeyer, for taking the time to meet with me to understand the scholarship and my interest and to welcome me into their team, as well as driving the internal requirements to make my placement a reality. I would also like to thank my team, Strategy & Partnerships – Digital & Flex Development for their support and inclusion. To Anne Jonker and Lauren McCarthy, I would like to say thank you for the office companionship and motivation to ride my bicycle to the office on very cold, wet, and windy days.

Undertaking the ES Cornwall Memorial Scholarship has meant taking extended leave from my role at Energy Queensland and as such I would like to acknowledge the support and flexibility of Energy Queensland in allowing me to step away from my role to participate in this once in a lifetime experience. I am also particularly appreciative of the efforts undertaken by Michelle Taylor and Sophie Allen in managing my absence from our Fringe of Grid work. I'm looking forward to sharing many learnings and stories upon my return.

This incredibly unique and extraordinary experience would not exist without the ES Cornwall Memorial Scholarship so I would like to once again express my gratitude and thank the scholarship and its Advisory Committee for providing this opportunity.

Disclaimer

This report provides a summary of the experiences and work undertaken by the author as part of an overseas ES Cornwall Memorial Scholarship placement. Statements and material contained within this report are the opinion of the author and do not reflect the opinion or positions of any other person or organisation. Reproduction or referencing of this report should also reflect this.

Executive Summary

The electricity industry is undergoing multifaceted change, driven by a number of diverse but interlinked factors including changing customer behaviours, changing climate and weather conditions, an increase in high impact events and the advent of new technologies. These changes have given rise to the need for an increased level of flexibility in our networks. Power system flexibility can be defined as the ability to respond to both expected and unexpected changes in demand and supply. Flexibility can also extend beyond this definition to encompass the overall fluidity of the electricity industry including the ability to facilitate greater participation and choice in the market for customers, the ability to shift load to mitigate maximum and minimum demand issues, and the ability to adapt to change. Flexibility is required in all parts of the electricity industry, spanning from generation to transmission and distribution networks, energy storage and demand. For this reason, my scholarship study plan is based around the theme of 'increasing network flexibility through technology innovation'.

This report provides an overview of the first quarter of my ES Cornwall Memorial Scholarship experience. During this quarter I began my first placement at TenneT TSO in Arnhem, Netherlands with the Strategy & Partnerships – Digital & Flex Development (STP-DFD) team. As part of the STP-DFD team, my work has been focused on two projects within their Digital Portfolio. Before commencing my placement at TenneT TSO I was also able to attend the CIGRE Paris Session 2022.

During the second quarter of my scholarship experience I will complete the remainder of my placement at TenneT TSO and continue working on the satellite data and EnAppSys trial projects introduced in this report as well as contributing to a third project within the STP-DFD Flexibility Portfolio relating to congestion management in Germany. I will also be making a presentation to the Network of European Transmission Trainees (NETT) providing an overview on the Australian Energy System and a comparison with the European System. I am also looking forward to continuing to participate in the CIGRE C6.45 Working Group.

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Glossary

AI	Artificial Intelligence
BAU	Business as Usual
CIGRE	International Council on Large Electric Systems
CO2	Carbon dioxide
DER	Distributed Energy Resource
DSO	Distribution System Operator
ENTSO-E	European Network of Transmission System Operators for Electricity
ESA	European Space Agency
EU	European Union
HV	High Voltage
LV	Low Voltage
MVDC	Medium Voltage Direct Current
NETT	Network of European Transmission Trainees
NGN	Next Generation Network (part of CIGRE)
OPEX	Operating Expenditure
PV	Photovoltaics (solar)
SD	Satellite Data
STP-DFD	Strategy & Partnership – Digital & Flex Development (team at TenneT TSO)
TSO	Transmission System Operator

Placement 1 – TenneT TSO

Background

My first placement as part of the ES Cornwall Memorial Scholarship has been at TenneT TSO with the Strategy & Partnerships – Digital & Flex Development (STP-DFD) team.

