The University Of Queensland AUSTRALIA

ES Cornwall Memorial Scholarship

SECOND QUARTER REPORT

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TenneT

Acknowledgements

The second 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 second quarter of my ES Cornwall Memorial Scholarship experience. During this quarter I completed 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 and one project within their Flexibility Portfolio. I also made 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.

During the third quarter of my scholarship experience I will commence my second placement at Scottish Power Energy Networks in Glasgow, Scotland.

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Glossary

aFRR	automatic Frequency Restoration Reserve
AI	Artificial Intelligence
API	Application Programming Interface
BAU	Business as Usual
BDL	Bidirectional Charging (project)
CBP	Crowd Balancing Platform
CO2	Carbon dioxide
DEER	Dezentraler (*germ.: decentralised*) Redispatch (project)
DSO	Distribution System Operator
EU	European Union
EV	Electric vehicle
FCR	Frequency Containment Reserve
HV	High Voltage
mFRR	manual Frequency Restoration Reserve
NETT	Network of European Transmission Trainees
OEM	Original Equipment Manufacturer
PV	Photovoltaics (solar)
SD	Satellite Data
SSI	Self-Sovereign Identities
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. By 2030, the European Union (EU) aims to reduce carbon dioxide (CO2) emissions by 55%. 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.

Strategy & Partnerships – Digital & Flex Development

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.

The many projects undertaken by the STP-DFD team are nested within the team's Digital and Flexibility portfolios. The STP-DFD team has a strong focus on collaboration and knowledge sharing and as such during my placement at TenneT I have had the opportunity to learn about and follow the progress of several projects beyond those which I have directly contributed to. As the innovation and learnings of these projects has relevance to the wider electricity industry, I have included a short summary on the portfolios and some of their projects below.

Digital Portfolio

The current challenges of the energy transition create the need for digitalisation in the electricity system. Digitalisation can help to integrate the growing share of renewable energy, and alongside data, it is becoming increasingly important in building an efficient, integrated European electricity market, while maintaining safe operation. The Digital Portfolio aims to build a data ecosystem as a foundation to create data-driven services. Within the portfolio, data-driven concepts and applications are developed and tested with strategic partners across both the Netherlands and Germany.

CO_2 Monitor – Digital energy services portal

A joint initiative of TenneT and gas network operator Gasunie, the CO_2 monitor portal (https://co2monitor.nl/en/) provides up-to-date insight into how green the energy mix in the Netherlands is at any given time. This offers opportunities for parties to match energy demand to moments when CO_2 emissions are lower, for example when there is a lot of generation from energy sources such as wind or solar. This initiative aims to continue developing to increase transparency of CO_2 emissions and provide additional data insights.

Figure 1 Snapshot of the CO_2 monitor portal displaying emission information for gas and electricity generation in the Netherlands

energy data-X – Energy data space for data exchange in Gaia-X

The goal of this consortium project made up of 17 partners is to develop a data space for the energy domain within the framework of the digital ecosystem Gaia-X. A data space is a federated data integration concept which allows data sharing without losing data sovereignty, where data sovereignty is being self-determined over your own data assets. Gaia-X is a not-for-profit association with the objective to design the next generation of a federated European data infrastructure. Through this development, Gaia-X is focused on delivering a Gaia-X architecture and rules, open implementation, and qualification authority for Gaia-X compliance. Gaia-X is part of a broader strategy to ensure European digital sovereignty. The energy data-X project also aims to show how efficient a data space can be in the energy sector through several selected smart services.

In the energy data-X project, the energy data space is made up of six federated services of data sovereignty service, service offering, federated catalogue, identity and trust, portal and Application Programming Interface (API), and compliance. This energy data space could then become the basis for a digital energy economy that efficiently reduces the handling complexity of the future renewable energy system.

