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Evaluation of the top sector policy energy from an evolutionary perspective

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Preface and acknowledgments

From the urge to unravel the causes of the Dutch strong dependency on fossil fuels and from the curiosity about what is going on behind the government's doors, one day I decided to take the train to the Hague, to end up behind the table of Dorette Corbey, director of the Advisory council for science, technology and innovation. With energy related projects very apparent in my Curriculum Vitae and both a bachelors as well as a year of my masters in Innovation Sciences, the decision was easily made: energy + innovation = *top sector policy energy*. Marcel Kleijn, to whom I am very thankful, showed me around in the political world of The Hague and was the one to clarify that textbook innovation happens differently when other (political) interests are involved. Maybe this was partly the reason that we always ended up having different conclusions on the base of the same data. In doing research, this is the best discussion partner you can have. Another very much appreciated person is Maaike den Heijer, doing her analysis on the *top sector policy* Life Sciences and Health. Thank you for your great reasoning in complex issues and the fun we had in the office. Also thank you Bart and Isabel for adding the necessary fun and craziness to my sometimes very focused and serious mode of working. I want to thank the AWTI in general for giving me such a nice (first) working environment and giving me the chance to interview important and interesting people.

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I want to thank all the interviewees, who stay anonymous in the report. Thank you for the time you took to answer every question in a sometimes very spontaneous and surprisingly honest way. You gave me a lot of inspiration, amazement, and interesting insights. You opened up a whole new world of policy and politics for me. It was a great pleasure to talk to you. I want to thank RVO for being helpful in providing the network data.

Similar to innovation, writing a thesis is a journey instead of a one-track race. And on every journey there are many roads to take, pitfalls, unexpected problems and obstacles. A few people were especially helpful in taking on this journey. In the case of these 'hard times'[1] you need to have people around you that you can complain to and do not take it too seriously. Thank you Intermate, especially the people of In 't Audt and Ymke de Jong for being there for me. I also want to thank Wouter Nij Bijvank, who was always available to help me through the difficult times by having great discussions with me on topics he did not know anything about. In a strange way, I gained very helpful insights from it while he was mostly left in confusion. In the end, without the unconditional support of my parents and sister not only during this project but also during my whole studies, I would never be able to have a result like this. Thank you for believing in me, also at moments when I did not believe in myself.

Lieke van Son

[1] 'hard times' is referring to the song called 'zwaar leven' by Brigitte Kaandorp (2012) (https://www.youtube.com/watch?v=JLNvBvJ-F00)

Contents

Table of figures

List of abbreviations

AET	Advisory and Evaluation Team
CO_2	Carbon Dioxide
ECN	Energy research Centre of the Netherlands
EnerGO	Energy saving for the Built Environment
DEI	Demonstration Energy Innovation
FES	Fund for Strengthening the Economy
Fte	full time employee
GDP	Gross Domestic Product
ISPT	Energy Saving in the Industry
KNAW	Royal Netherlands Academy of Arts and Sciences
KPI	Key Performance Indicator
kvk-number	chamber of commerce number
MARIN	Maritime Research Institute Netherlands
MKB	Small and Medium Entreprises
NLR	Nationale Aerospace Laboratory
NWO	Netherlands Organisation for Scientific Research
PBL	Netherlands Environmental Assessment Agency
pps	public-private partnership
R&D	Research and Development
RDA	Research and Development Discount
RVO	Netherlands Enterprise Agency
SDE+	Stimulation Energy Production
SME	Small and Medium Enterprises
STEM	Collaboration top sector energy and the society
STS	Science and Technology Studies
TO2	Organisations for applied research
TKI	Top consortium for Knowledge and Innovation
TNO	Netherlands Organisation for Applied Research
TRL	Technology Readiness Level
WSBO	Law to Stimulate Search and Development Work

Nederlandse samenvatting voor beleidsmakers

Energietransitie

Nederland heeft zichzelf doelen gesteld ten aanzien van een betaalbare en schone energievoorziening in de toekomst. Voor de kortere termijn (2023) zijn in het Energieakkoord breed gedragen afspraken gemaakt over energiebesparing en schone technologie. Voor de langere termijn (2050) is in de klimaatagenda het doel uitgesproken de CO_2 emissie met 80-95% te beperken. Innovatie wordt gezien als een onmisbare bouwsteen voor de transitie naar duurzaam energiesysteem. Voor deze grote maatschappelijke uitdaging zullen meerdere innovaties nodig zijn, waarbij het nu nog onmogelijk is om te voorspellen welke innovaties uiteindelijk doorslaggevend gaan zijn.