TenneT manages the high voltage grid in the Netherlands and large parts of Germany. Their network covers approximately 23,900 km of HV lines and supplies 42 million customers. TenneT is a leading European electricity transmission system operator (TSO) and provides transmission services, system services as well as energy market facilitation.

The Northwest European energy markets are transitioning in response to government targets for decreased emissions and the decommissioning of existing coal-fired power plants, similar to the Queensland Government's new target of 70% renewable generation by 2032[1]. By 2030, the European Union (EU) wants to reduce carbon dioxide (CO2) emissions by 55%[2]. As the first cross-border European TSO, TenneT intends to play a pioneering role in the transition to a clean, circular decarbonised energy system through its Target Grid 2045 strategy.

The STP-DFD team helps implement TenneT's ambition to drive the energy transition by developing innovative Digital & Flex solutions, together with internal and external stakeholders as part of the Target Grid 2045 strategy. Within the Strategy & Partnerships Unit, the Digital & Flex Development team was established to help the organisation achieve new ways of working to realise TenneT's ambition to advance the energy transition.

During the first quarter of my ES Cornwall Memorial Scholarship experience, I have worked primarily on two projects with the STP-DFD team. For these projects I have been investigating and evaluating the added value of satellite data and energy market data services for TenneT. As part of the STP-DFD Digital Portfolio, these projects address the pivotal role of data for the energy transition by testing data-driven services and data-driven concepts and applications. The details of these projects are outlined below.

Projects

Investigating the Added Value of Satellite Data

Satellites, and the data they provide, have been in use for many years. Rapid advances in accessibility and cost reductions in the last few years have given rise to the opportunity to utilise this technology in new applications. As a result, several case studies and projects have been undertaken within the utility and infrastructure industry to investigate the potential added value of satellite data.

With more companies and services offering data driven solutions by combining artificial intelligence (AI) and satellite data (SD), TenneT's STP-DFD team initiated a Trainee Consultancy Project on '*Can and how could AI and SD improve the processes of TenneT: Benchmark / Added Value / Advice*' in 2022. Following the completion of this Consultancy Project, the STP-DFD team decided to further investigate the added value of satellite data to business processes within TenneT through a new project exploring particular use cases which were highlighted by the Consultancy Project.

[1] Queensland Government Energy and Jobs Plan, 2022
[2] European Commission 2030 Climate Target Plan, 2020

The initial phase of this project has involved:

- Identifying possible use cases within the business,
- Defining project scope including aims and potential benefits,
- Engaging with internal and external stakeholders, and
- Undertaking a market scan of existing case studies and services.

One identified possible use case for TenneT is that of satellite data to assist with vegetation management. Vegetation management is a very important form of preventative maintenance in which trees and other vegetation are monitored and controlled in order to ensure safety and reliability. Satellite data is not currently utilised for vegetation management within TenneT.

In this project, how far satellite data and associated AI has progressed and its suitability for the TenneT use case of vegetation management will be investigated through pilot studies with externally provided satellite data services and internal business consultation.

This pilot project aims to:

- Investigate the potential added value of satellite data for current or future vegetation management processes,
- Validate satellite data against data collected through current Business As Usual (BAU) processes,
- Understand any current limitations of satellite data for vegetation monitoring, and
- Provide advice to TenneT business units on future adoption of satellite data solutions.

This pilot project is proposed for the number of potential benefits satellite data for vegetation management could provide to TenneT, which include:

- Reduced OPEX costs through reduced ground patrol and labour requirements,
- Reduced reliance on external vegetation contractor companies/services:
    - Mitigate the risk of contractors not being available to offer their services in the future, and
    - Future proofing by investigating alternative options such as satellite data,
- Improved worker safety through reduced requirements for travel and live asset inspection,
- Improved safety and fault prevention through increased identification of risks such as objects contacting live assets,
- Increased flexibility and automation with option to monitor assets more frequently or on an ad hoc basis without having to dispatch human resources,
- Reduced dependency on ground accessibility limitations e.g. in wet or difficult to reach areas,
- Increased efficiency and reduced human resource requirement which can free up resources for other tasks, and
- Improved ecological vegetation management, with a reduced requirement on CO_2 emitting travel and a positive impact for TenneT's corporate social responsibility.

