Chapter 10
Connecting Visions of a Future Renewable Energy Grid

Marloes Dignum

10.1 Introduction

Developments towards a renewable energy system are ongoing. Along with these developments, trends and ambitions on different geographical and governance levels are brought together. The European Union has the ambition to cut greenhouse gas emissions by 80–95% by 2050 (EC 2012). The 2009 European Third Energy Package strived for the realisation of a single European energy market.

Combining these developments, a future single EU electricity market should largely be based on renewable energy provision. As the current electricity system is highly dependent on fossil fuels, there are still ample possibilities for the technological and institutional configurations of a future renewable energy system. Energy conservation is an important aspect for realising the 2050 goal (EC 2012). In addition, a renewable energy system towards increasing decentralisation is developing. It combines small-scale production such as local (community) energy and larger scale production through for example offshore wind or utility solar power. The developments indicate that high voltage lanes and the level of solar panels on the roofs of homes are to become part of a single European electricity market. All these segments need to operate together with the current centralized grid that may, or may not, exist in the far future.

Current developments for renewable energy are largely decentralized and develop on a case-by-case basis. These developments occur on an increasingly large scale. If this trend continues, future renewable energy initiatives could increasingly include more characteristics of centralized systems. These large-scale developments include for example offshore wind energy projects and utility solar power. In addition, there are also other potential future technologies that promise a sustainable future energy provision and that are still in the development phase. For

M. Dignum (✉)
Delft University of Technology, Delft, Netherlands
e-mail: marloesdignum@gmail.com

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the centralized option this may be nuclear fusion, and large-scale solar power in desert areas (Desertec) (Lilliestam and Hanger 2016) and for the distributed option this is, for example, blue energy electricity (from mixing salt and fresh water). This creates a range of options for the more, and less, distant future with a large uncertainty regarding the energy supply options. While visions are versatile, some more extreme visions state a (almost) full energy and provision by only one of these options.

The developments of the distributed and more centralized renewable energy system have different actors that guide the development, different localities, and different scopes. Distributed energy currently develops from a spectrum of actors including grassroots developments of local (and often co-owned) solar and wind energy projects and more commercial efforts. Large scale developments, and most notably off-shore wind energy are guided by efforts of the national government. Yet, both developments simultaneously contribute to a future energy system. The question rises to which extent these developments are competing and to which extend they are synergetic. To create insight in this issue, this chapter centres the future visions of different distributed renewable energy systems and maps it against actual developments.

The analysis will focus on current developments in The Netherlands. The Netherlands has the ambition to actively pursue renewable energy development. This requires large efforts as the country is currently in the rear-guard of Europe. Currently, a spectrum of distributed energy initiatives is unfolding in The Netherlands. We zoom into two rather extreme forms that are rapidly growing and can contribute to a distributed energy system: communal energy and offshore wind energy development. This forms a good situation to study the simultaneous development and performativity of a spectrum of visions (see also Sect. 10.4).

For the analysis, the chapter centres the shaping capabilities of future visions and expectations. Visions are seen to guide contemporary developments of establishing a future energy system. This shaping capability is a general property of visions (Brown et al. 2000; Van Lente and Rip 1998; Dignum 2013). By portraying a discursive future image, a vision aligns thinking patterns and can create the possibility for allocating resources towards the envisioned. This is called the performativity of visions.

Section 10.2 forms a theoretical section on vision performativity, which results in the presentation of the analytical framework. Section 10.3 describes the approach. Section 10.4 describes the case study selection. Section 10.5 analyses the selected visions of offshore centralized electricity production and distributed electricity production in local solar and wind energy projects. Attention is paid to the synergy between these visions. Section 10.6 addresses the implications and forms a discussion. Section 10.7 concludes this chapter.

10.2 Vision Performativity and Analysis

This research takes the formative capabilities of visions as a point of departure. Future visions portray an image of the future that is in certain aspects more desirable than the current state in which society functions (Achterhuis 1998). Visions have a reflexive nature towards contemporary society and provide insight in how different constellations of actors depict a desirable future. This image implicitly, or explicitly, incorporates criticism to the way contemporary society functions (Michael 2000). The embedding of visions in current times also implies that visions can change along with new insights (Grin 2000). This reflects the learning that takes place.

The shaping characteristics of visions are often referred to as the cycle of promise and requirement (Van Lente 1993; Borup et al. 2006). The idea of this principle is that visions, and the process of envisioning, align actor thinking and provide possibility to allocate resources towards the envisioned. The allocation of resources is linked to promises that are aimed to realize the envisioned. The allocation of (additional) resources to progress on the envisioned path, creates a cycle of investments, developments, and new promises. This cycle can continue as long as the vision, or an update of the vision, is accepted and people act upon the vision (Van Lente 1993, 2000).

Analytically, two strands of futures research can be distinguished. The first strand is '*looking into the future*' this entails the process of envisioning and the visions that result from this envisioning process (Brown et al. 2000). Second, is '*looking at the future*' which is an analytical perspective focusing on real time activities (Brown et al. 2000). It includes the analysis of the structuration, content, and support of future visions as well as the time-span allocated to activities that are guided by visions (Borup et al. 2006; Van Lente 1993). This research focuses on looking at the real-time activities and the future visions that inspire these developments.

While much of the vision literature focuses on the developments of technological artefacts or technological fields (Van Lente and Rip 1998; Bakker 2011), this research focuses on the materialisation of visions through institutional structures (physically, regulatory, norms/behaviour). Complementarity and/or contestation becomes visible through institutional (mis)alignment. Therefore, this analysis includes the development of the physical and regulatory infrastructure. This chapter follows North (1991) in defining institutions: "*Institutions are the humanly devised constraints that structure political, economic and social interaction. They consist of both informal constraints (sanctions, taboos, customs, traditions, and codes of conduct), and formal rules (constitutions, laws, property rights).*" (North 1991, 97). This implies that institutions create the possibility space for new infrastructure developments to occur.

This chapter analyses renewable energy infrastructure development in the Netherlands through the lens of vision performativity. It maps the current developments including the drivers and the vision that are linked to these developments. By zooming into the more extreme types of contemporary performative visions (local community energy and offshore wind energy), the aim is to create insight in the synergy in the spectrum of renewable energy developments.