Flexibility Portfolio

The Flexibility Portfolio helps TenneT drive the energy transition by ensuring that flexibility technologies can be unlocked. As the electricity system shifts towards carbon-neutral targets, an increase in the generation of variable renewable energies and decreasing share of carbon-based energy sources means that flexibility plays an increasingly important role in the energy system. The Flexibility Portfolio coordinates flexibility-related activities at TenneT across both the Netherlands and Germany. The portfolio focuses on three segments – system balancing, congestion management, and the wholesale market, with the objective to remove any technical, economic, and regulatory barriers that hamper the unlocking of flexibility.

BDL (Bidirectional Charging)

The BDL project was a joint research project with partners including BMW, Kostal, bayernwerk, and FfE and was successfully completed in 2022. The aim of the project was to find a smart way to integrate the increasing number of storage capacities of electric vehicles (EVs) into the electricity system. From a TSO point of view, all of the necessary prerequisites for a successful integration could be achieved.

Crowd Balancing Platform

With an increasing share of renewable energy sources and need for flexibility, TenneT must ensure the grid is in balance at all times. Distributed flexibility can be unlocked through participation in the ancillary services market via the Equigy Crowd Balancing Platform (CBP). In this way, these flexible capacities can be used for system services to stabilise the electricity grid.

Equigy is a European CBP which enables aggregators to participate in electricity balancing markets with smaller flexibility devices, such as heat pumps, home batteries and electric vehicles. Equigy is owned by several European TSOs including TenneT.

The CBP is a blockchain-based data platform which securely links participating parties for flexibility transactions between aggregators, Original Equipment Manufacturers (OEMs), TSOs, and DSOs. Flexibility services include Frequency Containment Reserve (FCR), automatic Frequency Restoration Reserve (aFRR), manual Frequency Restoration Reserve (mFRR), redispatch, and congestion management.

Several projects are underway to continue to enable an increasing number of distributed flexibility assets to participate in the energy system via the CBP including the BDL, DEER and unIT-e^2 projects.

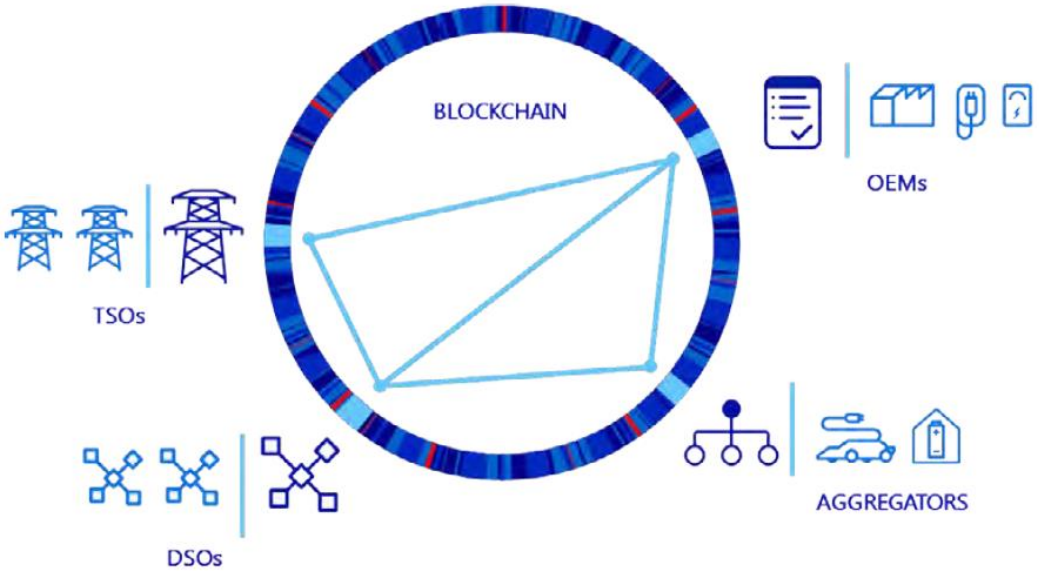

Figure 2 Overview of Equigy Crowd Balancing Platform (CBP) with blockchain-linked participants

