

Organizational integration between TenneT NL and TenneT GER

Final report for the Dutch Ministry of Finance (Confidential)

22 August 2019

E-Bridge
competence in energy

Content

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Background and scope

E-Bridge conducted a further analysis of synergy effects of the organizational integration of TenneT NL and TenneT GER based on the initial analysis performed by Strategy&. Based on its experience, E-Bridge substantiated and elaborated more on selected (technical, financial, and strategic) effects of the organizational integration between the TSOs.

E-Bridge focused not only on upsides of the German-Dutch cooperation but also on potential downsides and tried to give insight in the potential extra synergies or dis-synergies of shareholding by the German Government or KfW, although the assessment of the possibility and probability of a potential shareholding by the German Government or KfW was not in the scope of this study.

The scope of the study performed by E-Bridge was limited, as was the time available to perform the study.

- As such, no quantitative analyses have been made by E-Bridge.
- All numbers mentioned in this report originate from public sources or have been mentioned in interviews with TenneT.
- These numbers are estimates and should not be interpreted as exact numbers.
- The magnitude of the numbers presented is reasonable from E-Bridge perspective.

Although the information contained in this report has been presented with all due care, it is the responsibility of the Ministry of Finance to make own investigations, decisions, and inquiries about the information and to exercise own independent professional judgment when using (the information contained in) this report.

Methodology

The main objective of the study was to investigate and to present tangible, understandable, examples (“cases”) of how the integrated TenneT made a difference (in both a positive and/or negative sense). In those cases, E-Bridge investigated the role of TenneT, and the process followed by TenneT, to reach its objectives.

- As such, this study builds upon earlier work done, and adds a layer of detail to this earlier work performed (see list of reports / documents).
- The use of cases does imply that a spotlight is put on individual elements rather than the bigger picture. As such, the report does not intend to, and cannot, be complete.
- Where possible, numbers have been used to quantify the difference made by the integrated TenneT. Most often this is not possible, and a qualitative reasoning and description was used to demonstrate how the integrated TenneT made a difference.
- The “What if TenneT would not have been integrated”-question is a logical one to be raised in this context, and a difficult one to answer. Indeed, TenneT would have been pushed by the same drivers to reach its objectives, though it would have had to act differently as its toolset to reach the objectives would have been different.

The cases have been selected to provide:

- Qualitative and quantitative breakdown of effects (synergies) realized by organizational integration of TenneT NL and TenneT GER – from which TenneT has benefitted in the past (one-time benefits) and/or from which TenneT is still benefitting now (ongoing benefits).
- Qualitative and quantitative breakdown of effects (synergies) potentially to be realized from further organizational integration of TenneT NL and TenneT GER – ‘future potential’.
- Qualitative and quantitative breakdown of effects (synergies) being lost/downsides of an organizational split of TenneT NL and TenneT GER.

Methodology: example

As an example of a case - realized by the organizational integration of TenneT NL and TenneT GER from which TenneT is still benefitting now (ongoing benefits) - in the field of System Operations, the International Grid Control Cooperation (IGCC) is zoomed into:

- IGCC, launched in October 2010 by the German TSOs, enabled the implementation of the imbalance netting process.
- By setting the strategic conditions for the project from the TenneT management, that it should immediately become an international system and not just a German one, TenneT NL decided to participate from the start. The decision was made together with the other three German TSOs.
- IGCC was expanded - mainly driven by joint efforts of TenneT GER and TenneT NL - to a regional project and has grown to cover 10 countries (13 TSOs) across continental Europe. In the future this will grow further.
- IGCC led to total realized savings of ~€22-42 Million / year for TenneT NL
- This benefit will not be lost in case of an organizational split.

This is one example (case) to illustrate and make tangible how the integrated TenneT made a difference. Indeed, if TenneT had no activities in Germany, this IGCC would not have expanded as fast as it did now, nor would it have grown to the same international success with other important TSOs joining.

Methodology: overview

Analysis of inefficiencies as a result of organizational integration

- **Market design and market integration**
- **European regulation**
- **System operation**
- **Investment planning**
- **Energy transition, digitalization, sector coupling / hydrogen**

General description, and evaluation of effects in terms of:

Affordability, SoS, Sustainability

"Cases" –

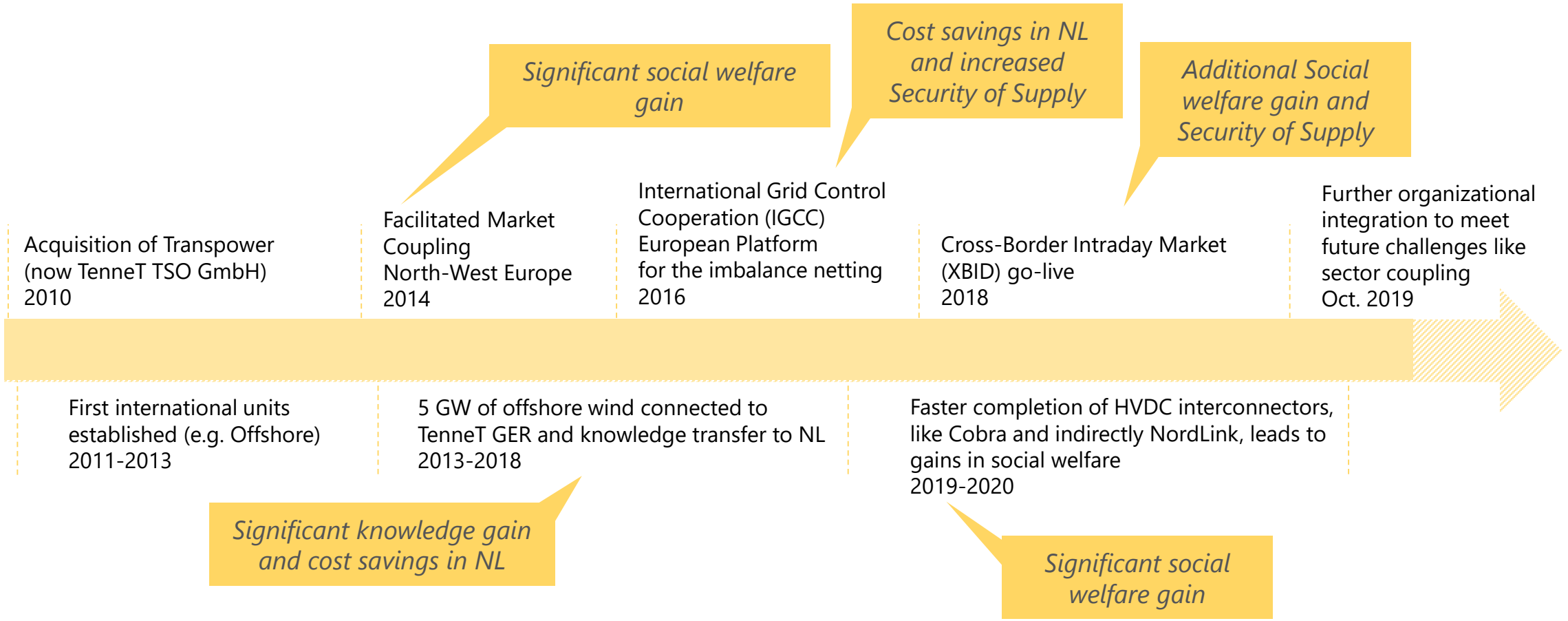
tangible, understandable, examples

Qualitative and quantitative estimate of the impacts

- Assessment for each scenario
  - Effects (synergies) TenneT benefitted in the past and/or from which TenneT may still be benefitting now.
  - Effects (synergies) potentially to be realized from further organizational integration of TenneT NL and TenneT GER – 'future potential'.
  - Effects (synergies) being lost/downsides of an organizational split of TenneT NL and TenneT GER.

Content

Major Milestones of the integrated TenneT



Game changers in the energy landscape: potential for additional synergies

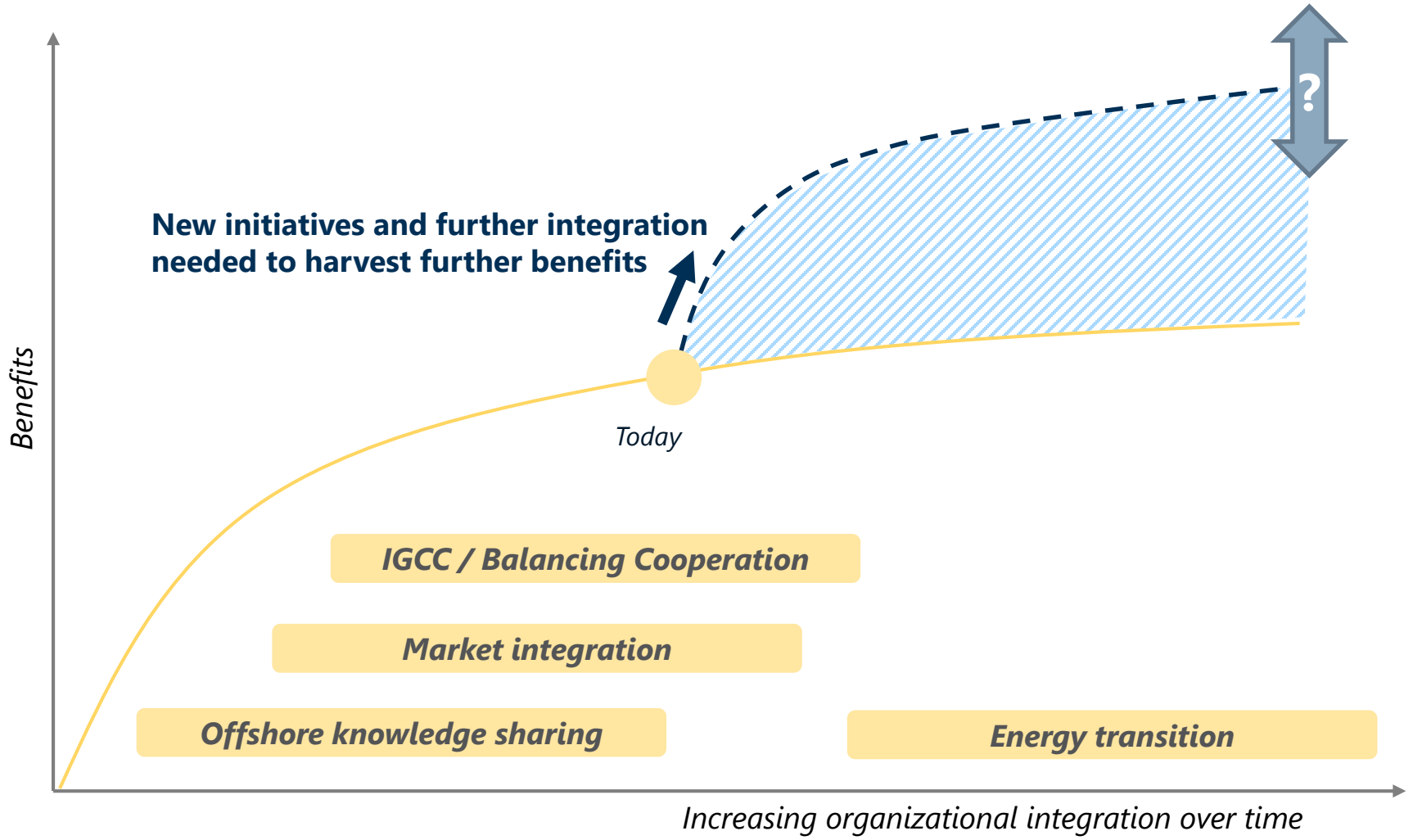
Wide spectra of drivers will lead to a significant change of the energy system and to an increasing complexity, which has to be considered by the integrated TenneT.