10.3 Approach

This chapter analyses a selection of visions and actual developments of renewable energy provisions to contrast the elements incorporated in centralized and distributed visions of future renewable energy system and assesses their complementarity.

Emphasis is placed on aggregated visions that represent a wide set of actor perspectives. A first selection was made from scientific papers on regulation and governance, sociotechnical design and/or analysis of future energy systems from the fields of responsible innovation and transition studies. The selection was expanded through snowballing. In the search, emphasis was placed on infrastructure development (both envisioned and realized). The final selection included scientific (overview) articles, EU and Dutch policy reports, scientific and technical working papers.

This chapter assesses the synergy of different renewable energy visions by highlighting infrastructure developments (both regulatory and physical) and the integration of these developments. It provides insight in the institutional development and the spectrum of dilemmas and choices actors face, some of which are largely invisible. The analysis of the development consists of two elements.

First, there is a general analysis that outlines the spectrum of renewable energy visions that currently influence concrete developments. A distinction is made between distributed and centralized systems.

Second, the chapter subsequently zooms in on communal energy and offshore wind visions and developments as these are the more extreme forms of current developments of renewable energy. It includes an analysis of the actor network and the future visions supported by the network. The shaping capabilities of these future visions are assessed by the references made to these visions combined with the actual developments. The actor analysis also includes the problem perception, motivations, and values that impact current developments. The analysis provides a reflection on the actual developments and the vision guiding these developments.

10.4 Case Study Selection

The analysis centres on developments in The Netherlands as a representative case study in which several renewable energy visions reached a level of performativity simultaneously (Yin 2009).

The Netherlands has a history of being guided by energy visions. For example, the transition from coal to gas was completed, with large political commitment, in slightly more than a decade (Correljé and Verbong 2004). Also, in 2006, a vision on Dutch gas market development resulted in a strategy to develop a so-called gas roundabout to continue to play an important role as a gas hub in Europe, and to profit economically, even when its gas reserves become depleted (Harris et al. 2010).

Currently, the Dutch fossil fuel energy system is largely centralized and based on fossil fuels. In 2015, the country generated 39 billion kWh electricity from coal, which represented an increase of 35% compared to the year before (CBS 2016).

In 2015, the country had a renewable energy provision of 5.8%. In 2013 the Dutch government in collaboration with private actors and NGOs agreed on a plan to establish 14% renewable energy in 2020, the so-called *Agreement on Energy for Sustainable Growth*. In 2050, a GHG reduction of 80–95% compared to 1990 is to be realised (SER 2013). Current ambition is placed even higher as in accordance to the 2016 Paris climate agreement, fossil fuel use should be largely eliminated. This hints towards the upper limit of the 80–95% ambition (Ministry of Economic Affairs 2016a, b).

Consequently, it is expected that the renewable energy developments will develop rapidly in the coming years. While near-term developments are ongoing, detailed long-term plans for large scale renewable energy provision are still ill-developed. Both distributed and centralized renewable energy projects are being deployed.

10.5 Visions of Renewable Electricity Systems

To realise the Dutch policy ambitions and the Paris climate agreement, a change towards energy conservation and renewable energy production is needed. The increase in renewable energy implies a trend towards decentralised energy. Even large-scale renewable energy provision through for example offshore wind fields offers a far more decentralized energy supply system compared to gas or coal power plants.[1] This section zooms into the versatility of the emerging renewable electricity systems by focusing on the more extreme forms of renewable electricity generation that become part of a future renewable energy system.

Section 10.5.1 introduces the concept of distributed energy production. It includes a range of communal energy projects, from small-scale energy production that is co-realised by joined local efforts, as well as fully decentralized production. Section 10.5.2 focuses on communal energy visions and current developments. Section 10.5.3 focuses on offshore wind energy visions and current developments.

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[1] When the energy production of the planned 5 Dutch offshore wind parks is compared to the domestic gas consumption, the parks produce 1.5 billion m^3 low caloric gas whereas the domestic low caloric gas consumption is 30 billion m^3 (Ministry of Economic Affairs 2016a, b).

10.5.1 Distributed Renewable Energy Systems

A shift towards renewable energy implies an increase in distributed arrangements of energy. However, the degree of (de)centrality drastically differs between different design options.

A distributed electricity system can be envisioned through combinations of different institutional structures. A general distinction can be made between decentralized and distributed systems. Decentralized systems are autonomous systems that operate without interactions to other units whereas distributed systems have the possibility to interact amongst each other or with the central grid (Alanne and Saari 2006). Consequently, decentralized systems are always distributed systems, but not all distributed systems are decentralized systems (Alanne and Saari 2006). The term distributed system, that is used in this chapter, thus forms a broader concept in which the decentralized, autarkic system is the most extreme form.

The concept of a distributed system is still an umbrella term as it can still be designed with great versatility in design choices. Figure 10.1 provides an example of a distributed system as conceptualized by Alanne and Saari (2006).

This example is a broad schematic representation of distributed energy and gives an impression of the potential spectrum of design choices. For example, the figure does not distinguish between types of energy, alternative storage options, and summer-winter fluctuations in demand and supply. These long-term fluctuations are hard to balance (Orehounig et al. 2014). The domestic focus of this image also raises the issue of energy demand for heating buildings, which is a crucial aspect of the energy demand of the built environment in the Netherlands. Heat demand could be cut through conservation measures such as increased insulation, heat pumps, or solar boilers. These conservation options can each be incorporated in a distributed system. When focusing solely on renewable electricity provision, as is the focus of this chapter, such measures represent a potential reduction of electricity demand.

Local electricity generation in homes is a focal point of Alanne and Saari's (2006) representation of a distributed energy vision. Within this focus, system boundaries, technologies, and infrastructure design choices remain an issue. Four examples are given.

First, the focus on distributed generation in neighbourhoods also implies uncertainty regarding the system boundaries and whether it also includes industry, office spaces, and mobility. These system boundaries are important to assess as well as the extent to which energy provision can be realised through such a system, and whether fluctuations in energy demand and supply can be handled by the distributed system or whether a centralized system remains needed for sectors or parts of society, and who (should) bear(s) the costs of the distributed system and the centralized system. The intensity of use of this neighbourhood system is not addressed and is highly dependent on the design choices and the phase of the transition.