Topsector Energie

Het voor energie specifieke innovatiebeleid is ondergebracht bij de topsector Energie, één van de negen topsectoren aangesteld door het Ministerie van Economische Zaken (EZ). De topsector Energie kent twee doelen: bijdragen aan de concurrentiekracht van Nederland en bijdragen aan de transitie naar een duurzaam energiesysteem. Het Energieakkoord biedt het kader voor de tweede doelstelling. Binnen de topsector Energie zijn er zeven Topconsortia voor Kennis en Innovatie (TKI's) opgericht, rond de volgende thema's: Wind op Zee, Zonne-energie, Smart Grids, Gas, Energiebesparing in de industrie, Energiebesparing in de Gebouwde Omgeving en de Biobased Economy. De TKI's Zonne-energie, Smart Grids en Energiebesparing in de Gebouwde Omgeving fuseren naar een nieuwe TKI Urban Energy. Daarnaast zijn er nog twee algemene thema's: Systeemintegratie en het STEM-programma (Samenwerken Topsector Energie en Maatschappij).

Het bestuur van de topsector Energie is in handen van het topteam, bestaande uit een boegbeeld vanuit het bedrijfsleven, een mkb'er, een onderzoeker en een vertegenwoordiger van de overheid. Daarnaast is er een regieteam, bestaande uit 'movers and shakers'; mensen die in staat zijn om de gestelde doelen te helpen realiseren. Naast de generieke (sectoronafhankelijke) innovatiemiddelen die het Ministerie van Economische Zaken beschikbaar heeft, beschikken de topsectoren over specifieke regelingen. De topsectoren kunnen binnen de TKI's gebruik maken van TKI-toeslag, een toeslag van 25% op het budget binnen een publiek-private samenwerking. Naast de TKI-toeslag, beschikt de topsector Energie over extra energie-innovatiemiddelen vanuit het Energieakkoord die zij naar eigen inzicht over de TKI's kunnen verdelen.

Onderzoeksvraag

In deze scriptie kijken we naar de vraag in hoeverre de topsector Energie leidt tot innovaties die bijdragen aan de energietransitie. Met een constructivistische, beschouwende aanpak – met name geschikt voor een sociaal complexe omgeving zoals de topsector Energie – proberen we met dit onderzoek bij te dragen aan reeds bestaande beleidsevaluaties. We hebben gekozen om een evolutionaire aanpak voor innovatie te hanteren, omdat deze met name geschikt is om de dynamiek van lange termijn processen te analyseren.

In evolutionaire theorie spelen drie mechanismen een rol; diversiteit (van actoren en van technologieën), selectie en retentie. Diversiteit is de mate waarin (het ontstaan van) verschillende opties gestimuleerd wordt of waarin er een verscheidenheid aan actoren betrokken wordt. Innovatie leidt tot diversiteit. De aard van de innovatie kan invloed hebben op de diversiteit die gecreëerd wordt. Zo kan het vroeg betrekken van de eindgebruiker helpen om de innovatie beter aan te passen op de uiteindelijke selectiecriteria. Ook kan radicale innovatie voor meer diverse opties zorgen dan incrementele innovatie. Andersom, kan diversiteit ook tot innovatie leiden. Recombinatie van al bestaande innovaties leidt vaak tot nieuwe innovaties. Diversiteit van technologische opties vergroot de kans op recombinatie en de kans op een optimale uitkomst op de lange termijn. Het betrekken van diverse actoren zorgt voor meer innovatieve ideeën en een democratisch proces. Welk pad er gekozen wordt, heeft immers impact op het energiesysteem van de toekomst en raakt iedereen. Het proces van selectie beschrijft op welke basis en welke criteria er voor bepaalde opties gekozen wordt en heeft dus sterke invloed op welk innovatiepad er gekozen wordt. Retentie geeft het proces van leren weer; in hoeverre de innovaties of innovatieve praktijken die goed presteren op basis van de selectiecriteria worden verspreid en gereproduceerd.