Vegetation management is currently undertaken independently by TenneT in Germany and the Netherlands. Both the varied current processes and differing regulations across the two countries must be considered when investigating the use case of satellite data for vegetation management at TenneT. Stakeholders representing vegetation management for both Germany and the Netherlands were consulted in order to understand both the current

vegetation management processes as well as important factors for consideration when investigating the potential added value of satellite data. For vegetation monitoring with satellite data, the ground conditions such as vegetation presence are assessed. The following were also identified as important to be included during assessment if possible:

- The condition of vegetation, as it can be an important factor in risk calculation and provide information on appropriate management action required (e.g. a dead tree may pose greater risk and therefore may be completely removed rather than trimmed),
- The condition of assets – checks of assets including pole/tower foundations for any visible disturbances from vegetation, fauna, or other cause, and
- Identification of the presence of fauna or evidence of possible presence.

As part of the initial project stage, a market scan was undertaken on the existing case studies and service providers of satellite data for vegetation management within Europe. The market scan found that several different projects and case studies have been undertaken both within the electrical utility industry and wider industry as well, as summarised in Table 1. In partner with, and separate to, these projects several companies and service providers currently exist within the market offering satellite data analysis for vegetation management. Table 2 highlights some of the key available services and companies.

Table 1 External Projects and Case Studies of Satellite Data for Vegetation Management within Europe

Project Name (if applicable)	Utility/Asset Company	Satellite Data Provider / Other Partners	Country/ies	Details
	Deutsche Bahn Railways	LiveEO	Germany	Automated vegetation management
GridEyeS	Norwegian DSO	ESA; Western Norway University of Applied Sciences	Norway	Automated vegetation management.
SatNetMonitor	European TSOs through ENTSO-E; Finnish DSOs	HeadPower & Terramonitor; ESA	Multiple countries across Europe	Vegetation & risk management system; feasibility & demonstration projects
	Finnish distribution company	Futurice; Skywatch	Finland	Vegetation management through imagery

Table 2 Market Scan of Available Services and Companies

Company/Service	Details
Meteory	Dutch based satellite analytics start-up, associated with ESA incubator.
SatNetMonitor	Created by Headpower and Terramonitor as part of ESA projects.
Flysight	Satellite and other aerial services such as helicopters and drones.
LiveEO	US based satellite analytics company utilising machine learning algorithms to analyse satellite imagery and identify vegetation. Also uses risk models to produce assessment that can prioritise maintenance and inspection based on risk.
Spottitt	Provides a vegetation monitoring product and has experience with DSOs.
StormGeo	Part of GridEyeS project.

With an understanding of the current state of vegetation management within TenneT and the available market of satellite data services, the current and next stage of the project involves continued collaboration with internal stakeholders and the formulation of a detailed pilot study scope for the use of satellite data and AI within TenneT.

Investigating the Added Value of the EnAppSys Market Data Platform

In order to help realise TenneT's digital ambitions in driving the energy transition, the STP-DFD team develops and tests data-driven concepts and applications in collaboration with strategic partners. Similar to the explorative Satellite Data project, the STP-DFD team is investigating the potential added value of an externally provided market data platform, EnAppSys, for use within TenneT through a trial project.

The aim of this project is to evaluate the potential added value that EnAppSys can provide TenneT. The project involves access to a yearlong trial licence for any TenneT teams and an option analysis driven by STP-DFD to determine whether the licence is allowed to expire or be extended, an alternative platform is sourced, or an internal platform is developed. The project was initiated in Q3 of 2022 and I have been involved in the option analysis as part of my role within the STP-DFD team. The outcome of the project will be to determine which option is preferred and to advise on the respective next steps for market data availability within TenneT.