Political Drivers

Technological Drivers

Social Drivers

Social welfare gains achieved and potential for additional synergies



High-level overview of areas, in which benefits were harvested by integrated TenneT

System Operation

Integrated TenneT enabled IGCC as European platform with savings for the Dutch society and increased security.

Market Integration

The market design facilitated by integrated TenneT supports the social welfare gain in NL & Europe.

Stakeholder/European Regulation

Integrated TenneT increased influence on regulatory future developments and practical implementation.

Investment Planning

Integrated TenneT realized benefits through knowledge transfer in wind offshore connection & HVDC.

Digitalization, sector coupling / hydrogen

Integrated TenneT established one single department responsible for digitalization in NL and GER.

Organizational Integration

Efficient governance and sharing of resources in an enhanced TenneT integration.

Detailed overview of areas, in which benefits were harvested and can still be harvested by integrated TenneT (1)

Areas

System Operation

Integrated TenneT enabled IGCC as European platform with savings for the Dutch society and increased security.

Progress of benefits harvested by the integrated TenneT

+ IGCC led to total realized savings of ~€22-42 Million / year for TenneT NL
+ Integrated TenneT enables further benefits in the European balancing cooperation.
+ One single SCADA system is currently being purchased, which provides costs savings and higher redundancy.

2019	2019
+€22-42 MEUR/ year (TenneT NL)	
+5-10 MEUR (CAPEX)	

Market integration

The market design facilitated by the integrated TenneT supports the social welfare gain in NL and Europe.

+ Due to Market Coupling, the number of hours with a full price convergence of the DA prices in NL and GER increased from negligible in 2005, for example to 28% (2015), 43% (2016), and 42% (2017)[1].
+ Significantly more ID volumes traded in 2017 (+63%) and 2018 (+49%).
+ Extension of the CWE FBMC to the Core region will establish a more efficient use of transmission capacity on the European continent.

2019	2019
+CWE FBMC: 132 MEUR (of which 57 MEUR in NL[2]) for the year 2014	+Core FBMC: further benefits expected, yet not quantified

Stakeholder/ European Regulation

Integrated TenneT increased influence on regulatory future developments and practical implementation.

+ Integrated TenneT has increased influence in energy policy and a stronger voice in European and worldwide developments.
+ TenneT's headcount in ENTSO-E working groups could be reduced significantly from approx. 70 – 80 to 40 – 60.
+ Influence on European regulation still crucial, as more and more areas of the energy sector are regulated by the European regulation instead of national regulation.

Please note that the figures presented above can be regarded as a lower bound; Indeed they only represent some examples of the benefits.

[1]: The one percent drop does not indicate a tendency; it does demonstrate that not every year is the same, in terms of weather conditions (e.g. cold winter).

[2]: Based on 8 million Dutch households, this boils down to an indicative 7 EUR for 2014 per Dutch household.

Detailed overview of areas, in which benefits were harvested and can still be harvested by integrated TenneT (2)

Areas

	Progress of benefits harvested by the integrated TenneT		2019	2019
Investment Planning Integrated TenneT realized benefits through knowledge transfer in wind offshore connection and HVDC		+ Substantial benefits through knowledge transfer: + Usage of 66kV cables, savings around 480 MEUR + Standardization of equipment (around 760 MEUR) and operations (520 MEUR) + Higher availability through modular concept (savings around 920 MEUR) + Faster completion of HVDC interconnectors leads to gains in social welfare (NordLink: 73 Million €/year for GER with indirect benefits for NL, COBRA: 60 Million €/year for NL).	+ 480 MEUR + 760 MEUR, 520 MEUR / year + 920 MEUR + 73 MEUR / year for GER [1] + 60 MEUR / year for NL [1]	
Digitalization, sector coupling / hydrogen Integrated TenneT established one single department responsible for digitalization in NL and GER.		+ Digitalization can partially prevent future expensive investments in grid infrastructure (similar to Suedlink (up to EUR 10 billion) with indirect benefits for NL). + One single TenneT data platform accessible for all functions and decision-making processes (estimated one-time savings of around 5-10 MEUR) + By developing P2H2 technology overall socioeconomic benefits can be achieved in the long-term, but high investments are needed by the industry in the mid-term	+ 5-10 MEUR CAPEX	+ Upto 10 BEUR for GER
Organizational Integration Efficient governance and sharing of resources in an enhanced TenneT integration.		+ Several units were established as international units, like the Offshore, European regulation, and Digitalization units. In Oct. 2019 a next step in the organizational integration will be made to face future challenges. + With a joint vision and strategy, cooperation among colleagues and management can be better based on trust and solidarity leading to lower transaction costs. – Housing and travelling are universal "inefficiencies" of an integrated international company and cannot be prevented.		

Please note that the figures presented above can be regarded as a lower bound; Indeed they only represent some examples of the benefits

[1]: These benefits were harvested earlier due to faster completion of HVDC interconnectors.

Conclusions (1)

E-Bridge did not identify major disadvantages of the integrated TenneT, yet there are challenges

In this study, E-Bridge did not identify major disadvantages of the integrated TenneT. A potential disadvantage of the integrated TenneT could have surfaced e.g. in projects being delayed or slowed down due to the integrated TenneT, or policy risks. No signs of this have been detected. Housing and travelling are universal "inefficiencies" of an integrated international company and cannot be prevented. A potential dis-synergy is the special financing constructions in Germany due to financial investors in lower levels of the company. This is out of scope of this study though.

One-time and enduring benefits were harvested by integrated TenneT

TenneT has been one of the frontrunners in the field of European electricity market design and market integration. Some of the initiatives that were initiated by TenneT, or where TenneT participated as one of the founding fathers, are now enforced in European legislation.

Integrated TenneT realized substantial benefits through knowledge transfer in wind offshore connections and HVDC.

Benefits of the one TenneT, obtained so far, are to a large extent "business as usual", such as the benefits in the field of market integration (e.g. flow-based market coupling, and cross-border intraday), and system operation (e.g. International Grid Control Cooperation).

Conclusions (2)

Future potential can be realized from further organizational integration but also risks need to me managed in the energy transition.

Though quite some benefits have been reaped by the one TenneT for the “business as usual” - such as the benefits in the field of market integration (e.g. flow-based market coupling, and cross-border intraday), and system operation (e.g. International Grid Control Cooperation) – there is future potential left, e.g. in system operations.

The main future integration benefits to be harvested are not in the scenario “business as usual”. When one would do the same exercise now (as performed at the time of the acquisition of Transpower) for the next 10 years ahead, one would face quite some challenges. Indeed, the future energy landscape is highly uncertain, where opportunities but also risks emerge. Solutions will be developed, and the future will be shaped, though the exact path cannot be predicted yet.

TenneT has an important role in the energy transition by connecting large wind farms to the grid and to make sure that the system is able to cope with the intermittent power infeed for renewables sources, amongst others through the interconnected network and the integrated market. This is not business as usual, but enters into the realm of innovation, digitalization, cross-sector cooperation / alliances with other actors to be prepared for the changes to come.

The integrated TenneT, with a base in NL and GER, makes a difference as knowledge sharing and learning effects e.g. from pilot projects are essential step stones towards this future, where standardization can be facilitated when a larger geographical area is served, and a larger voice takes part in the international discussions. Different cultures, and a wider range of industry partners are all aspects that are at hand with the integrated TenneT organization and help to a certain extent in paving the way forward.

Conclusions (3)

An organizational split may lead to synergies being lost

Benefits of the one TenneT obtained so far in the area of market integration and system operation would remain quite stable, even in case of an organizational split. In the area of offshore connections most of the synergies would be lost for the new projects, when TenneT would be split. There are about 11 projects, that are currently being realized jointly. A loss of flexibility, common standards, loss of know-how for operating a VSC HVDC system, and negotiating power is very likely.

In Oct 2019, TenneT will make a next step in the integration: an integrated top management level. The ad-vantage of this next step integration is an integrated decision-making within one integrated TSO instead of an alignment between two cooperating TSOs. Working and cooperating on a basis of trust is more efficient and flexible than when a cooperation is based on contractual arrangements. These achievements will be at risk in case of an organizational split.

The effects described in the future potential would be lost, as the influence on one of the major European markets and networks would be lost. In case of an organizational split, depending on the interests which influence the decisions of TenneT GER, also actions contrary to the interests of the Netherlands are possible, in particular if the positions of the four German TSOs are very strongly aligned.

TenneT NL may be too small to create the required momentum and economies of scale, needed to consolidate a leading role in the accelerated energy transition. There is uncertainty on the future energy landscape where the industries will have to go through a transition and require a leading counterpart.

Conclusions (4)

An assessment of the possibility and probability of a potential shareholding by the German Government or KfW is not in the scope of this study.

Potential shareholding by the German Government or KfW provides potential of extra synergies and dis-synergies

A potential shareholding by the German Government or KfW may bring further benefits in relation to political alignments in order to successfully implement the energy transition and to implement a showcase for how to run a decarbonized and innovative energy system.