Voor dit onderzoek zijn 18 gesprekken gevoerd, met diverse betrokkenen in en buiten de topsector Energie, zowel vanuit het management als meer uitvoerend, en zowel vanuit het bedrijfsleven, de kennisinstellingen, de overheid en maatschappelijke organisaties. Daarnaast is gebruik gemaakt van een door RVO ter beschikking gestelde projectendatabase om netwerkanalyses te maken van de ecosystemen van de verschillende TKI's.

Diversiteit is geen doel

Voor het management van de topsector Energie is diversiteit geen doel op zichzelf. Meer focus met betrekking tot technologische opties is juist het doel, met als argument dat de beschikbare middelen voor innovatie beperkt zijn. Deze wens naar meer focus wordt niet door iedereen gedeeld. Binnen sommige TKI's is de strategie om in toenemende mate ruimte te bieden aan verschillende opties. Dit gebeurt vaak vanuit een systeemgedachte; de eerdergenoemde fusie tussen drie TKI's maakt het bijvoorbeeld mogelijk dat technologische opties die voorheen tussen wal en schip vielen, nu wel kans maken op steun binnen de topsector energie.

Er is aandacht voor sociale en maatschappelijke aspecten via het STEM-programma (Samenwerken Topsector Energie & Maatschappij). Omdat dit programma de diverse TKI's overstijgt, is het separaat georganiseerd. Het risico daarvan is volgens diverse geïnterviewden dat sociale en maatschappelijke aspecten pas laat in het innovatieproces meegenomen worden, waardoor het meer het karakter van 'maatschappelijke acceptatie' krijgt, oftewel het accepteren van al bestaande technologie. Beter is om deze aspecten al in het begin te integreren met de technologische ontwikkeling.

Tot slot is gekeken naar de diversiteit van actoren. Er is diversiteit, maar deze lijkt toch wat beperkt. Er zijn vele bedrijven en kennisinstellingen die actief deelnemen in de TKI's, maar NGO's en overheden zijn minder betrokken. Eén NGO-vertegenwoordiger is lid van het Regieteam, maar dat is het. Ook in projecten zijn NGO's nauwelijks vertegenwoordigd. Hetzelfde geldt voor andere departementen, met name het Ministerie van Infrastructuur & Milieu (I&M). Gezien de doelstelling (CO_2-reductie) verwacht je een grotere betrokkenheid van dit ministerie, maar deze laat het realiseren van CO_2-reductie in de energiesector geheel over aan het Ministerie van EZ.

Relatief grote nadruk op incrementele innovatie

De aard van innovatie bepaalt hoe divers de technologische opties zijn. Door het Energieakkoord is er een druk om op relatief korte termijn (2023) resultaten te boeken. Een relatief grote nadruk op incrementele innovatie is het gevolg hiervan. Op de lange termijn zorgt dit voor het risico dat we vast blijven zitten in suboptimale technologieën, met nadelen voor zowel de duurzaamheids- als de economische doelen. Meer nadruk op 'vrij' fundamenteel onderzoek vergroot de kans op doorbraakinnovaties. Maar ook het verlagen van de barrières voor recombinatie levert enorme kansen, wat nu belemmerd wordt door de verdeling van technologieën in TKI's.

Selectie op basis van gelijke weging van twee hoofddoelen

De selectie van thema's en projecten geschiedt op basis van een gelijke weging van de twee hoofddoelen; economische groei (wat op diverse manieren gemeten kan worden, bijvoorbeeld export of werkgelegenheid) en bijdrage aan de transitie (gemeten via CO_2-reductie). Diverse geïnterviewden geven hierbij aan dat dit geen 'rocket science' is; het gaat vaak om het zo goed mogelijk maken van een inschatting hiervan. Soms worden thema's geselecteerd die niet direct te verdedigen zijn vanuit beide doelen, maar waarvan iedereen het gevoel heeft dat ze belangrijk zijn. Thema's als 'Smart Grids' en 'systeemintegratie' zijn hiervan een voorbeeld; deze leveren niet direct economische groei en dragen niet direct bij aan CO_2-reductie, maar kunnen op termijn wel eens heel belangrijk gaan worden als enabler voor andere oplossingen. Bij het thema 'systeemintegratie' speelt ook dat deze bijdraagt aan een doelstelling die niet expliciet is gesteld door de topsector energie, maar die wel door velen belangrijk wordt geacht: de betrouwbaarheid van het energiesysteem.