Second, the scale of interaction between this distributed production and centralized (single) energy consumption and distributed entities is variable. Figure 10.1 leaves the character of the single entity unmentioned. It can be an energy

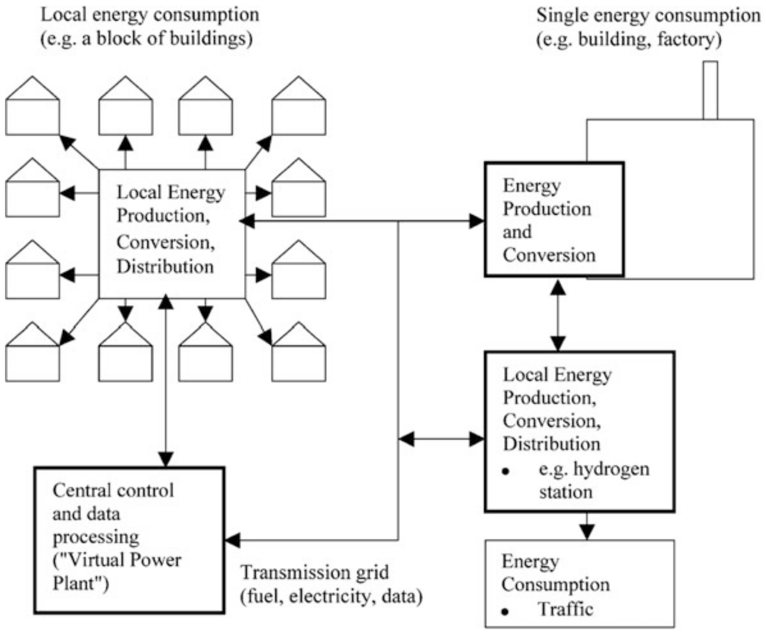

Fig. 10.1 An example of a distributed system. *Source* Alanne and Saari (2006, 544)

consuming factory or a power plant (conventional or renewable). A flexible and stable energy producing facility can serve as a backup system in case distributed production is not equipped for fluctuating supply and demand and can create additional security for electricity provision.

Third electricity storage is not part of our current system. Figure 10.1 addresses potential storage in hydrogen. However, while electricity storage is still difficult, a future system may incorporate storage options such as home batteries, neighbourhood batteries, car batteries of electric vehicles or conversion to gas such as hydrogen. Tests are done with these types of options.

A fourth interesting aspect is the emergence of a central control and data processing plant that balances electricity demand and production. This is a new type of role in the electricity system that emerges with increasing fluctuation in energy provision that coincides renewable production as balancing also needs to occur with centralized production. Trading becomes more frequent as many households and potentially small companies feed electricity into the grid on irregular times.

Along with these design choices, the range of technologies suitable for distributed generation initiatives is expected to increase as new technological options become available. The design choices only increase when more technological and (consequently) more institutional choices become available. These deliberations and design choices play a role in each of the options for distributed system development. We will tune into two more extreme options; communal energy and offshore wind.

10.5.2 Communal Energy Visions and Developments

This section focuses on the visions and developments of communal energy production. In addition to (inter)national renewability ambitions, renewable energy visions on a municipal or regional scale become increasingly prominent (van der Schoor en Scholtens 2015). Networks such as the Covenant of Mayors form a collective of cities that each have ambitious CO_2 emission reduction targets. Also on the level of the community itself, action for reaching renewable energy is increasingly taken. Additionally, property owners can individually arrange energy conservation and production measures, or communities can collectively act to realise communal forms of energy. Taken together, a whole spectrum of possibilities of communal energy emerges.

10.5.2.1 Vision, Actor Network, and Current Development

The contribution of communal energy provision, related to the total amount of energy demand in The Netherlands is small, but the speed of development is high. At the end of 2015, there was an estimated 1515 MW of solar energy and 3391 MW of wind energy generated in The Netherlands (CBS 2017a). A small portion was developed through communal energy project (115 MW wind energy and 23 MWp solar energy) (Schwencke 2016).[2] In 2015, the increase of community wind energy provision was 34 MW. Another 87 MW was planned (Schwencke 2016). In the same period, community solar energy tripled to 23 MWp and was expected to more than double in 2016 (Schwencke 2016). The number of energy cooperatives increased from 262 in 2015 to 313 in 2016 (Schwencke 2016). Also, the scale of the projects becomes larger. On June 18, 2017, a large communal solar energy system with almost 7000 solar panels opened.[3] Although this is about one fifth of the largest commercial solar park in the Netherlands,[4] it illustrates that in the future utility solar power may also be realized through communal energy development.

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[2] Home owners who independently position solar energy on their roofs, are not included. Even though this also increases the trend towards distributed energy.

[3] See http://www.zonnewijdebreda.nl/ (accessed 1 September 2017).

[4] In January 2017 the largest utility solar farm of The Netherlands was located in Delfzijl and counted 120.000 solar panels. https://www.delfzijl.nl/internet/nieuwsberichten_42511/item/grootste-zonnepark-van-nederland-officieel-in-gebruik_88723.html. Accessed 18 June 2017.

The visions of communal energy initiatives drastically vary. The spectrum includes the ambition to mobilise neighbours to install solar panels, to creating a completely energy neutral municipality based on local efforts (van der Schoor and Scholtens 2015) or autarkic visions. Some, of the initiatives depart from the notion that real change is to be developed from bottom-up under pressure based on contextual factors such as climate change that put pressure on current practices (Seyfang and Haxeltine 2012).

The drivers for initiating these projects are quite different compared to conventional energy projects. These initiatives generally share a loose vision to realise renewable energy (van der Schoor and Scholtens 2015). Some of these initiatives focus on the creation of an emission free geographical region and/or want to contribute to a better quality of life. An example of such an initiative is NEWNRG. This private entrepreneurial initiative focuses on achieving a fully local renewable energy provision in the Amsterdam metropolitan area by 2028. It actively stimulates community driven initiatives by bringing together experts, knowledge, and (generating) demand. Van der Schoor et al. (2016, 98) identified three main drivers for communal energy projects: the realisation of sustainability goals, maintaining financial resources in the region, and the democratisation of energy resources. On a higher level of organisation, the level of ambition appears to rise and the vision become more detailed. For example, when the municipality is involved, the vision is more detailed, but citizen involvement becomes reduced (van der Schoor and Scholtens 2015).