„Common learning curve" and „co-creation" is one of the key objectives for the integrated TenneT in the political discussions. Early involvement and sharing of concepts with the Dutch and German governments / ministries could provide further benefits. A common understanding of the Dutch and German governments and ministries may be easier explored by the integrated TenneT, in case of the German and Dutch government as a joint shareholder.

As quite some topics are "politically sensitive", e.g. the protection of the Energy-only Market (EoM), the bidding zone delineation, and potential different speeds of P2G and hydrogen implementation, a joint shareholdership with the German Government would bring the alignment on these topics directly to the political level to be solved. This benefit may also be perceived a disadvantage though, as discussions and alignment on a political level may lead to trade-offs.

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Stepwise increase of organizational integration of TenneT

With the acquisition of Transpower, several units within the integrated TenneT were established as international units, like the Offshore, European regulation, and later the Digitalization unit.

TenneT is on its way to move from a partially-integrated company to a fully-integrated company. Indeed, in October 2019 a next step in the organizational integration will be made, with the realization of an integrated top management level. The integration will extend to crucial IT systems as well: one ERP system (currently: SAP in GER and IFS in NL) and one SCADA EMS system.

Indeed, there is room for a more efficient operation of the one TenneT; this potential is to be harvested with the next step in the organizational integration in Oct 2019 and the years to follow – it will take some time before an integrated way of working has materialized. Certainly, attention needs to be paid to have not only a one TenneT to the outside world, but one TenneT in the perception of the employees as well.

A fully-integrated TenneT is / will lead to a TSO where

- An integrated decision will be taken within one integrated TSO, instead of an alignment of two cooperating TSOs.
- The cooperation among the colleagues and the management is built on trust and solidarity; a way of working that is more efficient and flexible than when a cooperation is based on contractual arrangements. This benefit has already been established to an important extent.
- Lower transaction costs can be realized.

Inefficiencies at TenneT as a result of the organizational integration

1. Housing and travelling are universal "inefficiencies" of an integrated international company and cannot be prevented.
2. A potential dis-synergy is the special financing constructions in Germany due to financial investors in lower levels of the company. This is out of scope of this study though.
3. The setup where TenneT GER is part of one integrated Dutch / German TSO may provide some tension. Indeed, TenneT GER is also one of the four German TSOs that are used to have an aligned position in Europe. A different view of the one integrated TenneT and the other German TSOs may put pressure on TenneT GER.
   - Please note that this may only be considered or labelled as a downside, when this situation has resulted in a delay of implementation projects or key decisions.
4. A potential inefficiency of the organizational integration can also originate from the political / regulatory playground, such as
   - On the regulatory side, BNetzA and ACM may have different interpretations, thereby putting TenneT in a difficult position (especially when BNetzA would put pressure on the other German TSOs as well).
   - On the legislative side, German law states that the German bidding zone cannot be split, thereby putting TenneT GER in a difficult position in bidding zone delineation studies and discussions and may lead to two different positions within the one integrated TenneT.

Overall the inefficiencies and risks seem to be relatively low compared to the benefits identified and described in the following chapters.

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Market design and market integration

TenneT has been one of the frontrunners in the field of European electricity market design and market integration. Some of the initiatives that were initiated by TenneT, or where TenneT participated as one of the founding fathers, are now enforced in European legislation. Examples are the Trilateral Market Coupling (TLC), an implicit allocation / price coupling of the Dutch, Belgian, and France Day-Ahead markets, that started off in 2006. The TLC was expanded to Germany, the so-called CWE market coupling, in 2008. In the Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management (CACM), it states: "*In order for the implicit auctions to take place Union-wide, it is necessary to ensure Union-wide price coupling process.*" Another example is the development of the flow-based (FB) capacity calculation. TenneT initiated the work on a regional basis (the so-called Central Western Europe region, CWE, consisting of the Netherlands, Belgium, France, and Germany) in 2006. The CWE flow-based market coupling went live in 2015 and is in operation today. The CACM states: "*There are two permissible approaches when calculating cross-zonal capacity: flow-based or based on coordinated net transmission capacity. The flow-based approach should be used as a primary approach for day-ahead and intraday capacity calculation where cross-zonal capacity between bidding zones is highly interdependent.*"

Or in other words: it was a.o. the pioneering work of TenneT – driven by the incentive to facilitate the market in the best possible way, while maintaining the balance with the operational security – that paved the way to the target models as they are described in the European network codes to facilitate the harmonization, integration and efficiency of the European electricity market. The fact that TenneT – as of 2009 – was consisting of both a Dutch and German TSO was certainly helpful in this respect to gain more momentum in the discussions and to have the concepts widely accepted. Each network code is an integral part of the drive towards completion of the internal energy market and achieving the European Union's 2030 energy objectives of: at least 40% cuts in greenhouse gas emissions (from 1990 levels), at least 32% share for renewable energy, at least 32.5% improvement in energy efficiency.

With the European network codes and guidelines, and the Clean Energy Package (CEP) - that will apply as of 1 January 2020 for the Electricity Regulation – the targets are now clearly set and the way to implement the Internal Electricity Market (IEM) leaves only a limited degree of freedom. In addition, the CEP introduces the so-called regional coordination centers: "*Regional coordination centers should carry out tasks where their regionalization brings added value compared to tasks performed at national level. The tasks of regional coordination centers should cover the tasks carried out by regional security coordinators pursuant to the Commission Regulation (EU) 2017/1485 11 as well as additional system operation, market operation and risk preparedness tasks.*" Or in other words: where formerly it was the pioneering work of an individual TSO / group of TSOs that led to best practices and target models for system operation and market integration, it is now legislation that sets the target that needs to be implemented. As such, the discretionary power of an individual TSO has reduced not only in terms of market design and market integration, but in terms of European cooperation and coordination as well.[1]

[1]: Please note: in principle legislation lags – with the future uncertainties and challenges ahead, this leaves room for innovation, and solutions to be developed, by TSOs.

TenneT built best practices & integrated TenneT accelerated market integration with price convergence between NL-GER and cost-savings for Dutch consumer

TenneT as frontrunner in European market integration

Market integration brings together European demand and supply on a single marketplace, thereby assuring that scarce transmission capacity is used in the most optimal way; this leads to an increase of socio-economic welfare, and a price convergence in Europe.
TenneT built best practices & integrated TenneT accelerated market integration with price convergence between NL-GER and cost-savings for the Dutch consumer.

Role of TenneT

In 2006 TenneT initiated together with Belgium and French TSOs and PXs the so-called Trilateral Market Coupling (TLC), the first market coupling initiative in Europe based on so-called implicit market coupling, which was the foundation towards the integration of the North-West European (NWE) electricity markets.
In parallel E.ON Netz (now TenneT GER) was one of the founders of the European Market Coupling Company (EMMC) in 2008 to couple the CWE and Nordic regions. Its first interconnection was between Germany and Denmark in 2009. Subsequently, the Baltic Cable linked Germany and Sweden, and the NorNed cable connected Norway and the Netherlands.
The integrated TenneT - consisting since 2010 of both a Dutch and German TSO – brought more momentum in the discussions on the European market integration, and a stronger push to have the concepts / best practices widely accepted.
In 2011 TenneT connected the Dutch day-ahead market via the BritNed cable to the UK market, and in 2014 the day ahead markets in NWE were successfully coupled, linking markets and TSOs all the way from Finland down to Portugal.
In 2015, amongst others driven by the integrated TenneT, the CWE Flow-Based Market Coupling was implemented - which further optimizes the efficiency of power trading by allocating cross-border transmission capacity between the different coupled spot markets, while ensuring that the physical limits of the grid are respected - leading to a higher price convergence between NL-GER and cost-savings for the Dutch consumer.

Affordability

- The number of hours with a full price convergence of the DA prices in the Netherlands and Germany increased from negligible in 2005, to 28% (2015), 43% (2016), and 42% (2017)[1].
- The estimated additional socio-economic welfare gain linked to the introduction of flow-based market coupling in CWE (in addition to the socio-economic welfare established under the CWE ATC market coupling) amounts to 132 MEUR (of which 57 MEUR in NL[2]) for the year 2014.

SoS

- With market integration, European demand and supply are brought together and matched on a single marketplace, thereby assuring that scarce transmission capacity is used in the most optimal way.
- Market integration establishes a balance between surplus and deficits of electrical energy, prices, and scarce infrastructure on a European level.

Sustainability

- Market integration contributes to a more efficient exchange of surplus and deficits of electrical energy, e.g. to cope with the intermittent renewable energy infeeds in the European system.
- Market integration establishes one integrated marketplace where the different geographical merits can be efficiently used and shared: wind production at the North Sea, solar production in the South of Europe, and hydro storage in the Nordics.

E-Bridge competence in energy

[1]: the one percent drop does not indicate a tendency; it does demonstrate that not every year is the same, in terms of weather conditions e.g. (cold winter)
[2]: Based on 8 million Dutch households, this boils down to an indicative 7 EUR for 2014 per Dutch household

Organizational integration contributed to the early implementation of the Intraday market which led to further efficient use of scarce capacity

Early implementation of intraday market (XBID)

The Intraday market offers the possibility for market participants to trade their imbalances, e.g. caused by an altered infeed from renewable energy sources, during the day of delivery, and started in 2006 in the Netherlands.

In 2018, the Cross-border Intraday Market (XBID) went live with 10 local implementation projects (LIPs) that deliver continuous trading of electricity across the following countries: Austria, Belgium, Denmark, Estonia, Finland, France, Germany, Latvia, Lithuania, Norway, The Netherlands, Portugal, Spain and Sweden.

Role of TenneT

In 2016 - at that time the go-live date of the XBID was very uncertain (XBID go-live was in 2018) - the integrated TenneT and others tried to reap quick-wins and established an early version of a cross-border intraday trade platform establishing an intraday implicit coupling between NL, BE, FR, GER/AT, and CH. The joint effort from TenneT NL and GER was key for this early implementation.

Some LIPs were organized on a regional level (like the Nordics and Baltics); most LIPs on the continent were organized on a bilateral border basis, e.g. Netherlands-Belgium, France-Belgium, and so on. An exception was the "scaled-up" LIP between Denmark (Energinet), Germany (TenneT GER and Amprion), and the Netherlands (TenneT NL) and the two NEMOs (EPEX and Nord Pool).