Dezentraler Redispatch (DEER)

The DEER project involves the investigation of digital technologies such as Self-Sovereign Identities (SSI) and zero-knowledge proofs with regard to their suitability for providing evidence of decentralised flexibility sources at the interface to flexibility platforms. Together

with project partners including Fraunhofer FIT, DKE, OFFIS, be.storaged and OLI Systems, DEER aims to unlock distributed flexibility for redispatch by introducing SSI to the blockchain-based Crowd Balancing Platform. This will allow the identification of individual assets that provide flexibility while maintaining high data security standards for the asset owners.

unIT-e^2

The unIT-e^2 project builds on the results of the BDL project and aims to optimise the integration of small flex assets into the energy system and reduce the market entry barriers for the provision of ancillary services from distributed flexibilities. This will be achieved through the development of flexibility processes for a harmonic grid integration of distributed flexibility to provide ancillary services, and the development of coordination processes between grid operators as well as interfaces between grid operation and market actors. The project is run in collaboration with external flexibility partners such as BMW, Mercedes Benz and Viessmann.

Project Work

During the second quarter of my ES Cornwall Experience, I have continued working 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. In addition to these projects, I also had the opportunity to be involved in a project within the STP-DFD Flexibility Portfolio relating to congestion management in Germany. The details of these projects are outlined below.

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.

Throughout my placement at TenneT I was involved in the initial phase of this project which has involved:

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

One identified possible use case for TenneT is that of satellite data to assist with vegetation management and this use case was detailed in my First Quarterly Report. Through engaging

further with internal and external stakeholders, a second use case of utilising aerial technology to assist with asset management was also identified.

Veg management use case:

- assess predictive and analytic capabilities of satellite data on one area of the TenneT grid. Risk profiles are created by the assessment of tower and power base state, vegetation health and size.

Asset management use case:

- assess predictive and analytic capabilities of advanced analytics by combining space imagery and drone inspections on one area of the TenneT grid. Risk profile of assets and vegetation is created by combining efforts of technology.

Commonalities across these use cases and relevant business units were explored with the role of STP-DFD to facilitate the optimisation of value from a pilot project and help demonstrate the potential moving forward.

In developing the project scope for a data-based pilot, the following were taken into consideration:

- **Pilot area** – to demonstrate the potential of SD to improve processes at TenneT, an area/s of the network should be chosen based on:
    - Consultation with internal vegetation and asset management teams
    - Understanding of 'minimum area' orders and available options from satellite data provider
- **Complexity and application of satellite data and AI assessment** – various case studies show how satellite data can be used in different application for vegetation management, including more simple present time monitoring (e.g. for this season what needs to be cut, what risks currently exist) and more complex predictive modelling (e.g. risk based assessment for future growth of vegetation over several years).
- **Investigation of different available satellite data solutions** – this may consider that:
    - Different resolutions are priced differently, so it is important to evaluate which is the appropriate resolution for the use case. Could also use a combination of coarse and fine monitoring – coarse to first identify areas of interest and then fine to provide the details required for those areas.
    - Different data types available – understanding required of how data will be used, for example false colour imagery based on wavelengths can be used with computerised analysis compared to what is required for human eye assessment.
- **Validation of pilot results is required** – A second dataset is recommended to validate the pilot results. This could include both business as usual (BAU) manual vegetation and asset inspections or the use of LiDAR for comparison with SD findings.

Following this initial explorative stage, STP-DFD will continue to work with internal and external stakeholders to progress the pilot project.

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 3 provides an overview of the option analysis scope for the project including the input activities required for assessing each option. The activities undertaken in the first quarter of my scholarship placement 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
- Collecting and analysing internal advice and trial user feedback.