In addition to these public actors, communal energy projects are by definition at least partly carried by the local community. The spectrum of community actors involved in these projects is diverse. These can be home owners, but also the active involvement of other organisations such as sports clubs, neighbourhood centres, schools, or grocery stores. Also, professional organisations can be involved, and initiatives can consist of mixes between volunteers and professionals (Geels 2014; Klein and Coffey 2016). Policy and regulations set the conditions for collaboration and the design choices of integrating renewable (small-scale) energy in the current energy system. Pioneering bottom-up initiatives generally operate on a non-commercial basis. The community participation of local communities can increase the support of renewable energy initiatives.

In The Netherlands individual energy initiatives are generally built on the national regulation that assist the small-scale developments of solar panel on residential roofs. Home owners can use the grid as a battery by delivering the solar power generated on their roofs to the grid in times of surplus, and use this power at a random time when they need electricity. However, as electricity is not stored, demand and supply fluctuation needs to be adjusted real time elsewhere. The small-scale generation on roofs is also more expensive than larger scale generation. Therefore, government support for this type of renewable generation is also based on increasing public awareness and acceptance of renewable energy (Ministry of Economic Affairs 2016a, b). The legislation will remain in place until 2020. In addition, the national government published a brochure that helps municipalities to govern local energy initiatives by local actors.[5]

Communal energy initiatives generally focus on wind energy or a solar farm. Most of the (smaller) initiatives tend to focus on the realization of one project at the time. For such a construction, the energy initiative generally operates as a legal entity such as a cooperative. When focusing specifically on these projects, there appears a trend towards larger projects and an increase in projects (Schwencke 2016).

As the number of local energy cooperatives grows, so does their level of organisation. When a communal energy projects materializes, the collaboration also takes the form of a legal entity. These entities often become members of regional, or national cooperatives. Specialised NGOs are emerging in the field for communal energy. For example, in The Netherlands, ODE Decentraal safeguards the interests of cooperatives, HIER Opgewekt collects and disseminates knowledge on communal energy developments, and RESCOOPNL facilitates project realization. These organisations can act as intermediaries that collect and disseminate knowledge.

Often, these cooperatives are rooted at a certain geographical location and focus on realising renewable energy there. This can link up with municipal CO_2 reduction ambitions (Arentsen and Bellekom 2014). Other cooperatives have a national focus (e.g. Windvogel, Qurrent). Local initiatives can also link up together and realise regional energy networks (Van der Schoor et al. 2016). There appears to be an increasing organisation and formalisation.

This diversity of involved actors and ambitions, generates a spectrum of possibilities of distributed energy provision based on different forms of initiation, ownership, and division of profits. Klein and Coffey identify eight forms of community participation of local energy development: Purchasing a private installation; Purchasing electricity; Green planned housing development; Intentional sustainable communities; One time funds; Power Purchase Agreements (PPA), Shared Ownership (Klein and Coffey 2016, 875). The degree of community involvement differs per form. Exclusion of community involvement can enhance public resistance (Devine-Wright 2011).

10.5.2.2 Implications and Reflection

The current increased level of self-organisation facilitates learning, knowledge dissemination, and the identification of best practices. Intermediaries emerge that aggregate knowledge and practices and bring together relevant actors (Dignum,

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[5] This is a publication of the Ministry of Infrastructure and Environment (see: http://www.rwsleefomgeving.nl/publish/pages/98212/gemeente_vol_energie_leidraad_stimuleren_en_faciliteren_van_energieneutraal_wonen_binnen_de_gemeente.pdf. Accessed: September 1, 2017). A similar brochure exists in the USA: Solar Powering Your Community: A Guide for Local Governments, Department of Energy 2011 (Klein and Coffey 2016).

forthcoming). Initiatives like these can make the market more transparent and can help to bring together demand and supply efficiently. It can also help to enhance visibility of the initiative and increase demand.

Visions help in building a local network. These visions extensively vary in level of detail. The enhanced level of structuration coincides with increasing commitment to visions on this higher level of organisation. Actors start to commit and aim for ambitious targets and identify future visions.

While some of these visions are ambitious, there tends to be no detailed plan for their realisation. The strategy centres on one project at the time and quick acceleration. When municipalities, and potentially more embedded actors are involved long-term planning and level of detail increase. Distributed energy development has a largely local dynamic, that builds from local communities strengthened by professional organisations. However, there is little reflection on what this growth implies in relation to systemic change.

More specifically, local energy initiatives operate largely autonomously and have the (legal) space to deliver power to the grid while this grid functions based on a system coordination (Arentsen and Bellekom 2014). The institutional structure and the functioning of the grid is taken as a given within this development whereas there are limits in how much energy fluctuations the grid can handle. In order to cope with increasing fluctuations larger changes to electricity infrastructure and grid operation are needed. Adaptations could include energy storage in electric vehicles, and enhancing high grid responsiveness and capabilities (Battaglini et al. 2009; Kempton and Tomić 2005). If these changes are not made, this will either result in grid instability or result in blocking renewable energy harvest at times of peak provision.

10.5.3 Visions of Offshore Wind Energy and Developments

The Netherlands has excellent conditions for offshore wind energy development (Jacobson et al. 2017). There is a good wind climate, relatively shallow waters, experienced industry, harbor facilities, and supporting facilities (RVO 2015b). Despite these conditions, offshore wind development was relatively modest until 2013. This recently changed and offshore wind development became more intense.

10.5.3.1 Vision, Actor Network, and Current Development

The 2013 *Agreement on Energy for Sustainable Growth* gave a boost to offshore wind development in The Netherlands (SER 2016a). These developments are strongly coordinated by the national government. Guided by the 2013 Energy Agreement, the Dutch government implemented three major policy changes regarding offshore wind development. These measures took effect in 2015–2016 and included: government appointment of zones for competitive tenders in Dutch territorial waters; government responsibility for site surveys; and the appointing of TenneT as an Offshore Transmission System Operator (OTSO) (Van den Akker 2016). The OTSO is responsible for connecting the offshore wind park to the grid connection onshore.

For the period 2015–2023, the operational Dutch offshore wind energy provision was set to grow by 3500–4450 MW. The actual and projected wind energy provision is depicted in Fig. 10.2, indicating that current developments are ahead of schedule. For the period 2024–2030, offshore wind development is expected to proceed at a minimum of 1000 MW annually (Van Nerven et al. 2017). There are spaces allocated in the Dutch territorial waters for these windmills and additional spaces will be developed in the coming years (SER 2016b).