The effort of TenneT NL and GER, to have this "scaled-up" LIP, facilitates the easy incorporation of the COBRA cable in the XBID without any dependency on the other XBID extensions (second- and third-wave go-lives). This allows that the (investments in the) COBRA Cable can be utilized within the XBID shortly after the commissioning.

Affordability

- In TenneT's Annual Market Update 2018, it states "The months after the (XBID) go-live show increased cross-border trade when compared to the same months of 2017. In general, the intraday market is becoming more important, both in terms of volumes and amount of trades."
- This contributes to the efficient use of scare transmission capacity (such as the COBRA cable) and to establish the European Internal Electricity Market.

SoS

- With market integration, European demand and supply are brought together and matched on a single marketplace, thereby assuring that scarce transmission capacity is used in the most optimal way
- Market integration establishes a balance between surplus and deficits of electrical energy, prices, and scarce infrastructure on a European level

Sustainability

- In TenneT's Annual Market Update 2018, it states "Significantly more ID volumes traded in 2017 (+63%) and 2018 (+49%). A possible explanation is the larger share of variable renewables in generation. Market participants use the intraday market to optimize their position, since new information (better renewable feed-in forecasts, demand changes, unexpected outages, etc.) becomes available after closure of the DA market. More variable renewable generation thus leads to a shift of trade closer to real-time."

Integrated TenneT is protecting and strengthening the "energy-only market"

TenneT is strengthening the "energy-only market"

The energy-only market (EoM) brings the economic principle of supply and demand to the power market. This makes the market more efficient, reduces overcapacity, and encourages flexibility in power production. The effectiveness of the energy-only market was challenged in different European countries, and the need of capacity markets were intensively discussed.

Capacity mechanisms operate within the timeframe of the energy market, in other words relatively far in advance of real-time. Consequently they always interfere with the operations of the EoM to a large degree.

Role of TenneT

In 2012/13 E-Bridge Consulting prepared a white paper regarding the "Challenges in the electricity market and guidelines for a sustainable market design" on behalf of TenneT TSO B.V. The results were published on 21 October 2013 and were subsequently discussed with ministries, regulatory authorities, market players, associations and other stakeholders. In order to cope with future challenges the EoM needed to be enhanced by ensuring that market participants adhere to their supply and purchasing obligations.
A safety net, an optional and potentially temporary backup measure for reducing the implementation risk during the energy transition, is proposed. The proposed safety net is a "physical safety net" which serves to avoid controlled load shedding as a last resort for stabilizing the system. In November 2014 the Federal Ministry for Economic Affairs and Energy (BMWi) published a Green Paper on future electricity market design in Germany. The proposals set out in the Green Paper for enhancing the electricity market design in Germany are broadly consistent with the cornerstones described above. Referring to the physical safety net, the BMWi proposed the introduction of a so-called capacity reserve. In 2015 BMWi published the White Paper "An electricity market for Germany's energy transition" including the limited capacity reserve.
TenneT made an effort to keep the capacity reserve as small as possible.

Affordability

- One of the major objectives of the proposed market design is to ensure that market participants adhere to their supply and purchasing obligations and to protect the EoM. The EoM generates appropriate pricing signals so that the market players which operate in the wholesale market are able to respond both in the long- and short-term to any potential endangering of the security of supply.
- The ultimate design of the safety net will be the result of a considered trade-off between minimizing the costs involved in providing the safety net and minimizing its influence on the energy market and balancing energy market.

SoS

- A safety net, an optional and potentially temporary backup measure for reducing the implementation risk during the energy transition, is implemented in Germany. It is called a "capacity reserve".
- This capacity reserves is a "physical safety net" which serves to avoid controlled load shedding as a last resort for stabilizing the system.

Sustainability

- The proposed market design supports the full integration of renewables into the market.

European legislation now sets the target and further potential of integrated TenneT is limited

Extension of CWE FBMC to the Core region

The flow-based market coupling (FBMC) has been developed and established in the CWE region (Belgium, France, Germany, Luxembourg, and the Netherlands); CWE FBMC went live in 2015.

The ACER decision on the TSO's proposal for the determination of Capacity Calculation Regions (CCRs) dates November 17, 2016. The Core CCR covers the former CWE (Central West Europe) and CEE (Central East Europe). ACER decided on the Core capacity calculation methodology (CCM) in February 2019 and aligned it with the relevant elements from the Clean Energy Package (CEP).

The CEP states "*for borders using a flow-based approach, the minimum capacity shall be a margin set in the capacity calculation process as available for flows induced by cross-zonal exchange. The margin shall be 70% of the capacity respecting operational security limits…*"

The go-live date for the Core FBMC is December 2020.

Role of TenneT

FBMC is now being implemented in the Core CCR, where the operational experience in CWE from TenneT Netherlands and Germany – and the alignment among themselves – helped to move the discussion with ACER (Agency for the Cooperation of Energy Regulators), and the project forward.

In the Core CCM, ACER incentivizes the Core TSOs to abandon internal critical network elements in the market coupling, and to cope with them by applying redispatch, grid reinforcements, or bidding zone delineation.

Where formerly it was the pioneering work of an individual TSO / group of TSOs that led to best practices and target models for system operation and market integration, it is now legislation that sets the target that needs to be implemented.

As such, the discretionary power of an individual TSO is more restricted in terms of market integration, and the future potential of one integrated TenneT is limited in this respect.

Affordability

- The extension of the CWE FBMC to the Core region, in line with the ACER decision / CEP legislation, will lead to more cross-border exchanges in the European system, and as such more price convergence and increased socio-economic welfare. The cost of redispatch or network reinforcements may rise though to facilitate this.
- Especially for TenneT GER, being part of the former CWE and CEE regions, with the step to one harmonized approach for capacity calculation and allocation on most of its borders, a benefit can be realized

SoS

- The extension of the CWE FBMC to the Core region (former CWE and CEE region) brings an additional efficiency gain in the use of transmission capacity on the European continent.
- With one coordinated capacity calculation and allocation extended over a larger part of Europe, the uncertainty for TSOs decreases (what happens on the other side of Europe is now an integral part of the methodology and no longer an assumption).

Sustainability

- The extension of the CWE FBMC to the Core region (former CWE and CEE region) establishes a more efficient use of transmission capacity on the European continent, thereby providing the flexibility needed in the system to cope with the increasing amounts of renewable infeed in the various part of Europe.

In case of an organizational separation, the impact on existing synergies would be limited

Impact of organizational separation on the market

With TenneT – and CWE (Central West Europe; Belgium, France, Germany, Luxembourg, and the Netherlands) – being a front-runner in the field of market integration, many of the synergies that can be reached have already been harvested and will remain unchanged in case of an organizational separation of TenneT.

Role of TenneT

Where formerly it was the pioneering work of an individual TSO / group of TSOs that led to best practices and target models for system operation and market integration, it is now legislation that sets the target that needs to be implemented.

As such, the discretionary power of an individual TSO is more restricted in terms of market integration, and the future potential of one integrated TenneT is limited in this respect.

Affordability

- Many of the synergies that can be reached have already been established and would remain unchanged in case of an organizational separation of TenneT.

SoS

- The CEP shifts a larger number of tasks to the regional coordination centers.
- Coordination on a regional / pan-European level is not the tasks of the TSO anymore.
- As such, in case of an organizational separation of TenneT, the impact would be limited.

Sustainability

- Legislation sets the target that needs to be implemented, and to reach the objectives (at least 40% cut in greenhouse gas emissions, at least a 27% share of renewable energy consumption, and at least 27% energy savings), while the discretionary power of an individual TSO has reduced in terms of market integration.
- As such, in case of an organizational separation of TenneT, the impact would be limited.

Content

European regulation

Successful voluntary TSO cooperation was the role model for Europe in the creation of day-ahead, intraday, and balancing markets as well as in other areas of market integration, system security, and investment planning. The main objective of the cooperation between the TSOs and NRAs during the last decade was the increase of European social welfare. In these processes the organizational integration of TenneT contributed significantly to aligning positions within TenneT and executing influencing powers on these developments.

European regulation is now the game changer in Europe leading to a significant change of roles and responsibilities between European TSOs and NRAs and a more formal way of cooperation. European NRAs have now the responsibility to approve methodologies based on the requirements in the Guidelines and Codes. European TSOs need to be more transparent and should share methodologies and findings; an early involvement of NRAs is envisaged in order to make the right decisions, and European NRAs need to build up own competences and increase cooperation between the European NRAs.

Regularly, the European Commission draws up an 'annual priority list' of areas to be included in the development of network codes for electricity, with input from a public consultation. The Commission, with further input from the Agency for the Cooperation of Energy Regulators (ACER) and the European Network of Transmission System Operators for Electricity (ENTSO-E), adopts proposals for network codes (sometimes the new rules are adopted as 'guidelines' rather than 'network codes'), which are subsequently - after approval of the Council of the European Union and the European Parliament - legally binding regulations.

The Corporate Regulation unit was one of the first corporate units at the integrated TenneT. This unit increased the voice and influence of TenneT in international cooperation.

For example, the European TSOs were significantly involved in drafting and reviewing the European Guidelines and Codes via associations (e.g. ENTSO-E) and policy makers. As a result of the organizational integration of TenneT NL and TenneT GER, TenneT had a better position to strengthen national energy policy by firmly anchoring it in the European context and to contribute to an effective national energy policy.

The integrated organization has enabled efficiencies in analyzing for example the impact of new European guidelines and codes, or the impact of the Clean Energy package. The implementation of the European regulations and Codes has led to significant work loads in European working groups but also in national implementations. The headcount for TenneT's representation in the ENTSO-E working groups could, at the same time, significantly be reduced from approx. 70 – 80 headcounts to 40 – 60 due to the integrated organization.

„Common learning curve" and „co-creation" is one of the key objectives for the integrated TenneT in the European regulation. Early involvement and sharing of concepts with the Dutch and German NRAs, ministries, and other stakeholders on expert level may provide further benefits.

The integrated organization creates also potential tensions - in the sense that TenneT GER has to align positions with the German TSOs (and has to act like one German TSO) while on the other side is one integrated TSO in the Netherlands and Germany - on topics like network investments, market coupling, and bidding zones.