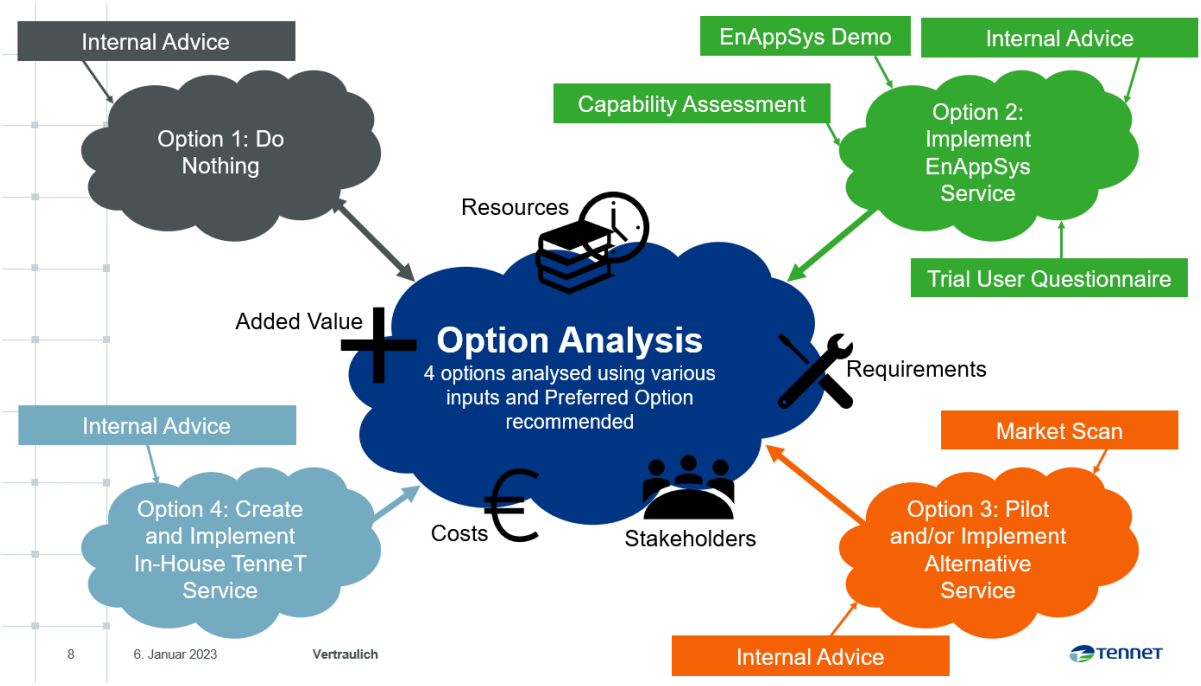

Figure 3 Overview of Option Analysis for EnAppSys Project

The second quarter of my scholarship placement has involved undertaking further analysis based on the initial feedback received from key users to determine potential use cases for EnAppSys within TenneT in order to finalise and report on the option analysis and provide advice on the preferred option to senior management.

In analysing business use during the trial licence period, it was found that EnAppSys can be used within TenneT for multiple purposes. The highest EnAppSys use has been within the future focused and big picture departments as opposed to those focused on day-to-day operations. These departments can utilise EnAppSys for accessing market and pricing data, and to look back at historical data to better understand current markets and system developments when planning the grid of the future. EnAppSys can be used by multiple departments for quick data insights and ad hoc project tasks. Example identified potential future use cases included: access to pricing data and redispatch cost calculations for forecasting tasks; quick analysis on trends of forward markets (2025-2030); and ability to improve understanding of market development, and market and stakeholder positions.

To help determine an appropriate licencing strategy, the following user profile types were identified throughout the business:

- Individuals / key users: require frequent and guaranteed access. Ownership of licence at the individual may be more challenging in some cases.
- Teams with common use cases: require frequent and guaranteed access but could share several desk licences. Ownership at a team or department level.
- Ad hoc uses: do not require frequent or guaranteed access but option to utilise licence on occasion as ad hoc needs arise. Ownership at a wider company level or reliance on other user profile ownership.
- Future users: may require access in the future based on new or not yet identified use cases. Ownership to be determined as need arises, with some reliance on other user profile ownership.