In 2016, a large step was made in the realization of the offshore wind energy ambitions with the opening of wind park Borssele in the Dutch territorial waters, 22 km from the shore (SER 2016b). Upon completion, this offshore wind park was considered a price breakthrough. The tender system, with competition between the bids, helped in achieving this reduction (Ministry of Economic affairs 2016a, b). This cost reduction was perceived as a good indicator for future projects. Based on the success of this project, general enthusiasm was high. The Dutch parliament even requested the expedited development of planned offshore wind parks and the development of additional offshore wind energy projects (Dutch Parliament 2017).

The 2013 Energy Agreement was formed by a coalition with diverse Dutch actors. The agreement gave a boost to offshore wind development in The Netherlands. Also, other North West European countries have favorable wind climates and invest in offshore wind energy.

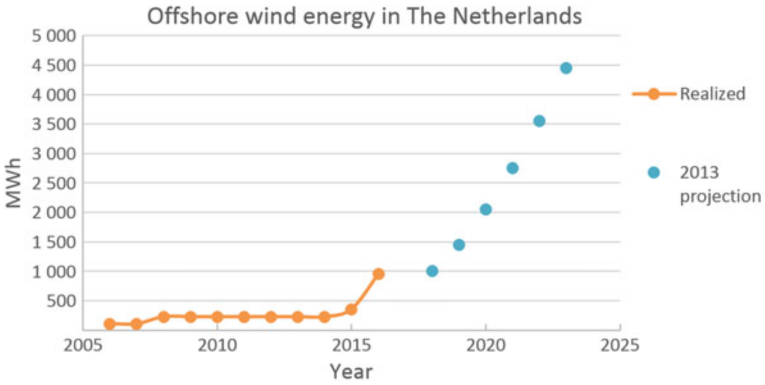

Fig. 10.2 Offshore wind energy in the Netherlands (MWh): realized and projected. *Sources* CBS (2017b), SER (2013)

The industry actors of wind energy development, construction, and substruction are also clearly international. The businesses in the sector represent a mix of incumbent actors (originally from neighboring fields) and new entrants (Wieczorek et al. 2013). The Dutch market actors for specifically offshore construction are strong and operate internationally (e.g. Mammoet, Ballast Nedam, and VanOord (Wieczorek et al. 2013). The development, operation and ownership often lies with large international utility companies such as Dong Energy (DK), Vattenvall, Eneco, RWE, E.on (Wieczorek et al. 2013; RVO 2015a). Development and substruction involves both of incumbent and new entrants (Wieczorek et al. 2013). The combined involvement of established and new firms can serve knowledge cross-fertilization, investment climate, and sector expansion (Wieczorek et al. 2013).

On the level of the grid connection, decisions are more nationally oriented while the entire system has an international nature. The current main system of grid connection is a radial connection in which the offshore wind energy system is connected to the main grid based on distance and grid capacity (Mehos 2016).

In a radial grid design, the connection of wind farms to the shore is provided on an individual basis (EC 2014). The option of a meshed grid forms a coordinated grid connection in which wind farms are connected to offshore hubs, from where connections to various countries are made (EC 2012). See Fig. 10.3.

Compared to a radial grid, a meshed grid reduces the total cable length. It allows easier transport from electricity from coastal sites where electricity is generated to geographical sites where electricity is needed creating some resilience against intermittent fluctuations of energy generation (Mehos 2016). A meshed grid also has flexibility to connect future renewable energy source (e.g. wave or tidal energy or osmotic power) (Mehos 2016) and has less environmental impact (EC 2012). The connection to different coastal sides creates redundancy in case of cable malfunctions (Mehos 2016). However, a meshed grid needs additional coordination and the initial costs are higher. A wide arrange of studies comparing both types of

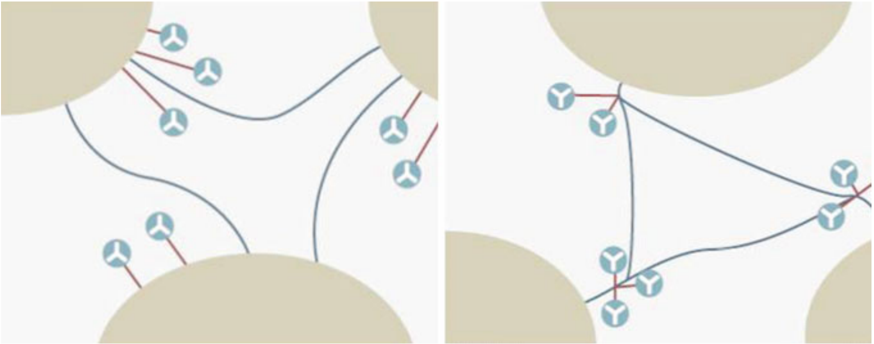

Fig. 10.3 Representation radial grid (left) and meshed grid (right). *Source* NSCOGI (2012, 1–2)

grid connections all conclude that in the long run the advantages of a meshed grid outweigh the disadvantages in comparison to a radial grid (Mehos 2016).

There are also grid structure designs that mix the characteristics of a radial grid and a meshed grid. These designs mix the (dis)advantages of radial and meshed grids (EC 2012).

Currently, near-term offshore wind energy ambitions are high and developments are unfolding rapidly. Experiments of flexible design options for a future meshed grid are encountering financial and legislative difficulties including ambiguous jurisdiction, responsibilities, ownership and distribution on costs and benefits (Mehos 2016). Grid connection to multiple countries raised questions regarding the division of responsibility between Transmission System Operator (TSO), Offshore wind developers, and the national regulator (Müller 2015). This resulted time delays and design adjustments to make the developments more comparable to radial connections (Mehos 2016).

Current developments continue based on radial connections of wind farms (Mehos 2016). Uncertainty regarding the responsibility of operating an international meshed grid and the lack of regional planning prevents potential meshed grid developments (Woolley et al. 2012). The rapid development to EU near-term renewable energy targets stimulate the continued development of radial grid developments (Mehos 2016).