Kennisdeling tussen TKI's is een uitdaging

Hoe wordt kennis gedeeld binnen de topsector Energie? Binnen de TKI's is er veel aandacht voor kennisdiffusie naar de deelnemers, via wetenschappelijke tijdschriften, nieuwsartikelen op de TKI-website, emails en bijeenkomsten. Kennisdeling tussen de TKI's – ook die van andere topsectoren – is een grotere uitdaging en vindt nog maar beperkt plaats. Met name vanwege het beperkte budget en menskracht waarover TKI's beschikken, sneuvelen vaak de plannen om kennis met andere TKI's te delen. Ook RVO, die de STEM-regeling uitvoert en daarmee een ideale positie heeft om diverse TKI's met elkaar in contact te brengen, heeft te maken met een krimpend budget voor de uitvoering van de STEM-regeling. Ook hier sneuvelen vooral de additionele inspanningen om kennisdeling tussen TKI's te faciliteren.

Tweede orde effecten

Naast directe effecten van de topsector Energie op duurzame innovatie in Nederland, heeft de topsector Energie ook indirect effecten op het onderzoeks- en energiebeleid. Het zwaartepunt van het beleid in de topsector Energie ligt op de middelste fase van het innovatieproces. Het risico daarvan is dat de focus in de topsector Energie op enkele specifieke technologieën een aanzuigende werking heeft op zowel eerdere als latere fasen van het innovatieproces. Het fundamenteel energieonderzoek wordt mogelijk meer toegespitst op de onderwerpen binnen de topsector Energie, omdat ze later moeilijk verdere doorgang kunnen vinden. Technologieën die buiten de topsector Energie vallen, hebben in latere fasen minder kans om zich verder te ontwikkelen en kostenefficiënt te worden. Dit reduceert hun kansen binnen de regelingen DEI (Demonstratie energie-innovatie) en SDE+ (Stimulering Duurzame Energieproductie), die zijn gericht op implementatie en opschaling van duurzame energietechnologie en waarvoor kostenefficiëntie een voorwaarde is.

Conclusie

In deze scriptie hebben we gekeken naar de topsector Energie en de vraag gesteld hoe de topsector Energie presteert door de lens van de concepten van het evolutionaire perspectief, te weten: diversiteit van actoren, diversiteit van technologieën, selectie en retentie. Selectie blijkt relatief veel aandacht te krijgen van het topsector management, ten koste van diversiteit en retentie. Het voordeel van selectie is dat het op korte termijn leidt tot economische efficiënte. Meer diversiteit leidt echter op lange termijn tot een robuuster systeem, minder kans op lock-ins in suboptimale technologieën en een grotere kans op recombinatie en radicale innovaties. Zowel diversiteit als selectie is belangrijk en daarom moet een goede balans tussen beiden worden gevonden. Juist vanwege de grote onzekerheden bij het bepalen van deze balans is het gebrek aan aandacht voor retentie een gemiste kans. Evolutionaire ontwikkeling in een gewenste richting gaat namelijk over het repliceren van geschikte innovaties en innovatieprocessen; voldoende aandacht voor het uitwisselen van kennis en ervaring is daarbij essentieel.

Aanbevelingen

We formuleren een aantal beleidsaanbevelingen op basis van de analyse. De eerste aanbeveling is om meer op diversiteit te focusseren. Dit kan worden bereikt door zowel meer diversiteit in actoren als meer diversiteit in technologieën als beleidsdoel te stellen. Hierbij kan worden gedacht aan het anders organiseren van thema's; minder focus op specifieke technologieën en meer organiseren rondom thema's, doelen of systemen verhoogt zowel de diversiteit van actoren (omdat thema's technologische velden doorkruisen) als de kans op recombinatie tussen technologieën. De nieuwe TKI Urban Energy is hier een goed voorbeeld van.