The option analysis for the project involved the exploration of four options as shown in Figure 3. Along with the activities shown in the figure and used to assess each option, the following were also considered for each option:

- Is the option able to be implemented immediately? What is the timeline and resources required for delivery?
- How does the option align with the wider business and other commitments/processes in place?
- How adaptable is the option, how extensive is it, is it already used within the business?

Following the presentation of analysis results and recommendations to senior management, and in preparation of the completion of my placement with TenneT, the EnAppSys project was handed over with the next steps of deepening ownership within key departments and finalising decisions underway.

Congestion Management via Aggregated Flex Devices in Germany

The Equigy Crowd Balancing Platform (CBP), outlined above within the *Flexibility Portfolio* overview, has undergone testing through several pilot projects involving the use of decentralised flexibility from domestic batteries and electric vehicles. As the market share of heat pumps is expected to increase in the coming years, TenneT is undertaking the ViFlex pilot project to understand the flexibility potential of heat pumps for redispatch and congestion management on the German grid through the CBP.

The aim of the ViFlex pilot project, together with heat pump manufacturer Viessmann and German TSOs 50Hertz and TransnetBW, is the pooling of heat pumps to form a virtual power plant and provide flexibility for congestion management. This can support the provision of redispatch services to avoid both renewable generation curtailment and having to start up conventional power plants due to congestion. At the same time, it is essential to maintain comfort and efficiency for customers' hot water and space heating requirements.

From a pool of heat pumps with smart control, Viessmann offers flexibility for redispatch services via the Equigy CBP. TenneT can enable this flexibility to avoid the curtailment of renewables and costly start-ups of conventional power plants. The operation schedules of the heat pumps make use of the thermal storage capabilities of buildings and hot water storage tanks when, for example, there is excess electricity for solar and wind power that cannot be transported to other regions in Germany.

As part of this ongoing project, the STP-DFD utilises Grafana dashboards to visualise and monitor connected heat pumps and flexibility activities. During my placement I was able to upskill in the use of Grafana and the open-source relational database management system, MySQL to help make additions to the existing dashboards.

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.

Additional key takeaways from the qualitative discussions and option analysis undertaken as part of the EnAppSys project included:

- Services such as EnAppSys sit within the larger data puzzle which exists in large utilities and therefore it is important to continually review and link to other internal data platforms and the progress of similar services.
- The existence of internal barriers and siloed data management reduces the accessibility of data that would otherwise be available internally, for free.
- With stronger data management, greater collaboration could be achieved with the wider industry by sharing more data and potentially enabling market parties to support TSOs and network operators like TenneT in its challenges and likewise better enable the market itself. This will be increasingly valuable through the energy transition.
- For strong data development within a large organisation like a network operator, an internal data vision, mandate and budget is required.

It was also a wonderful learning experience to be able to upskill in the use of Grafana and the open-source relational database management system, MySQL as part of the ViFlex project within the STP-DFD Flexibility Portfolio. Through this work I also gained a deeper understanding of the ViFlex project and how aggregated flexibility can be used to address congestion management in the electricity grid. As the demand on the grid and the number of small-scale devices such as electric vehicles and heat pumps increases, there is a necessity, as well as an opportunity, to explore the potential of these devices to provide flexibility, a key requirement of the energy transition. A broad range of flexibility options must be considered as the most effective mix is difficult to predict. The level to which different innovative

technologies may contribute to network flexibility will depend on trends in consumer uptake, technological capabilities, and costs.

Additional Learnings

During the second quarter of my ES Cornwall Memorial Scholarship experience I completed my first placement at TenneT TSO. Throughout my time with TenneT I have had the opportunity to gain insights into the Dutch and German, and wider European, energy systems. Working with TenneT has increased my understanding of electricity transmission, which has been a valuable learning to take back to my nominal role in electricity distribution. Working for the first cross-border TSO in Europe, and my first time working for an international company, has also been a new and worthwhile experience in gaining knowledge of how differing local laws and regulations, drivers, and communities and culture can impact interconnected systems across borders and the approaches which can be utilised to work together effectively. In addition to this, a summary of three further learnings gained during my second placement are provided below.