10.5.3.2 Implications and Reflection

Offshore wind energy is being deployed rapidly. The Netherlands has a domestic industry in the field as well as policy commitment and public support. While neighboring countries are also developing offshore wind energy, this development, including grid connection, largely remains a national endeavor. Earlier research indicated that increased internationalization could benefit the innovation system (Wieczorek et al. 2015) and that it would be beneficial to internationally coordinate grid connection as a meshed grid connection has benefits over the current business as usual development (Mehos 2016).

Focusing on The Netherlands, the current developments proceed with high coordination, planning, and facilitation by the Dutch national government. However, these efforts focus primarily on the short and medium term. While there are long-term ambitions there is little attention on the infrastructure implications of such a system. While information is available, institutional barriers and lock-in prevent optimal decision making regarding offshore grid developments, resulting in a suboptimal lock-in position.

10.6 Implications and Discussion

In the Netherlands, distributed energy systems are developing rapidly. While the annual increase in renewable energy rises dramatically, the share is still very modest as Netherlands comes from a very low level of renewable energy provision. Regarding the developments, three observations stand out.

First, the 2013 *Energy agreement for sustainable growth* and the Paris climate agreement shape current developments. The widely accepted 2013 Energy agreement, acts as a performative vision that details the separate segments of renewable energy provision that need to take place by 2023. The 2016 Paris climate agreement creates a sense of urgency to stay at the upper limits of the 2013 energy agreement. This puts speed at the centre of the developments. Considerations of which institutional and infrastructural requirements are needed to support the transition and to maintain energy sustainability, security, and reliability on the long-term attract far less attention.

This is particularly visible in the lack of attention for integrating the centralized, currently dominant, fossil energy grid with the newly developing decentralized renewable grid. The fossil energy supply fosters security of supply as power production can be controlled (and quickly changed in the case of gas). During the energy transition, this existing fossil fuel network can provide backup power in times of high demand and/or limited availability of renewable energy. This is an important option as long as storage of intermittent energy supply for summer and winter variation still needs development.

Second, the system boundaries of current developments are narrowly defined. Local and offshore wind energy developments occur rather isolated. When placing renewable energy developments in an international perspective, it becomes visible that additional international alignment regarding offshore wind energy facilitates a more robust European electricity system. This enhanced robustness on the centralized level could potentially create flexibility for decentralized developments.

However, politically this type of alignment proves far-fetched. The focus on long-term systemic developments and consequently changing international relations and regulations appears to be a road that has too many near-term hurdles to proceed even though the long-term benefits are clear.

This international positioning creates an additional layer to the (de)centralized renewable electricity development. There is the possibility to align both central and decentral visions, but also to align centralized visions internationally. This could contribute to a more efficient and robust future renewable energy system. However, such aligned developments are hardly happening.

Lastly, once renewable energy is installed, it becomes available at near zero marginal costs. Therefore, the pricing system of the backup power, including the infrastructure needed, requires considerations. Policy recognizes that this backup power is likely to come at a relatively high price for these plants to be economically viable (EC 2012). This also implies that when renewable energy provision increases even further, the need for this (backup) power is likely to decline. One could argue that demand is likely to become so infrequent that commercial exploitation becomes difficult or impossible to afford during calamities. Especially, for actors with a financially weaker position society (e.g. civilians). The societal dependence on energy might justify policy involvement here. At the same time, investment in fossil fuels might increasingly evoke public resistance.

A longer-term vision, and more in-depth discussion, on how the *transition* should be taken place instead of ad hoc speed driven developments can help in ensuring more robust development regarding reliability, affordability, and sustainability of energy provision. This includes attention on aligning of simultaneous developments for renewable energy and intermediary and end goal articulation including the safeguarding of the principles of EU energy policy of affordability, sustainability, and reliable throughout the transition. This also implies operationalisation of the safeguarding of these three principles throughout the entire transition process *and* in the 2050 energy provision system.

10.7 Conclusion

This chapter provided insights in the versatility of efforts for creating a renewable future electricity system. A spectrum of decentralized renewable energy visions is simultaneously shaping the future electricity system. For depicting this versatility more extreme forms of distributed energy development in The Netherlands were analysed. The chapter specifically focused on communal energy and offshore wind.

A spectrum of renewable distributed developments are supported by the government of The Netherlands. The 2023 energy conservation targets appear leading. However, the separate elements in this plan are developing with limited attention for the consequences of these developments for the entire system. Also, for the planned developments, a spectrum of design choices can be made. In the case of offshore wind, near-term planning, a national focus, and the need for short-term results, led to rapid development and suboptimal design choices. For communal energy, the vision of the pioneering entrepreneurial actor is more important, which results in near-term development with unclear larger scale prospects.

The institutional developments need to accommodate the development of a divergent influx of electricity sources. The institutional setting needs to be developed that facilitates both centralized and decentralized energy generation and the interaction between these levels while accommodating the values of a (new) energy system (reliability, affordability, and sustainability).

Currently, there is little interrelation between these developments of these different scales (distributed and centralized), nor the integration of these developments in the national grid or the international market. The system boundaries of these developments are narrowly defined whereas interaction and attention for the process of systemic change is needed.

The actors guiding communal and offshore energy development are diverse. There are only a couple of actors that span across these realms such as governments, regulators, Transmission System Operators. The connection of the diverse developments towards a renewable energy system also needs to occur with coordination from these actors.

A development of an integrated vision that links current renewable energy initiatives with the ambition of an almost completely renewable energy provision in 2050, and the institutional and infrastructural options that accommodate design choices, can help this complex development process. Attention also needs to be paid to the stability of the developing renewable energy grid, especially in the transitional period in which there is (some) reliance on fossil energy.

When developing this synergy attention needs to be paid to the scales of these developments. Compared to decentralized communal developments, offshore wind energy is a far more centralized form of renewable energy development with different actors involved. Additionally, the central grid is increasingly used as a buffer zone to cope with fluctuations in demand and supply over the day and through the seasons this also needs to be incorporated.

The empowering and the inclusion of relevant actors on all of these levels in the envisioning process is crucial. This creates a nested, interrelated development. While it is valid for each actor to have its own motivation for supporting renewable energy development, it is important to have insight in how these developments add up to an institutional and infrastructure level.

Actors that support visions on either side of the spectrum should also be invited to identify linkages between the visions. The linking of these developments allows for contextualisation, innovation and experimentation as well as learning across different scales (Goldthau 2014). From there a well-informed reflexive vision can be developed that shapes developments and prevents sub-optimal lock-in.