EnAppSys is a market data platform that provides valuable energy market insights by combining data from multiple sources as well as its own modelling and forecast data. EnAppSys aims to be a single source for European energy market data in which users can choose which markets they want to analyse and get immediate and real-time access to market information and insights. Data is collected from international sources, consolidated and visualised through a customisable platform with multiple dashboards and charts. The data is also downloadable, and API enabled.

Figure 1 provides an overview of the option analysis scope for the project including the input activities required for assessing each option. The activities undertaken so far have included undertaking a market scan of comparable services and products; developing and distributing a feedback questionnaire for trial users as well as identified potential users; assessing the capability of the EnAppSys platform through use of the platform and a demonstration session; and collection and analysis of internal advice and trial user feedback.

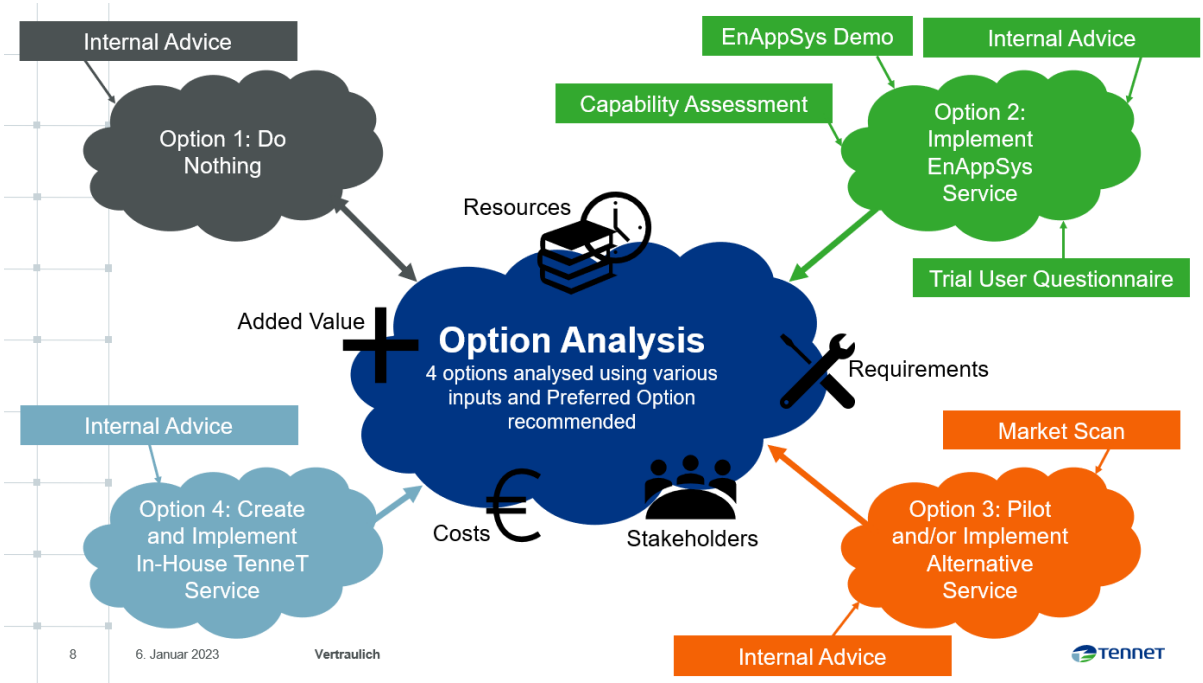

Figure 1 Overview of Option Analysis for EnAppSys Project

For the market scan, several key market sources were researched and compared based on the type of data they provide, the presentation (such as visualisation) of data and its downloadability, and data access costs. Existing services assessed included Bloomberg, EnergyLive, Energy-Charts, Energy Market Price and the ENTSO-E transparency platform.

Trial users were asked to complete a questionnaire for feedback on:

- Current EnAppSys use – how often, what for, which countries,
- Future EnAppSys use – beyond trial period, shared and desk-licencing,
- Experience with EnAppSys – general comments, benefits, limitations, and
- Use of other data platforms/services.