Dunkelflaute

During my placement at TenneT I was introduced to the German term ‘dunkelflaute’, which refers to an extended period of time with minimal sunshine and wind. Sunshine and wind are two key components required to generate solar and wind power, respectively. The rise in these renewable technologies means that such a natural phenomenon has the potential to have an increased impact on the energy system of the future.

These periods, which are also known as an 'Elfstedentocht-scenario' in the Netherlands, are most likely to occur in winter, when demand for energy such as lighting and heating is at its highest. These periods aren’t new, and nor are they uncommon, occurring between 50 and 100 hours every winter in Northern Europe. However, their impact on the energy system is changing as the energy mix transitions to more renewable based technologies.

The occurrence of dunkelflaute or similar phenomenon can impact the reliability of high penetrations of renewable technologies and raises the question of what to do to mitigate this situation. For these periods many people think that fossil fuel power stations should provide the most affordable back up capacity. This is accompanied by the fear that if renewables push gas and coal out of the energy mix, they might not be available in times of need. This could result in blackouts or increased energy costs.

An alternative approach could be found through innovation or increased utilisation of energy storage. The energy system of the future needs to be reliable and resilient, and with the known risk of dunkelflaute comes the opportunity and motivation to innovate to address that risk. This could lead to improvements and innovations in intermittent renewable technologies or alternative energy sources such as hydrogen or nuclear power. The intermittent nature and reliance on weather conditions of solar and wind technologies can be somewhat mitigated by storing the electricity they generate for more on-demand usage. In this way, energy storage can help provide increased reliability to these technologies and assist in riding out periods of low generation. Due to the extended nature of a dunkelflaute period, sufficient storage capacity, especially that which relies on battery storage technologies such as lithium ion, could be a challenge to achieve. Pumped hydro presents itself as a promising storage technology in this area. Again, the concern about dunkelflaute could drive innovation in storage technologies such as batteries, hydrogen fuel cells and thermal storage.

Daunkelflaute does pose a challenge to increased renewable penetration in the energy mix, but that challenge can be approached with either a resolution not to change or a motivation to innovate and create opportunity in the face of challenge.

ElaadNL Digital Data Day

TenneT's Digital Data Days involve the voice of stakeholders from and related to the energy sector and focus on presenting system needs, challenges and trends for unlocking and accelerating innovation, new flexibilities, and digitalisation. As part of my placement with TenneT I attended a Digital Data Day Coffee Talk with ElaadNL.

ElaadNL is an initiative of grid operators in the Netherlands which began in 2009 with the focus of investigating the impact of electric mobility on the grid. Addressing the chicken and egg situation associated with charging infrastructure installation, the initiative decided to start building a grid of charging stations to provide one free charger for every 10,000 people in a municipality. As the EV market grew, so did the question of who is responsible for EV charging. As this responsibility transitioned to the market, ElaadNL shifted into a knowledge centre. ElaadNL now do analytics, and make prognoses for the future, which are used for planning and to inform the grid operator partners. EV chargers are now installed by municipalities and councils in Netherlands and ElaadNL helps these groups with understanding standards and processes. ElaadNL is also undertaking a variety of electric mobility related projects such as on smart charging and cybersecurity both nationally and internationally. With their test lab they are able to perform electrotechnical tests for power quality, to help manufacturers improve the robustness of elements such as car transformers.

While the Netherlands is in a relatively good position compared to other parts of Europe and the world in terms of EV infrastructure development, there is still a long road ahead with 2 million EVs predicted by 2030. This significant increase presents challenges including safety and cybersecurity and will place stress on the capacity of the grid. These challenges need to be addressed along with regulations and laws to provide appropriate smart charging rules and processes.