The current omission of a long-term vision and the absence of infrastructure and institutional linkages between different elements of the renewable energy visions and developments, limit the benefits a vision may have in relation to reflectivity, learning, and integration. The synergy between the different developments is currently missing or at least underdeveloped. This is particularly important as ill integration may affect the principles of affordability, security of supply and sustainability that are core to our energy system.

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References

Achterhuis, H. (1998). *De erfenis van de utopie*. Amsterdam: Ambo.

Alanne, K., & Saari, A. (2006). Distributed energy generation and sustainable development. *Renewable and Sustainable Energy Reviews, 10,* 539–558.

Arentsen, M., & Bellekom, S. (2014). Power to the people: Local energy initiatives as seedbeds of innovation? *Energy, Sustainability and Society, 4*(1), 1–12.

Bakker, S. (2011). *Competing expectations; The case of the hydrogen car*. PhD thesis, Utrecht University. Oisterwijk: BOXPress.

Battaglini, A., Lilliestam, J., Haas, A., & Patt, A. (2009). Development of supersmart grids for a more efficient utilisation of electricity from renewable sources. *Journal of Cleaner Production, 17*(10), 911–918.

Borup, M., Brown, N., Konrad, K., & van Lente, H. (2006). The Sociology of expectations in science and technology. *Technology Analysis & Strategic Management, 18*(3–4), 285–298.

Brown, N., Rappert, B., & Webster, A. (Eds.). (2000). *Contested futures: A sociology of prospective techno-science*. Aldershot, England: Ashgate Publishing Company.

Centraal Bureau voor de Statistiek (CBS). (2016). *Elektriciteitsproductie uit steenkool opnieuw hoger*. News report, June 28. https://www.cbs.nl/nl-nl/nieuws/2016/26/elektriciteitsproductie-uit-steenkool-opnieuw-hoger. Accessed June 18, 2017.

Centraal Bureau voor de Statistiek (CBS). (2017a). Hernieuwbare elektriciteit: productie en vermogen. Statline. http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=82610ned&D1=6-7&D2=0-2,5-10&D3=23-25&VW=T. Accessed June 18, 2017.

Centraal Bureau voor de Statistiek (CBS). (2017b). Windenergie; elektriciteitsproductie, capaciteit en windaanbod per maand. http://statline.cbs.nl/StatWeb/publication/?PA=70802NED. Accessed June 18, 2017.

Correljé, A., & Verbong, G. (2004). The Transition from coal to gas: Radical change of the Dutch gas system. In B. Elzen, F. Geels, & K. Green (Eds.), *System innovation and the transition to sustainability: Theory, evidence and policy* (pp. 114–134). Cheltenham U.K.: Edward Elgar Publishing.

Devine-Wright, P. (2011). *Renewable energy and the public*. New York: Taylor&Francis.

Dignum, M. (forthcoming). *Urban Platform Intermediaries and the Governance of the Energy Transition,* In M. van Geenhuizen, A. Holbrook, & M. Taheri (Eds.), *Cities and sustainable technology transitions: Leadership, innovation and adoption*. Cheltenham U.K.: Edward Elgar.

Dignum, M. (2013). *The power of large technological visions; the promise of hydrogen energy (1970-2010)*. PhD Thesis, Eindhoven University of Technology. Boxtel: Boxpress.

Dutch Parliament. (2017). Motie van het lid van Tongeren c.s. over het aanpassen van de energieagenda overeenkomstig aangenomen moties, February 7, https://www.tweedekamer.nl/vergaderingen/plenaire_vergaderingen/details?date=14-02-2017#2017A00494. Accessed June 18, 2017.

European Commission (EC). (2012). Energy roadmap 2050. https://ec.europa.eu/energy/sites/ener/files/documents/2012_energy_roadmap_2050_en_0.pdf. Accessed September 8, 2017.

European Commission (EC). (2014). Study of the benefits of a meshed offshore grid in the northern seas region. Final Report. Directorate-General for Energy, Luxembourg. https://ec.europa.eu/energy/sites/ener/files/documents/2014_nsog_report.pdf. Accessed September 8, 2017.

Geels, F. W. (2014). Regime resistance against low carbon transitions: Introducing politics and power into the multi-level perspective. *Theory, Culture and Society, 31*(5), 21–40.

Goldthau, A. (2014). Rethinking the governance of energy infrastructure: Scale, decentralization and polycentrism. *Energy Research & Social Science, 1,* 134–140.

Grin, J. (2000). Vision assessment to supporting shaping the 21st century society? Technology assessment as a tool for political judgement. In J. Grin & A. Grunwald (Eds.), *Vision assessment: Shaping technology in 21st century society*. Berlin, Heidelberg, New York: Springer.

Harris, D., Bazelon, C., Humphreys, B., & Dickson, P. (2010). *Economic impact of the Dutch gas hub strategy on The Netherlands*. Ministry of Economic Affairs, Agriculture and Innovation by the Brattle Group. https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/rapporten/2010/12/08/dutch-gas-hub-strategy-on-the-netherlands/10183259-bijlage.pdf. Accessed June 18, 2017.

Jacobson, M. Z., Delucchi, M. A., Bauer, Z. A. F., Goodman, S. C., Chapman, W. E., Cameron, M. A., et al. (2017). 100% Clean and Renewable Wind, Water, and Sunlight (WWS) All-Sector Energy Roadmaps for 139 Countries of the World. Stanford. http://web.stanford.edu/group/efmh/jacobson/Articles/I/CountriesWWS.pdf. Accessed June 8, 2017.

Kempton, W., & Tomić, J. (2005). Vehicle-to-grid power implementation: From stabilizing the grid to supporting large-scale renewable energy. *Journal of Power Sources, 144*(1), 280–294.

Klein, S. J. W., & Coffey, S. (2016). Building a sustainable energy future, one community at a time. *Renewable and Sustainable Energy Reviews, 60,* 867–880.

Lilliestam, J., & Hanger, S. (2016). Shades of green: Centralisation, decentralisation and controversy among European renewable electricity visions. *Energy Research & Social Science, 17,* 20–29.

Mehos, D. C. (2016). Toward a transnational North Sea meshed grid. Working Paper FLOW project. Delft University of Technology.