Potential users who were initially identified in the project but are not currently registered with EnAppSys accounts were also asked for feedback on any other energy and market data sources or services used and if there are any other data sources/services that are currently missing, and which would add value to their work.

Several qualitative discussions were also undertaken with test users and data subject matter experts within the business to understand the potential use cases of EnAppSys as well as the wider data environment at TenneT. These discussions highlighted the importance of an internal data vision and allocation of appropriate resources for digitalisation and transparency in the energy transition.

The next steps of the project include undertaking further analysis based on the initial feedback received from key users to determine potential use cases for EnAppSys within TenneT departments in order to finalise and report on the option analysis and provide advice on the preferred option.

Project Learnings

Working on both the Satellite Data and EnAppSys trial projects as part of STP-DFD's Digital Portfolio has given me the opportunity to learn more about the role that data and digitalisation play in supporting flexibility and the energy transition. Data and digitalisation are key in making existing operations more flexible and efficient and in enabling more effective collaboration and transparency within the electricity industry.

Digital technologies have been adopted by the electrical industry for many years. However, as the world becomes more electric and greater visibility and control through smart technologies is required to manage a rapidly evolving energy system, the pace and importance of digitalisation in energy is increasing. The digital transformation required for the energy transition is not a simple undertaking. This is due to the sheer amount and types of data, the challenges of updating existing business models, and the increasing complexity of the energy system and parties involved. A key takeaway from the analysis done so far as part of the EnAppSys project has been that data transformation and leadership within the energy transition requires strong commitments in terms of initiatives and resources, and a united vision. This project has highlighted the importance, and equally the challenge, of data accessibility and management within large organisations and across the electricity industry. Much of the data provided by the EnAppSys platform is available through other means within TenneT or external platforms but is scattered widely and often reliant upon manual processes for visualisation and analysis.

While data leadership is important, it shouldn't be defined to encourage participants in the electricity industry to forge ahead in silos, but rather to focus on collaboration and transparency. Both the Satellite Data and EnAppSys projects have highlighted the wealth of

information and services that already exist within the industry, and the advantages that can be gained without the need to reinvent the wheel. By looking at what is already available, large participants such as system operators can more efficiently utilise both internal and external resources. The recent growth in commercially available satellite data services is one such example of where collaboration with external partners can provide the opportunity to achieve greater efficiency and flexibility. Likewise, by system operators providing more open data to the market, participants in the market can in return offer better services to assist with future grid system operation challenges.

With the digitalisation of many aspects of the electricity industry through the energy transition there is, and will increasingly continue to be, a lot of data available for monitoring, management and analysis. Data may be produced and visible within a company or available externally, through public access or paywall protection. Both transparency and efficiency are key tools for the energy transition and the effective access and utilisation of this abundance of data will have meaningful impact on the success of the required digital transformation.

Additional Learnings

During my placement, I have also sought out opportunities to learn about other projects and activities at TenneT which has broadened my understanding of both TenneT and the wider European electricity system. Some highlights from these learning opportunities included:

System operations – I had the opportunity to attend two workshops and visit one of TenneT TSO's control rooms; one workshop covered system operations within the control room, and the other was a deep dive into system operational planning (day-ahead planning). During these sessions I learnt about leveringszekerheid (security of supply) and balanshandhaven (balancing) within TenneT's network and the wider interconnected European network. The goal of day-ahead operational planning is to make sure that everything is read for the next day when operation is 'live' to ensure a balanced system. This operational planning utilises a number of internal and external software programs and processes and relies on extensive communication with other system parties e.g. other TSOs and balance responsible parties. TenneT Netherlands is quite unique in Europe in that balance data is published publicly in near real time which enables more transparency and educated participation within the market.

Assessing the impact of climate (change) on future resource adequacy – this session presented results from a joint study by TenneT, Utrecht University and the University of Groningen. The energy system of the future is more weather dependent – both in terms of supply and demand. This session covered how to cluster and define weather types and patterns, and the impact of weather, and different weather types, on adequacy within the electricity system. Results of the study show that adequacy issues can occur with any weather type for zones within Europe but that different types affect zones differently. Modelling of these weather types and impacted zones can help planning and operation of the future energy system.