The Netherlands is also advantaged by the existence of a collaboration such as ElaadNL, which has provided the opportunity for grid operators and other EV stakeholders to work together. Earlier successes of this collaborative culture have been in the decision to standardise Radio Frequency Identification (RFID) card types and in the development of open charge point protocols which evolved into the world standard for that type of communication, and this culture will help the EV sector in the Netherlands moving forward.

International Women's Day

As part of a male dominated industry, International Women's Day (IWD) is a fantastic opportunity for electrical industry companies to both celebrate the achievements of women and the work done to promote equity to date, as well as to take the time to acknowledge and deep dive into how much more must still be done in our industry and beyond. Having attended similar events in Australia it was a wonderful opportunity to participate with TenneT during my placement to increase my international understanding and gain insight into what similarities and differences there might be between Australia and the Netherlands.

From the panel speakers and broader discussion, the impression I gained is that generally the situation is very similar, both in terms of statistics and the experiences of women in the industry. This highlights that on an international level, our industry still has a long way to go. It was also introduced however that there may be some overlap in the strategies required to

transform the electrical industry during the energy transition and those required to transform gender equity and that this could provide an opportunity for greater success in achieving both transformations.

Presentation to the NETT

The Network of European TSO Trainees (NETT) is a trainee-led initiative with the aim to connect trainees working in different TSOs all over Europe. During my placement at TenneT I was able to join three editions of the NETT Talks, an online events series with guest speaker presentations and networking sessions, twice as a participant and once as a guest speaker. The editions I attended included talks on the topics of the System of the Future, presented by 50Hertz Transmission GmbH, and Emerging Tech – EV Grid Integration, presented by TenneT TSO.

For my presentation to the NETT, I provided an overview on the Australian energy system including our gas and electricity networks and markets, and our energy mix and energy future. Throughout this overview, I also provided a comparison of how aspects of the Australian energy system relate to those of the European energy system. In researching and presenting on this topic, I noted several areas of comparison, which are summarised below:

- Due to the difference in network topologies (Australia has long and thin versus Europe's meshed and dense), transmission network charges typically contribute more to end prices in Australia than in Europe and are more than double that of some countries in Europe.
- A higher percentage of average household energy consumption is used for heating in the EU than Australia. As such, the electrification of heating from traditional gas systems to heat pumps is having a significant impact on electricity demand in Europe, but also provides new opportunities for small scale flexibility.
- Based on share of household disposable income, Australians typically spend less on electricity, gas and other heating fuels compared to the EU average.
- On a per capita basis, Australia added over four times the Variable Renewable Energy than the EU did in 2018, and five times in 2019-20.
- The size of Australia shapes our energy networks, and the term tyranny of distance is an Australian coined term which represents the challenge of operating across such a large area. This could be compared to some of Europe's offshore wind projects and is a challenge we will all have to overcome as many of the world's sunniest and windiest places are far from major population centres.
- In Australia, there has been enormous growth in household solar. In 2008, there were just 14,000 solar PV systems installed on our rooftops. Today we have more than 3 million. More than a quarter of Australian households have rooftop solar PV, the highest penetration in the world. However, even though Australia's total number of electric vehicles almost doubled in 2022, their market share is still less than 5%. Compared to an EU average of 17%, this is an area that we are at an earlier stage of technology uptake. This highlights that while both Australia and Europe are undergoing a similar energy transition, there is still variability in the pathway to net zero and in the uptake of specific technologies.
- Both the European Union and Australia have created hydrogen strategies. As part of a common energy transition, international collaboration on hydrogen can be of mutual benefit and there are already several international partnerships between parts of Europe and Australia, which include:

- A Hydrogen Accord between Australia and Germany. The accord includes several new initiatives to accelerate the development of a hydrogen industry. As part of this accord, Australia will contribute $50 million, and Germany will contribute €50 million.
- Australia and the United Kingdom have agreed to collaborate on research and development across technologies crucial to decarbonising the global economy, including clean hydrogen.
- The Australian Government, and state governments such as South Australian Government, have signed a memorandum of understanding to investigate clean hydrogen exports with the Port of Rotterdam in the Netherlands.