De tweede aanbeveling is om meer aandacht te geven aan retentie. Regelmatig reflecteren over de grenzen van individuele TKI's heen is nodig, zowel om de balans tussen selectie en diversiteit te verbeteren als om succesvolle innovatiepraktijken te reproduceren. Er liggen kansen op het gebied van leren over de verschillende energie-innovatie regelingen, zodat leerervaringen uit de topsector Energie kunnen worden gebruikt als terugkoppeling naar fundamenteel onderzoek, maar ook voor terugkoppeling naar wat de potentieel beste technologieën zijn om uit te rollen via de SDE+ regeling. Een pleidooi voor meer diversiteit en retentie druist in tegen de wens om directe positieve effecten van beleid te meten. Beleidsmakers moeten hun beleid verantwoorden en willen de resultaten van hun inspanningen met concrete indicatoren meten. Dit is lastig met doelstellingen als diversiteit en retentie die moeilijk te meten zijn.

Een laatste aanbeveling van dit onderzoek is daarom om in het beleid meer nadruk te leggen op het organiseren van het innovatieproces, in plaats van het gebruik van indicatoren om beleid te verantwoorden. Een regelmatige reflectie met verschillende actoren is belangrijk om de politieke dimensie van innovatie te erkennen en om weloverwogen besluitvorming mogelijk te maken.

1. Introduction

Today, the way in which we fulfill our needs in many domains is not sustainable in the long run and already causing problems on a large scale (Schot, 2014) (Wieczorek and Hekkert, 2012). Water supply and sanitation have to tackle issues with insufficient access to low income countries, transportation is challenged by congestion, energy supply is confronted with rapid depletion, air pollution and green house gas emissions and other sectors have to deal with similar challenges (Markard *et al.*, 2012). These are lasting problems that are likely to worsen when economic growth returns and lead to intensified climate change, societal commotion and tensions (Schot, 2014). Optimizing current technologies, like burning fossil fuels more efficiently, will not solve the problem or may even increase it, since it may reinforce the fossil fuel economy (Geels, 2002).

By many, innovation is seen as an important mean to solve the central, complex issues of our time, since many problems are related to the use of polluting and energy intensive technologies. The body of literature on sustainable energy transitions has the underlying assumption of a central role of innovation in transforming the society towards more sustainable modes of production and consumption (Markard *et al.*, 2012). On the other hand, there are no guarantees that any particular realised innovation will necessarily be positive (Stirling, 2015). Innovation may 'go forward' quickly, but in the wrong direction. To solve great challenges, diverse kinds of innovation are needed (Steward, 2008) (Scrase *et al.*, 2009). Innovation policy should open up innovation portfolios to allow for diversity and experimentation (Schot, 2014). Next to that, the innovation policy should acknowledge the political nature of the interests driving possible pathways. Crucial choices have to be made across a variety of continually branching alternative pathways for change (Dosi, 2000). Alternative pathways will routinely differ in their social distributions of benefits and harms, winners and losers. Then, innovation is not about optimizing a single trajectory to the future, but about collaboratively exploring diverse and uncertain pathways (Stirling, 2015).

However, many innovation policies are still based on the old linear model of innovation, which handles innovation as a 'race to the future' (Stirling, 2015) and uses support for R&D as a narrow indicator to drive competition between nations (Schot, 2014) (Veugelers, 2012). Innovation is frequently discussed in policy documents as if it were a one-track race (Broers, 2005), simply about whether to 'go forward' or not. Policy is stated as 'pro-innovation' – as if this were a purely technical matter and always self evidently good (Stirling, 2015). Entrepreneurial activities are stimulated in order to stimulate economic growth and afterwards the negative impacts are solved by regulation and compensatory measures; the role of the state limited to distributing the benefits and managing the risks (Schot, 2014).