Integrated TenneT increased influence on international developments and cooperation

Constructive international cooperation

Successful voluntary TSO cooperation was the role model for Europe in the creation of day-ahead, intraday, and balancing markets, as well as in other areas of market integration, system security, and investment planning. Trustful cooperation between the TSOs and NRAs in the European interest, with the objective of European social welfare, increased during the last decade. In these processes the organizational integration of TenneT contributed significantly to aligning positions within TenneT and executing influencing powers on these developments.

Role of TenneT

The Corporate Regulation unit was one of the first corporate units at the integrated TenneT. The organizational integration of the regulation functions contributed significantly to aligning positions within TenneT. This integrated unit increased lobbying power to influence energy policy and the voice of TenneT in European and worldwide developments, and increased influence of TenneT in international cooperation.

This would never have been the case without being a significant player in Germany. In contrast, discussions with other countries take place via an official and political channel, as a result of which content is sometimes lost, and matters take up a great deal of time. Because of the formal relationship between TenneT as a German TSO and the German government, the dialogue is more efficient than with countries where TenneT does not have a formal role but where cooperation takes place on the basis of contracts and manuals.

Furthermore, TenneT can progress developments by individual actions, e.g. pilot projects in system operations for better use of network capacities, new digital markets, Security of Supply and hence overcoming TSO positions of one or more of the other German TSOs (like a "Pull-effect" of TenneT taking the other TSOs with them). This then opens scope for significant changes in the National and European Regulation. In the past, the IGCC was an example for this.

Affordability

- "Pull-effect" for the introduction of IGCC in Germany and later-on Europe leading to effects in the range of ~22-42 M€/year (see System Operation).

SoS

- Benefits are, to a large extent, already taken into account in the areas market integration, system operation, and investment planning.

Sustainability

- Benefits are, to a large extent, mainly already taken into account in the areas market integration, system operation, and investment planning.

Integrated TenneT increased influence on energy policy and European regulation

Influence on associations and policy makers

The European TSOs were significantly involved in drafting and reviewing the European Guidelines and Codes via associations (e.g. ENTSO-E) and policy makers. As a result of the organizational integration of TenneT NL and TenneT GER, TenneT had a better position to strengthen national energy policy by firmly anchoring it in the European context and to contribute to an effective national energy policy.

Affordability

- The implementation of the European regulations and Codes has led to significant workload. The headcount for TenneT's representation in the ENTSO-E working groups could, at the same time, significantly be reduced from approx. 70 – 80 to 40 – 60, due to the integrated organization.
- Other financial effects are already taken into account in the areas market integration, system operation, and investment planning.

Role of TenneT

Without the organizational integration, TenneT would have much less influence than it has today. In terms of influence, TenneT is among the leading TSOs in Europe and needs to be considered in European developments, regulation, and policy making. This provides strong advantages to the Netherlands. The activities in Germany make it easier for the Dutch government to draw attention to energy policy in a North-West European context, as well as to maintain a level-playing field for Dutch companies by continuing to draw attention to the energy-only market.

Apart from direct lobbying, the roles of the board of TenneT, as board members and president of ENTSO-E and Steering Group member of DENA III, supported the Dutch agenda to achieve a more integrated energy-only market.

In addition, strategic positions are held within CIGRE (International Council on Large Electric Systems) to build up and share knowledge (at a global level) and influence technical standardization.

SoS

- See above

Sustainability

- See above

Integrated TenneT will keep influence on future policies, developments, and practical implementation

Future potential in European regulation

The routes of influence on European regulation are likely to stay similar as present, with the future potential of more areas of the energy sector being regulated by the European regulation instead of national regulation, e.g.

- Sector integration.
- CEP implementation, incl. SoS, remedial actions
- Market Coupling, incl. Core, Nordics, remedial actions
- Bidding zone review
- Balancing: Picasso, Mari, IN
- Flexibility platforms
- Capacity markets
- Change of generation portfolio (coal, wind, …)
- Strategy of network planning

Role of TenneT

Within European regulation, an integrated TenneT has increased influence concerning future conceptual developments and practical implementation.

Affordability

- Benefits are, to a large extent, already taken into account in the areas market integration, system operation, and investment planning.

SoS

- Concerns are increasing on the future SoS in Europe due to shifts in the generation landscape: the generation mix in the various countries will be very much similar (mainly driven by large amounts of wind and solar) thereby increasing the common cause effects (e.g. wind switching off due to a severe storm wind front, or a solar eclipse). The influence on the European regulation and the practical implementation is of high importance.

Sustainability

- The effects of changes due to the named examples are typically leading to more sustainable electricity production, or are facilitating it due to more flexibility, better balancing, better network capacities, better coupling of markets with renewables and markets with controllable generation.

In case of an organizational separation, the influence of TenneT would be reduced

Impact of organizational separation

In particular the effects described in the future potential would be lost, as the influence on one of the major European markets and networks would be lost.

In case of an organizational split, depending on the interests which influence the decisions of TenneT GER, also actions contrary to the interests of the Netherlands are possible, if the positions of the four German TSOs are very strongly aligned.

Role of TenneT

The voice of TenneT in Europe, in case of an organizational split, would reduce significantly.

Affordability

- The effects at stake are at least those described in the future potential.

SoS

- See above

Sustainability

- See above

Content

System operation

A society and economy without electricity is hardly imaginable. The stability of the European electricity supply is organized on the level of the transmission systems.

The transmission grids enable the exchange of electricity between the regions with surplus generation and demand and are thus the basis for all electricity trade and the European internal electricity market. The stability of the electricity grid at the transmission level is ensured by the European transmission system operators (TSOs), which balance generation and demand – measured at a stable frequency of 50Hz – and keep power flows and voltages within safe limits.

The electricity exchange and its volatility have increased significantly. The introduction of competition in the electricity supply sector at the end of the last century created the basis for today's pan-European electricity trading, allowing traders to optimize their generation and supply portfolios through tradable electricity products at competitive market prices. In addition, the integration of renewable energy sources (RES) has been greatly facilitated across Europe, where installed wind and photovoltaic capacity in the EU has increased from almost zero in the last two decades to 236GW in 2015. The overlap of both factors has led to a very volatile and increasing trade in electricity within and between EU Member States, while the physical performance of electricity grids cannot keep pace with these developments and market rules require further harmonization.

Regional security coordination and the European balancing cooperation have become essential and the integrated TenneT organization played an important role in these processes.

Due to the increasing and volatile exchange of electricity throughout Europe, one TSO is no longer in a position to guarantee security of supply, in its area of responsibility, on its own. This was made clear on 4 November 2006, when a miscalculation of the operating staff led to a division of the continental transmission network with Europe-wide distribution among 15 million European households. In their joint analysis, the European transmission system operators confirmed the demand for uniform criteria for regional and interregional TSO coordination approaches aimed at regional safety management, improved data exchange, the results of safety analyses and planned remedial measures.

This disruption was the birth of a stronger TSO security coordination, in which the integrated TenneT organization was among the drivers.

In order to achieve a better integration of markets and renewable energies and their compatibility with physical laws, European legislation was continuously adapted. At the level of regional security coordination, the so-called 3rd EU Energy Package has led to important new regulations that also legally introduce the role of regional security coordinators. Although the current legislative package is still being implemented, the next legislative package, the so-called Clean Energy Package, is already in force.

Besides the TSO security cooperation (TSC) the integrated TenneT organization had an important role in the development of the International Grid Control Cooperation (IGCC), which is the implementation project chosen by ENTSO-E in February 2016 to become the future European Platform for the imbalance netting process (IN-Platform) as defined by the guideline on electricity balancing (EBGL Art. 22).

Integrated TenneT enabled the development of the IGCC to the European platform which led to savings for the Dutch society and increased security

International Grid Control Cooperation (IGCC)

IGCC, launched in October 2010 by the German TSOs, enabled the implementation of the imbalance netting process, which was originally established to avoid the counter-activation of automatic frequency restoration reserves (aFRR) in Germany. It was expanded – also driven by joint efforts of TenneT GER and TenneT NL - to a regional project and has grown to cover 10 countries (13 TSOs) across continental Europe. In the future this will cover 24 countries (27 TSOs) including all those that need to implement the IN-Platform according to the EBGL.

Imbalance netting is the process agreed between TSOs of two or more Load Frequency Control (LFC) areas, that allows avoiding the simultaneous activation of frequency restoration reserves (FRR) in opposite directions by considering the respective frequency restoration control errors as well as the activated FRR, and by correcting the input of the involved frequency restoration processes accordingly. IGCC performs imbalance netting of automatic frequency restoration reserves (aFRR).

The International Grid Control Cooperation (IGCC) is the implementation project chosen by ENTSO-E in February 2016 to become the future European Platform for the imbalance netting process (IN-Platform) as defined by the guideline on electricity balancing (EBGL Art. 22).

Role of TenneT

If TenneT had no activities in Germany, this IGCC would not have expanded as fast as it did now, nor would it have grown to the same international success with other important TSOs joining.

By setting the strategic conditions for the project from the TenneT management, that it should immediately become an international system and not just a German one, TenneT NL decided to participate from the start. The decision was done together with the other three German TSOs.

Affordability

- Use of reserve capacity: Savings for Dutch society: ~7-11 mln / year (Booz&co, 2015, p.23)
- Contracting reserve power: Savings for TenneT NL: ~10-21 mln / year (Booz&co, 2015, p.24)
- Primary reserve power (for malfunctions): Savings: ~€5-10 mln / year (Booz&co, 2015, p.25)
- Total realized savings in balance enforcement costs: ~€22-42 mln / year, NPV: €330-630 mln (Booz&co, 2015, p.26), NPV: ~€450 mln ('One TenneT', 2017, p.1)
- Expected savings in balance sheet maintenance in 2009: ~€11-19 mln / per year, ~9-15% of the balance sheet enforcement costs (Booz&co, 2009, p.11) *)

SoS

- As part of the responsibility of TSOs towards electricity transmission systems, the IGCC operational members are obliged to maintain the balance between electricity generation and consumption at all times in their respective LFC areas.
- Imbalance netting across LFC areas enables all participating TSOs to decrease the use of balancing energy while increasing system security.

Sustainability

- Imbalance netting allows avoiding the simultaneous activation of frequency restoration reserves (FRR) in opposite directions. The over- or under-production of energy produced from renewable sources can be better captured and therefore this system has positive effects regarding sustainability.

*): Note that the assessment of these figures was not in the scope of this study. The magnitude is reasonable from E-Bridge perspective. The numbers are available at TenneT.