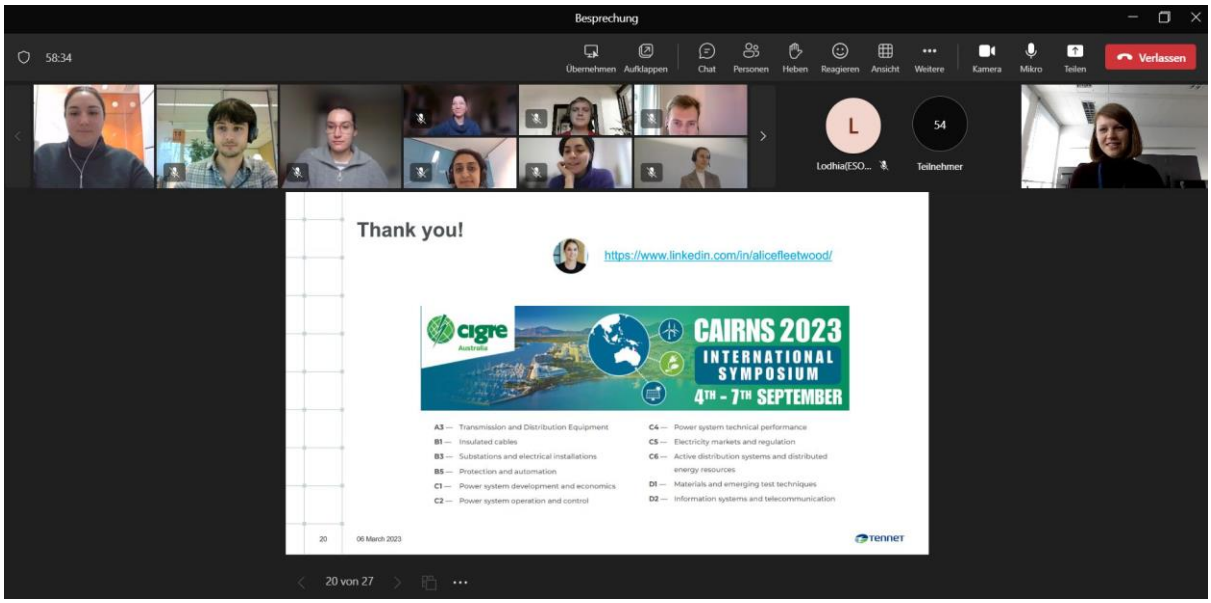

Figure 4 Screenshot of online presentation to the NETT

Europe and Australia are part of the same globalised planet – and while this may seem obvious, it means that there are actually a lot of similarities between our energy systems. We have had similar developments over time to both become mature, reliable systems. We are both undergoing an energy transition, in which we have access to similar technology advancements such as renewables and storage and we are subject to similar climate changes, consumer expectations and the laws of physics. Because of this, we have the opportunity to work together, such as in the area of hydrogen development, for better future outcomes.

There are also differences between our energy systems, such as in the uptake of different technologies and in some aspects of our networks' topologies. But these differences can be equally valuable in providing opportunities to learn from each other. For example, Australia can look to Europe in preparation for an increase in electric vehicles on our roads. And similarly, the lessons we have learned from high levels of rooftop solar can be shared with Europe.

Plan for Next Quarter

For the third quarter of my ES Cornwall Memorial Scholarship experience I will commence my second placement at Scottish Power Energy Networks in Glasgow, Scotland with the Network Planning and Regulation – Asset Management and Investment team.

Thank You TenneT

Thanks again to TenneT, and specifically the Strategy and Partnership department and the Digital and Flex Development team, for an incredible six months. Thank you for welcoming me into your team, I am very grateful to you all. I wish you all the best and I can't wait to see the amazing things that STP-DFD achieves in the future.