Towards a circular energy transition: critical metals – this session addressed what critical metals are projected to be needed for the energy transition and the possible geopolitical dominances through supply chains for extraction and processing. The four circular strategies of Rethink, Reduce, Repair - Refurbish - Repurpose, and Recycle were outlined and their potential impact on lowering the demand for critical metals modelled. This session highlighted the importance of these strategies in helping all parties within the energy transition to take responsibility and a more holistic approach in increasing their corporate sustainability.

CIGRE Paris Session 2022

Outside of my work at TenneT, as part of my ES Cornwall Memorial Scholarship experience, I was also able to attend the CIGRE Paris Session in August-September 2022. This was an incredibly inspiring experience and a fantastic platform to engage with the energy industry on a global level. Across the Session there was a common theme promoting action and collaboration to accelerate the energy transition and address challenges to implement new technologies. The many workshops, poster sessions, tutorials and technical exhibition provided an excellent opportunity to gain deep insights and participate in open conversations.

Highlights of the Session included:

- **Opening Session** – keynote speaker Arshad Mansoor, CEO, EPRI spoke about the importance for a climate ready power system with a focus on net zero, affordability and reliability. With a call to action, and a key takeaway of 'let's not wait', the capabilities of existing technologies were highlighted along with the need for better adaptability, proactive change and weather preparedness.
- **C6 Group Discussion Meeting** – topics included: Digital Twins; Model Validation; LV Statcoms; MVDC System Design; and Off Grid Alternatives. The integration of new technologies and how this is impacted by customer behaviours was discussed as well as the need for greater flexibility management to cope with the variability renewable energy integration presents in the move towards decarbonisation and net zero targets.
- **C6 Poster Session** – topics included: DER Solutions and Experiences for Energy Transition and Decarbonisation; Innovative Planning and Operation of Active Distribution Systems; and Aggregated DER for Enhancing Resilience, Reliability and Energy Security of Distribution Systems. A huge breadth of research was presented with global insights from a *Mini-grid Concept for Rural Electrification in Georgia* to *Smart Inverter Functions to Increase PV Hosting Capacity in New York*.
- **Women in Energy Forum** – with a theme of 'Next steps for women in energy transition' this forum addressed the role of women in the energy transition, and the Net Zero Initiative, and celebrated the achievements of women in CIGRE.
- **C2 and C5 Large Disturbances Workshop** – topics included: European System Split 2021, Frequency Situation at 2022 Fukushima Earthquake, Israeli System Cascade Separation, Low Probability High Impact Events: India, Cyclone Seroja in Western Australia. This workshop reviewed these recent system and market events to understand the lead up to the events, their causes and to examine what has been done to prevent their recurrence.

During the CIGRE Paris session I also participated in activities and volunteered with the CIGRE Next Generation Network (NGN). As part of CIGRE, the NGN is a professional network for engineers studying or in the early stages of their career in the power industry. The NGN is continuing to grow with chartered representation in many countries around the world and provides a great gateway into CIGRE as well a strong support network. The NGN activities at the CIGRE Paris Session included a presentation showcase, forum, booth, and a social evening.

Following my attendance at the Paris Session, I have joined the newly formed CIGRE Working Group C6.45 - The Impact of Distributed Energy Resources (DER) on the Resilience of Distribution Networks. I am looking forward to contributing to this working group as my ES Cornwall Memorial Scholarship experience continues.

Plan for Next Quarter

For the second quarter of my ES Cornwall Memorial Scholarship experience I will continue my placement at TenneT TSO. Both the satellite data and EnAppSys trial projects will continue, and I will also be working on another trial project which addresses the issue of congestion management by unlocking flexibility from aggregated heat pumps in Germany.

I will also be giving a presentation to the NETT (Network of European TSO Trainees) at their next NETT Talks session, providing an overview on the Australian Energy System and a comparison with the European System.