Future potential: Integrated TenneT tenders for a new SCADA EMS system

New SCADA EMS system

In the control center, the transmission and distribution of electrical energy is monitored, coordinated and controlled. The SCADA Energy Management System (EMS) is the interface between the operator and the actual power system. An indispensable part of the EMS is the SCADA system: the Supervisory Control and Data Acquisition system. The main functionalities of the SCADA system are to collect real-time measured data from the system and to present it to the computer screen of the operator, and to control actual components in the network from the control center. The actual network status is stored in the 'real-time telemetered database', which is used as input for the other EMS functions. The EMS is in fact an extension of the basic functionality of the SCADA system. This includes tools for the analysis and the optimal operation of the power system. The SCADA / EMS system is the "heart of the TSO". TenneT NL is in the process of replacing their SCADA / EMS system.

Role of TenneT

TenneT decided to have one SCADA / EMS system for the integrated company. TenneT issued a tender for a new SCADA / EMS system with a possibility to expand the implementation of the system to TenneT GER as well. To that end, joint requirements have been drafted by TenneT NL and GER. With this approach significant savings are foreseen: one vendor, one data warehouse, one training. The biggest gain of having one TenneT in this case is the speed of implementation that can be realized when expanding the system from TenneT NL to TenneT GER as well. The system will be first tested in the NL system and in a next step rolled out in the GER system. This reduces the risks related to the usual implementation risks of new systems. In addition this provides a further redundancy, as there will be four locations with the same SCADA system in the future.

Affordability

- The joint effort of TenneT NL and GER to acquire a new SCADA / EMS is expected to bring savings, in the order of magnitude of 5-10 MEUR (CAPEX).
- TenneT NL together with TenneT GER do provide a strong voice in the future vendor's SCADA / EMS user's group, which offers an easier means to have new features supported in the future.

SoS

- Although each TSO is legally obliged to have its own national backup control center (no possibility to the backup control center of TenneT NL in the control center of TenneT GER, and vice versa), it does provide a fallback solution for the situation where both the control center and the backup are failing.

Sustainability

- The SCADA EMS system will have new functions that will be capable of handling the more dynamic / volatile nature of an energy system with high RES infeed. The system is therefore relevant to be able to increase the sustainability of the energy system in NL and GER.

Integrated TenneT enables further benefits in the European balancing cooperation

European balancing cooperation

The EBGL foresees the harmonization and further development of the balancing energy processes, in particular in four implementation projects (running for the next 3 years):

- IN (IGCC) - process to avoid the simultaneous activation of aFRR in opposite directions via imbalance netting across different LFC.
- PICASSO – Platform for the International Coordination of Automated Frequency Restoration and Stable System Operation (aFRR)
- MARI - Manually Activated Reserves Initiative (mFRR);
- TERRE - Trans-European Restoration Reserves Exchange (RR)

EBGL requires the definition of standard products for RR, aFRR, and mFRR to be exchanged using pan-European platforms. A Common Merit Order List (CMOL) is created and the TSOs' upward and downward needs are matched commonly to that CMOL.

All European balancing platforms will have an activation optimization function (AOF), which aims to balance the system in an efficient way, and to minimize the exchange of balancing energy on borders between bidding zones or LFC areas. The EBGL requires all TSOs to harmonize the imbalance settlement period (ISP) by 2021, or at the latest by 2025, to an ISP of 15 minutes.

Affordability

- IN: Since the Netherlands, Germany, and most neighbors are already part of the IGCC since 2012, most effects were already realized.
- The harmonization of products, platforms, processes, and balancing prices is expected to deliver more efficiency and higher competition in the electricity balancing market, leading to significant cost benefits to the customer.

SoS

- Imbalance netting across more LFC areas enables all participating TSOs to decrease the use of balancing energy while increasing system security in the future.

Role of TenneT

Examples for future potential benefits by TenneT (by influencing internal processes):

- Due to differences in the existing balancing markets, TSOs foresee a progressive harmonization, with only the essential concepts being harmonized before the launch of the pan-European platforms
- TSOs may request their respective NRA to approve the usage of specific products to fulfil their dimensioning requirements.

Sustainability

- Imbalance netting allows avoiding the simultaneous activation of frequency restoration reserves (FRR) in opposite directions. The over- or under-production of energy produced from renewable sources can be better captured, and therefore this system has positive effects regarding sustainability.

In case of an organizational separation, the impact on existing benefits in the European balancing cooperation would be limited

Impact of organizational separation

The IGCC and the future EBGL implementations are governed by rules and regulations which are organizing the cooperation on balancing energy between TSOs.

Role of TenneT

In case of separation between TenneT NL and TenneT GER, this could lead to a general decrease of coordination between the system operations.

Affordability

- No significant effect on the existing IGCC work is expected.
- Regarding the future development according to the EBGL the effects described in the previous slide on future potential may be partly lost.

SoS

- No significant effect is expected.

Sustainability

- No significant effect is expected.

Content

Investment planning

To balance the future generation mix, ENTSO-E identified which new European cross-border interconnections present the highest societal cost benefit gains. The suggested capacity increases are driven by optimization of socio-economic welfare, security of supply, and European climate goals.

Additional interconnector reinforcements will help to reduce average market prices (through increased competition), to decrease levels of curtailed energy, and to increase security of supply, especially for scenarios with a low percentage of energy from conventional power sources.

Across Northwest Europe, and for Germany and the Netherlands, ENTSO-E projects almost a doubling of interconnection capacity until 2040. The largest increase in interconnector capacity will have to take place by 2030 to balance the strong increase in intermittent renewables in this time period.

Extensive increases in installed capacity, share of RES, and decentralized production already poses strong challenges for the national grids of the NWE countries.

For Germany, considerable transmission grid reinforcements need to take place independent of the scenario, even without considering additional cross-border capacities. For the Netherlands, the amount of reinforcement varies depending on the scenario, however important expansions and reinforcements are still needed.

The reinforced grid will aid in reaching the ambitious renewable targets by reducing curtailed energy and overall CO2 emissions. Improved cross-border connectivity with the adjacent countries will benefit the Dutch public interests.

The offshore group was one of the first integrated corporate (international) units at the integrated TenneT organization. Lessons learned in Germany were valuable for the development of innovative solutions that are to be applied in NL. Valuable synergies with TenneT Germany have been achieved in both application of HVDC technology as well as in connecting offshore wind farms (both with AC and DC technology).

Integrated TenneT realized benefits through knowledge transfer in wind offshore connection and HVDC technology

HVDC Technology and Wind Offshore Connection

HVDC represents an important technology for the future, that has been rapidly expanding in the last years. Currently it is mainly used for the interconnection of non-synchronous areas in Europe as well as for the connection of remote offshore wind farms. Valuable synergies with TenneT Germany have been achieved in both application of HVDC technology as well as in connecting offshore wind farms (both with AC and DC technology). In the last 5 years, over 5 GW of offshore wind capacity has been connected to the mainland and successfully integrated into the transmission system of TenneT GER, mostly using HVDC technology.

Role of TenneT

Lessons learned in Germany were valuable for the development of innovative solutions that are to be applied in NL. One example is the usage of 66kV direct connections of wind farms to a common substation platform, which reduces the total cable length and number of needed offshore platforms. Furthermore, HVDC offshore connection is planned for the future ("IJmuiden Ver", 4 GW, to be commissioned in 2027). Cost reductions have also been achieved by standardization of equipment and operational processes related to planning and construction. Besides cost reductions, technical know-how has been gained, resulting in higher reliability of offshore wind farms.

Close cooperation in the development and construction of HVDC interconnectors with TenneT GER has resulted in a faster realization of projects, knowledge transfer and a common benefit. Besides technical aspects related to project realization, cooperation took place in organizational, political, and financial terms. As an example, collaboration and contacts of TenneT NL with Stattnet in the "NorNed" project enabled the faster realization of the "NordLink" project. As previously stated, "know-how" gained in German offshore wind connection accelerated the realization of HVDC interconnectors. Further benefits are expected through cooperation in the operation of HVDC. This is, for example, due to the high impact of COBRA cable on the transmission grid in Germany.

Affordability

- Benefits achieved through knowledge transfer in wind offshore connection:
  - Usage of 66kV cables, savings around 480 mln €, (1.5% reduction of Levelized Energy Cost)
  - Standardization of equipment (around 760 mln €) and operations (520 mln €)
  - Higher availability through modular concept (savings around 920 mln €)
- Faster completion of HVDC interconnectors led to gains in social welfare (for example expected benefit of NordLink is 73 mln €/year, and of COBRAcable around 60 mln €/year).

SoS

- HVDC interconnectors have positive impact on SoS, as they introduce additional flexibility in the system. Following effects are to be highlighted:
  - Increase of possible imports from Nordic
  - Enhancing system stability and robustness (voltage support, black start capability)
- Increased reliability of offshore wind farms increases the SoS, especially regarding the growing share and size of the offshore wind in the generation mix.

Sustainability

- HVDC interconnectors enable a better link to hydro storage in Norway. In this way, excess infeed of renewables in GER and NL can be stored and reused, enhancing the sustainability.
- COBRA cable increases transmission capacity, reducing wind curtailment in Denmark / GER-Nord.
- Faster completion and increased reliability of offshore connections maximizes the infeed of renewable energy.
- Standardization of equipment and processes increases robustness in project realization.

The implementation of Suedlink will have impact on the Dutch transmission system and reduction of congestions in NL is expected

Suedlink cable

TenneT is a partner in all development projects of HVDC links in Germany. In total, 8 GW of HVDC long-distance transmission corridors should be commissioned in 2025. The central corridor, Suedlink cable, is also important for the Dutch grid. Germany has a major part of the production in the North and consumption in the South, leading to large North-South flows. The flows fan out in the AC grid, in the East through Poland and Czech, and in the West through the Netherlands, Belgium, and France – the so-called loop flows. The loop flows through the Netherlands can be as high as about 30% of the inner German North-South commercial exchange.
The implementation of the Suedlink cable, an HVDC link within Germany connecting the North with the South, will manage a significant part of the North-South flow, thereby reducing the loop flows in the neighboring countries. A positive impact on Dutch transmission system and reduction of congestions is expected. Due to its flexibility and considerable cross-border impact, the operation of Suedlink will be both a challenge and an opportunity. For example, due to a high number of controllable HVDC links in the region (Nordlink, offshore wind connections, COBRA cable etc.) a strong cross-border coordination will be needed.