Michael, M. (2000). Futures of the present: From performativity to prehension. In N. Brown, B. Rappert, & A. Webster (Eds.), *Contested futures: A sociology of prospective techno-science* (pp. 21–39). Aldershot, England: Ashgate Publishing Company.

Ministry of Economic Affairs. (2016a). Energieagenda: Naar een CO2- arme energievoorziening in 2050. https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/rapporten/2016/12/07/ea/Energieagenda-2016.pdf. Accessed July 31, 2017.

Ministry of Economic Affairs. (2016b). Windpark Borssele goedkoopste ter wereld. Announcement 05, July 2016. https://www.rijksoverheid.nl/ministeries/ministerie-van-economische-zaken/nieuws/2016/07/05/windpark-borssele-goedkoopste-ter-wereld. Accessed June 18, 2017.

Müller, H. K. (2015). *A legal framework for a transnational offshore grid in the North Sea*. PhD Thesis, University of Groningen.

North, D. C. (1991). Institutions. *The Journal of Economic Perspectives, 5*(1), 97–112.

NSCOGI. (2012). The North Seas countries' offshore grid initiative. http://www.benelux.int/files/1414/0923/4478/North_Seas_Grid_Study.pdf. Accessed September 1, 2017.

Netherlands Enterprise Agency (RVO). (2015a). Overview: Offshore wind: kansen op de international markt. http://www.tki-windopzee.nl/files/2015-12/overview-wind-op-zee-nov-2015.pdf. Accessed June 18, 2017.

Netherlands Enterprise Agency (RVO). (2015b). Offshore wind energy in the Netherlands. https://www.rvo.nl/sites/default/files/2015/03/Offshore%20wind%20energy%20in%20the%20Netherlands.pdf. Accessed June 18, 2017.

Orehounig, K., Mavromatidis, G., Dorer, V., & Carmeliet, J. (2014). Towards an energy sustainable community: An energy system analysis for a village in Switzerland. *Energy and Buildings, 84,* 277–286.

Schwencke, A. M. (2016). Nationale energie monitor. Hier Opgewekt. https://www.hieropgewekt.nl/sites/default/files/hier_opgewekt_monitor_2016.pdf. Accessed September 3, 2017.

Social-Economic Council of the Netherlands (SER). (2013). Agreement on energy for sustainable growth. http://www.ser.nl/~/media/files/internet/publicaties/overige/2010_2019/2013/energieakkoord-duurzame-groei/energieakkoord-duurzame-groei.ashx. Accessed June 18, 2017.

Social-Economic Council of the Netherlands (SER). (2016a). Agreement on energy for sustainable growth; Progress report. http://www.energieakkoordser.nl/publicaties/voortgangsrapportage-2016.aspx. Accessed June 18, 2017.

Social-Economic Council of the Netherlands (SER). (2016b). Factsheet wind op zee. http://www.energieakkoordser.nl/nieuws/2016/factsheet-wind-op-zee.aspx. Accessed June 18, 2017.

Seyfang, G., & Haxeltine, A. (2012). Growing grassroots innovations: Exploring the role of community-based initiatives in governing sustainable energy transitions. *Environment and Planning C: Government and Policy, 30*(3), 381–400.

Van den Akker, W. (2016). Netaansluitingen Windparken. TenneT, 11 October. http://www.stibbeblog.nl/wp-content/uploads/2016/10/Wat-komt-er-kijken-bij-aansluiting-van-een-windpark-op-het-elektriciteitsnet-Wouter-van-den-Akker.pdf. Accessed June 18, 2017.

Van der Schoor, T., van Lente, H., Scholtens, B., & Peine, A. (2016). Challenging obduracy: How local communities transform the energy system. *Energy Research & Social Science, 13,* 94–105.

Van der Schoor, T., & Scholtens, B. (2015). Power to the people: Local community initiatives and the transition to sustainable energy. *Renewable and Sustainable Energy Reviews, 43,* 666–675.

Van Lente, H. (1993). *Promising technology; The dynamics of expectations in technological developments*. PhD Thesis, Twente University.

Van Lente, H. (2000). Forceful futures: From promise to requirement. In N. Brown, B. Rappert, & A. Webster (Eds.), *Contested futures: A sociology of prospective techno-science* (pp. 43–64). Aldershot, England: Ashgate Publishing Company.

Van Lente, H., & Bakker, S. (2010). Competing expectations: The case of hydrogen storage technologies. *Technology Analysis & Strategic Management, 11*(6), 693–709.

Van Lente, H., & Rip, A. (1998). The rise of membrane technology: From rhetorics to social reality. *Social Studies of Science, 28*(2), 221–254.

Van Nerven, J., Vrijhoef, D., Willems, R., Inderdjiet, A., Kluver, M., & Sterk, R. (2017). Vervolgroutekaart windenergie op zee. Joint initiative of the Ministry of Economic Affairs, Ministry of Infrastructure and Environment, Netherlands Enterprise Agency, Rijkswaterstaat, TenneT, Nature and Environment, and the Dutch Wind Energy Association. https://www.noordzeeloket.nl/images/Vervolgroutekaart%20Windenergie%20op%20Zee%20-%20Samen%20meerwaarde%20cre%C3%ABren%20op%20zee%202024-2030_5378.pdf. Accessed June 18, 2017.

Wieczorek, A. J., Hekkert, M. P., Coenen, L., & Harmsen, R. (2015). Broadening the national focus in technological innovation system analysis: The case of offshore wind. *Environmental Innovation and Societal Transitions, 14,* 128–148.

Wieczorek, A. J., Negro Simona, O., Harmsen, R., Heimeriks, G. J., Luo, L., & Hekkert, M. P. (2013). A review of the European offshore wind innovation system. *Renewable and Sustainable Energy Reviews, 26,* 294–306.

Woolley, O. A., Schaumberg, P., & St. Michel, G. (2012). Establishing an offshore grid: A legal analysis of grid developments in the North Sea and in US waters. In M. Roggenkamp, L. Barrera-Hernandez, D. Zillman, & I. del Guayo (Eds.), *Energy networks and the law: Innovative solutions in changing markets* (pp. 180–204). Oxford: Oxford University Press.

Yin, R. K. (2009). *Case study research: Design and methods* (4th ed.). Thousand Oaks: SAGE Inc.