Role of TenneT

Integrated TenneT pushed for the implementation of Suedlink, as it will have a positive impact on the Dutch transmission system and a reduction of congestions is expected. Furthermore, the Suedlink project will introduce many innovations in the field of power transmission. It will be among the first long-distance HVDC lines over land in Europe. As this will be realized using underground cables and IGBT converter technology, it will provide new experiences in planning, developing, and operating such assets. Although no overland HVDC lines are planned in NL at the moment, this know-how is valuable for the future. As it was the case with offshore wind connections, knowledge transfer and economy of scale could lead to substantial savings in the realization of such projects. The integrated organization will support to harvest these future benefits.

Affordability

- The 70% CEP requirement can be met for TenneT NL - according to TenneT studies - due to the Suedlink implementation, which leads to limited extra investments and reinforcements of the Dutch transmission system and reduced costs for congestion management.
- Potentially savings through knowledge transfer, if similar projects (bulk-power HVDC over land) are to be realized in the Netherlands.

SoS

- Increase of SoS due to
  - Reduced loop flows and congestion in the NL
  - Increasing operational flexibility and robustness, as HVDC lines can be adjusted within seconds and can provide different system services (like voltage support)

Sustainability

- Suedlink will enable further integration of the Nordlink cable into the system, and therefore provide even more opportunity to store excess renewable energy in Norwegian hydro plants.

Integrated TenneT has a potential to enable innovations in the investment planning and the power system operations until 2030

InnoSys, NEP 2.0

The joint project 'InnoSys 2030' is analyzing possible innovations in the power system operations until 2030. The project aims to make innovative technological progress in the fields of flexibility and automation of grid operation as a response to a sharp increase of the transmission grid loading caused by the transition to renewable energy sources. Within the framework of the project, the four German transmission system operators, several distribution network operators, and two industrial companies are working together with institutes and universities in Germany. The project is being coordinated by TenneT GER.

In addition TenneT GER has conducted a study together with E-Bridge in the so-called "Innovations in the NEP 2.0". The aim of this study was to develop a proposal for a systematic consideration of innovations in the Network Development Plan (NEP).

Role of TenneT

If TenneT had not been a player in Germany, these two projects would not have been approached in this progressive way. Because TenneT is a single company, the knowledge gained in these German innovation projects can be shared with the Netherlands and can therefore also be used in the Netherlands for the benefit of the Dutch energy transition (without TenneT NL being a formal project partner). Without the organizational integration, the learning effects could not already be used in the Netherlands. With the publication of the Netzstresstest report in 2016 by TenneT, the discussion on better use of the existing network has started. By proposing the new NEP-process approach and starting the DENA 3 study, a follow-up has been carried out in order to put this direction into practice. In collaboration with Copenhagen Economics and E-Bridge, a report was published in June 2018, the results of which were presented at the BDEW congress in June 2018. The BNetzA confirmed the findings and innovations are now considered in the Network Development Plan process. TenneT and E-Bridge published an article on this new approach in the leading trade journal EW in September 2018. By also drawing attention to innovation and system solutions at the BMWi and BNetzA, TenneT is taking a progressive and proactive role in Europe.

Affordability

- TenneT GER is the consortium leader. Lessons learned can be shared internally within integrated TenneT and used for example to solve congestion problems in the Dutch transmission system.
- Digitalization can partially prevent future expensive investments in grid infrastructure (similar to Suedlink (up to EUR 10 billion)). It has been decided that 5 GW of transport needs from Northern to Southern Germany will not be solved in a traditional way within the NEP process. In NL, these innovative solutions may be used to deal with congestion issues in the North of the country resulting from the installation of solar and wind capacity.

SoS

- These initiatives offer additional opportunities to transport electricity more efficiently through Germany, thereby reducing congestion (also in the Netherlands) and offering more flexibility to the system.

Sustainability

- Renewable energy can be better transported through Germany, and existing production and transport capacity will be used more efficiently. In principle, more capacity can be installed in NWE, and more renewable energy can be brought into the system in total. Without this approach, there would be congestions, which would have to be solved with (costly) re-dispatch.

In the case of separation, losses are expected due to the “economy of scale” and loss of “know-how” synergies

Impact of organizational separation

- Increasing complexity of the investment planning due to
  - High fixed costs that are expected in the mid-term to facilitate integration of renewables and functioning of EU electricity market.
  - High uncertainty in the investment planning related to the future structure and spatial distribution of generation / consumption.
  - Emerging technologies (large-scale battery storage, phase-shifting transformers (PSTs) etc.) in the power transmission, that enable better utilization of existing assets (instead of building new lines) but are adding complexity to the network planning and operation.

Role of TenneT

- In the case of separation, losses are expected due to the “economy of scale”
  - More assets and personnel needed to cope with uncertainties
  - Increasing interest rates for investments
  - “decision-making” in joint projects (such as North Sea Wind Power Hub) will become more complicated
- Furthermore, “know-how” synergies would be lost, especially regarding the application of new technologies.

Affordability

- Negative impacts on social welfare, due to “economy of scale” effects in increasingly complex environment for investment planning.
- Reduced “know-how” synergies in application of new technologies would result in additional costs.

SoS

- No adverse effects on security of supply, assuming that management of the risks (associated to SoS) remains unchanged in the investment planning process.
- However, additional costs are required for risk management.

Sustainability

- No adverse effects on sustainability, assuming that investment plans remain unchanged.
- As with SoS, additional costs are induced due to “economy of scale”.

Content

Energy transition, digitalization, sector coupling / hydrogen

TenneT has an important role in the energy transition, e.g. by connecting large wind farms to the grid (on- or off-shore), and to make sure that the system is able to cope with the intermittent power infeed for renewables sources; large changes to take place, and taking place, in the energy landscape in the Netherlands, Germany, and the rest of Europe. This is not business as usual, but enters into the realm of innovation, digitalization, cross-sector cooperation / alliances with other actors (such as car manufacturers) to be prepared for the changes to come, and to get a grip on / build this uncertain future world. A bigger TenneT, with a base in both the Netherlands and Germany, makes a difference as knowledge sharing and learning effects e.g. from pilot projects are essential stepstones towards this future, where standardization (e.g. in terms of technology to allow car batteries to participate in the balancing market) can be facilitated when a larger geographical area is already served and a larger voice takes part in the international discussions. Different cultures, and a wider range of industry partners are all aspects that are at hand with the integrated TenneT organization and help to a certain extent in paving the way forward. In this section some of the enabling technologies to allow for this energy transition such as digitalization are presented as a tangible case where an integrated TenneT facilitates this transition, and where – with the Netherlands being equipped with a luxurious gas infrastructure and know-how – the spot light will be put on the case of sector coupling, where in certain cases hydrogen may be the energy carrier rather than electricity, and where the gas infrastructure may provide storage functionality.

Power-to-gas (P2G) technology could strengthen the benefits for an integrated energy system planning approach – however, timing of economic viability is uncertain. Power-to-gas technology, splitting water into hydrogen and oxygen with electricity (electrolysis), is a rapidly developing technology. Resulting hydrogen can be stored or transported by injecting it into the natural gas grid (similar to LNG) – directly or after conversion to methane.

Benefits of this technology vs. other flexibility sources include:

- Gas pipelines function as large storage facility (e.g. German natural gas network can store >200,000 GWh, several months of national energy requirements).
- Transportation of gas is done with much less loss (<0.1%) compared to electricity (1-3%).
- Synergies from electricity and gas may increase as a result of utilization of this technology, as system flexibility can be improved through cross-utility coordination.

The North Sea area is important for the energy transition, currently experiencing a strong ramp up of offshore wind energy construction. It further hosts other relevant activities, such as oil and gas production, sand and shell extraction, etc.

The Netherlands forms a key bridge in connecting this energy to (industries in) Germany and other European countries. TenneT and Gasunie are crucial players, as they provide energy transmission in both NL and parts of Germany. Several initiatives in NL aid implementation of P2G technology as part of energy transition, e.g. the Waterstof Coalitie is an initiative that pushes the agenda for integration of hydrogen in the Dutch energy system, and the North Sea Energy project is a collaboration supporting offshore energy systems integration.

A current E-Bridge study analyzes possible mechanisms and regulation policies regarding hydrogen. There are potential benefits through further integration by a coordinated approach to develop and utilize the potentials of sector coupling, which could reduce the costs for long-term development of transmission infrastructure. Joint activities and collaboration in the field of regulation, in order to enable efficient legislation and prevent potential flaws, are needed.

Further integration of TenneT would be an advantage for the development and usage of $P2H_2$ technology, which could result in further savings and overall socio-economic benefits. A tight cooperation and joint approach would be especially useful.

TenneT has a single department responsible for digitalization in NL and GER

Digital transformation

The digital transformation unit is an integrated international unit within TenneT; the department started in 2016 and counts 25 people now. It is an example of one department covering both the NL and GER organization, where innovation projects and investments are conducted together in one integrated unit. The department has both an internal and external scope.

External: Data hub, that facilitates to collect all measurement data from DSOs for example. The data hub is a market-facilitating platform; pilots are ongoing. One integrated TenneT offers learning effects for both TenneT NL and GER.

Internal: One single TenneT data platform, which makes all internal data (sensor data, weather data, …) accessible for all functions and decision-making processes within TenneT. The organizational integration of TenneT allowed for the building of one single data platform for both TenneT NL and GER, which comprises significant savings compared to the development of two (national) systems. The savings are estimated by TenneT to be around 5-10 MEUR. In addition the single data platform opens all information (both NL and GER) to all relevant users in NL and GER. Besides providing an easy and efficient access, it also reduces the number of use cases.

Role of TenneT

The digital transformation unit is also responsible for blockchain developments. This technology offers a solution to allow new market participants to enter the market and is e.g. able to have car batteries participate in the European balancing market. With this solution being tested both in NL and GER, it is easier to expand to other markets and scale up to a European level. There is an opportunity to set a de-facto standard, which – in case of a split company – would not have been possible as the momentum of TenneT NL only is too small. This momentum is important as, in case a different European standard would be adopted, the current investments and efforts done by TenneT NL (and GER) would be lost, as a new platform would need to be adopted.

Affordability

- Digital transformation being organized in one single department for both TenneT NL and GER offers, besides learning effects, a momentum. This momentum is important to have the TenneT solutions transferred into a de-facto standard (like the Blockchain solution), so that the investments will not turn into sunken cost.
- One integrated TenneT allowed for the development of one single TenneT data platform, which makes all internal data (sensor data, weather data, …) accessible for all functions and decision-making processes within TenneT. The savings are estimated by TenneT to be around 5-10 MEUR.

SoS

- The blockchain technology offers a solution to allow new market participants to enter the market and is e.g. able to have car batteries participate in the European balancing market. This flexibility / additional degrees of freedom will be necessary in the increasing volatile grid to maintain the balance and security of supply.

Sustainability

- Increasing volatility in the grid is to a large extent linked to the increasing level of renewable generation in the system. Digitalization, and technologies as blockchain, facilitate new market participants to enter the market, and is e.g. able to have car batteries participate in the European balancing market. These are necessary developments in the energy transition.

Integrated TenneT has a high potential to enable cost reductions through coordinated planning and development of infrastructure for sector coupling

Sector coupling / hydrogen

TenneT NL has conducted an infrastructure outlook together with Gasunie with the aim to explore potential synergies between gas and electricity transmission infrastructure. The results of the study show that complementary development and operation of these infrastructures could lead to substantial economical benefits.

The second phase of the study is being carried out together with the technical university in Aachen (IAEW - RWTH Aachen) in order to quantify the corresponding benefits in Germany.

In order to promote coupling of the power and gas sector, it is necessary to provide investment incentives and stimulate innovations in the field of hydrogen electrolysis and power-to-gas (P2G) technology. On behalf of TenneT and other project parties, E-Bridge has analyzed possible mechanisms and regulation policies to this regard[1].

Potential benefits through further integration by

- Coordinated approach to develop and utilize the potentials of sector coupling, which could reduce the costs for long-term development of transmission infrastructure
- Joint activities and collaboration in the field of regulation, in order to enable efficient legislation and prevent potential flaws

Role of TenneT

Pro-active assessment of the future synergies between the gas and electricity infrastructure in the future. The Dutch study triggered a similar exercise for the German side of the story. An example of a pilot project where the learning effects, and potential follow-up actions, spill over to the other part of the company.

Affordability

- Reduced cost through coordinated planning and development of infrastructure for both sector coupling and power transmission.
- Potential gains in social welfare by joint regulation, especially with regards to incentivizing P2G technology and hydrogen production.

SoS

- Coupling provides additional flexibility therefore increasing the security of supply in different energy sectors:
  - Additional production of gas (hydrogen, methane) using excess electricity from RES has a positive impact on the security of gas supply.
  - Produced gas can be stored and re-used to generate electricity.

Sustainability

- Use excess renewable energy to generate hydrogen.
- Reduction of congestions and CO_2 emissions.
- Reduced need of building new power transmission lines.

E-Bridge
competence in energy

[1] "Wasserstofferzeugung in Kombination mit Offshore-Windausbau", E-Bridge, 2018

Integrated TenneT has potential to enable the usage of Offshore Power-to-Hydrogen, which would result in further savings and socioeconomic benefits

Offshore Power-to-Hydrogen ($P2H_2$)

By converting a part of the offshore wind electricity to hydrogen, the investment costs for electrical connection of offshore wind farms can be reduced. This possibility could be considered in the case of "IJmuiden Ver" wind farm, due to existence of several pipelines that could be used for the hydrogen transport. As the results of a DNV-GL study show, offshore power-to-hydrogen ($P2H_2$) could be an emerging technology in the longer-term future, as further developments in the area of PEM electrolysis, as well as an increasing volatility of electricity prices, are expected. The use of pipelines is not as feasible as thought (i.e. pipes too small, lifetime not meeting the 25 years scope, and pipes did not allow the end-to-end). Therefore, in the current framework, an electrical solution will be followed.

A similar case-study could be conducted for offshore wind farms in Germany, considering existence of pipelines and even larger capacity of wind turbines. If $P2H_2$ technology is shown to be beneficial, large-scale usage could follow in the "North Sea Wind Power Hub" project (from 2035).

Role of TenneT

Further integration of TenneT would be an advantage for the further development and usage of $P2H_2$ technology, which could result in further savings and overall socioeconomic benefits. A tight cooperation and joint approach would be especially useful in following steps:

- Conducting case studies
- Realization of pilot projects
- Encouraging and supporting the work on efficient regulation
- Coordinated long-term investment planning of both gas and electricity networks, considering the impact of $P2H_2$ technology.

Affordability

- By developing $P2H_2$ technology overall socio-economic benefits can be achieved in the long-term, but high investments are needed in the mid-term.

SoS

- Additional production has positive impact on SoS in the hydrogen sector.

Sustainability

- Sustainable integration of offshore wind farms by producing green hydrogen.
- Reduced need of building new transmission lines and offshore wind connections.

Content

A potential shareholding by the German Government or KfW may enable a stronger political alignment of interests of German and Dutch government (1)

An assessment of the possibility and probability of a potential shareholding by the German Government or KfW is not in the scope of this study.

Nevertheless E-Bridge was asked to provide some reflections on the potential impacts of a stronger political alignment of interests of German and Dutch government in case that the German government may become a potential shareholder (directly or indirectly via KfW).

In the following slide E-Bridge illustrates that the potential shareholding by the German Government or KfW may enable a stronger political alignment of interests of German and Dutch government.

With having two shareholders instead of one, the reporting requirements on TenneT are likely to increase. This increased administrative burden can be seen as a disadvantage of bringing in additional shareholders.

A potential shareholding by the German Government or KfW may enable a stronger political alignment of interests of German and Dutch government (2)

Potential shareholding by German Government

A fully-integrated TenneT will lead to a TSO where an integrated decision will be taken within one integrated TSO, instead of an alignment of two cooperating TSOs. This benefit has already been established to a large extent. On political level the alignment of interests of German and Dutch government could be still enhanced in the future.

A potential shareholding by the German Government or KfW may bring further benefits in relation to political alignments in order to successfully implement the energy transition and to implement a showcase for how to run a decarbonized and innovative energy system.

Role of TenneT

„Common learning curve" and „co-creation" is one of the key objectives for the integrated TenneT in the political discussions. Early involvement and sharing of concepts with the Dutch and German governments/ministries could provide further benefits. A common understanding of the Dutch and German governments and ministries may be easier explored by the integrated TenneT, in case of the German and Dutch government as a joint shareholder.

As quite some topics are "politically sensitive", e.g. the protection of the EoM, the bidding zone delineation, the 70% requirements from the Clean Energy Package (CEP), and the acceleration of sector coupling, a joint shareholdership with the German Government would bring the alignment on these topics directly to the political level to be solved. The benefit explained above, may also be perceived a disadvantage though. Indeed, discussions and alignment on a political level may lead to trade-offs. Some insight on the "politically-sensitive" topics is provided in the box on the right-hand side of the slide.

To what extent there is as risk for political misalignment, and how this could be resolved, is out of scope of the study and could be subject to a follow-up study.

Example topics for political alignment

Energy-only Market

- An energy-only market only compensates power that has been produced, whereas a capacity market compensates the mere readiness, or capacity, for power production.
- In an energy-only market, peak-load units need to earn their money in a limited amount of hours per year; as such the price in those hours needs to be able to reflect the scarcity.
- High energy prices are politically sensitive.

Different speeds of P2G and hydrogen implementation in the energy transition

- Several initiatives in NL aid implementation of P2G technology as part of energy transition, e.g. the Waterstof Coalitie is an initiative that pushes the agenda for integration of hydrogen in the Dutch energy system, and the North Sea Energy project is a collaboration supporting offshore energy systems integration.

Integration of German TSOs versus cross border synergies

- In Germany the focus may be on the integration of the 4 German TSOs whereas in NL the main focus is on the cross-border synergies.

Bidding zone delineation

- Germany is one bidding zone, and the large internal German north-south exchanges are therefore not subject to the allocation in the market coupling.
- Splitting up Germany in a north and south bidding zone would lead to different prices in the north (low price) and the south (high price): politically sensitive, and German law states that the German bidding zone cannot be split.

70% requirement from the CEP

- The Clean Energy Package (CEP) requires the TSOs to provide at least 70% of the (cross-border) capacity to the market; this combines with the ACER decision on the Core CCM stating that internal network elements are not allowed to limit the cross-zonal trades.
- In order to do so, TSOs may need to apply (extensive) costly redispatch or apply bidding zone delineation (split their bidding zone e.g.) – both politically sensitive.

Content

List of Abbreviations

- AC – Alternating Current
- ACER – Agency for the Cooperation of Energy Regulators
- CACM GL – Guideline on Capacity Allocation and Congestion Management
- CAPEX – Capital Expenses
- CCM – Capacity Calculation Methodology
- CCR – Capacity Calculation Region
- CEE – Central East Europe
- CEP – Clean Energy Package
- CIGRE – International Council on Large Electric Systems
- CMOL – Common Merit Order List
- CWE – Central West Europe
- DA – Day Ahead
- DC – Direct Current
- DSO – Distribution System Operator
- EBGL – Guideline on Electricity Balancing
- EMS – Energy Management System
- ENTSO-E – European Network of Transmission System Operators for Electricity
- EoM – Energy-only Market
- FB – Flow based
- FBMC – Flow Based Market Coupling
- FRR – Frequency Restoration Reserves
- HVDC – High Voltage Direct Current
- ID – Intraday
- IEM – Internal Electricity Market
- IGCC – International Grid Control Cooperation
- IN – Imbalance Netting
- ISP – Imbalance Settlement Period
- LFC – Load Frequency Control
- LIP – Local Implementation Project
- MARI – Manually Activated Reserves Initiative
- MC – Market Coupling
- NEMO – Nominated Electricity Market Operator
- NRA – National Regulatory Authority
- NWE – North West Europe
- OPEX – Operating Expenses
- P2G – Power to Gas
- $P2H_2$ – Power to Hydrogen
- PICASSO – Platform for the International Coordination of Automated Frequency Restoration and Stable System Operation
- PST – Phase Shifting Transformer
- PX – Power Exchange
- RES – Renewable Energy Sources
- SCADA – Supervisory Control and Data Acquisition system
- SoS – Security of Supply
- TERRE – Trans-European Restoration Reserves Exchange
- TLC – Trilateral Market Coupling
- TSC – TSO Security Cooperation
- TSO – Transmission System Operator
- XBID – Cross-Border Intraday

Content

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