One of the innovation policy instruments of the Netherlands is the *top sector policy*. The *top sector policy* was established to solve the perceived problem of a relatively (to other European countries) low spending (in percentage of GDP) of the private sector to R&D. It aims to stimulate private investment in R&D in order to climb in the global knowledge rankings to become the fifth knowledge economy of the world. The *top sector policy* aims to reach these goals by aligning private sector demand and knowledge supply in areas in which the Netherlands currently has a strong knowledge base and industry. The energy sector is one of the nine top sectors, since it is an important sector for the economy (Ministry of Economic Affairs, 2015). We will refer to the *top sector policy* for the energy sector as the *top sector policy energy*. While this sector is viewed as having high potential to increase the innovative capacity of the Netherlands, the energy system of the Netherlands is largely dependent on fossil fuel use, which is confronted with rapid depletion of natural resources, geo-political dependency, air pollution and green house gas emissions (for more information about the energy sector see appendix 3) (Markard *et al.*, 2012). Therefore, the *top sector policy energy* set, next to creating a structural bigger income potential by stimulating innovation in the energy sector, also the goal of realizing a transition towards a more sustainable and CO_2 poor sector (Topsector Energie, 2013). From the goal of contributing to a more sustainable energy system, the general aim of the research is: How can we evaluate the *top sector policy energy* on bringing about innovation that contributes to a more sustainable energy system in the Netherlands?

To answer this question, we are taking an evolutionary approach on innovation. In need for transforming the energy system in a sustainable direction, the way we look at innovation goes beyond the simplified technological and 'pro-innovation' discourses. The innovation process is not a single-track race to the future (Stirling, 2015), but about diverse options that are exposed to a selection environment and replicated in case they are well adapted to the selection environment (Campbell, 1969). Continuously, one of the most important findings in the field of innovation studies is, that innovation is more like an evolutionary process than a race (Nelson and Winter, 1982). Innovation increases diversity but the outcomes of the innovation process are inherently uncertain. Repeated selection may take place, stimulated by scale benefits and learning effects causing path dependencies. An evolutionary approach embraces these complex dynamics and therefore offers a vocabulary suitable to clarify the innovation process specifically to engage with complex challenges of today (van den Bergh and Kallis, 2013). Next to providing a useful perspective on innovation, the concepts of the evolutionary perspective are also used in literature to clarify policy making and innovation process. Literature suggests, that the composition of participating actors as well as the power to influence the policy content, may provide explanatory value to clarify the innovation policymaking process (Kallis and van den Bergh, 2013). The choice for this approach will be further underpinned by the literature review.

Therefore, the main question this research answers is; how does the *top sector policy energy* perform through the lens of the concepts of the evolutionary perspective; diversity of actors, diversity of technologies, selection and retention? The concepts of the evolutionary perspective are used as analytical tools to clarify the practices and choices made by actors in the innovation process.

This research firstly provides an important theoretical contribution to the field of evolutionary theory. Evolutionary theory is in need for more studies on innovation policies, to add empirical weight to the often quite abstract and theoretical discussion of evolutionary theory on innovation policy (Kallis and van den Bergh, 2013). The research helps to assess, shape and extent evolutionary theory to increase its validity to study innovation processes and enlarge its applicability to evaluate innovation policy on. Secondly, by studying the innovation process as an evolutionary process, it gains new insights on the policy instruments and how to improve its effectiveness.

The literature review (chapter 2) will address the broader research aim and give partly answers to it. It will explain different ways of evaluating policies and choose the one arguably providing the most interesting and novel insights. Thereafter, the literature review will explain the evolutionary approach as a useful approach to evaluate innovation policy on, both on the innovation policy content as well as the innovation policy process. The method section (chapter 3) describes the research design. The case of the *top sector policy energy* will be described in chapter 4. Chapter 5 then continues by analysing the empirical data with help of evolutionary concepts. Lastly, conclusions are drawn in chapter 6.

2. Literature review

This research aims to evaluate the innovation strategy of the *top sector policy energy*. This literature is going to narrow down the general research aim in a specific research question by looking at how to evaluate policy, how to define innovation and how to evaluate the innovation process.

2.1 Policy evaluation

Evaluations are formalized, systematized and sometimes research-based investigations of public activities, policies, programs and projects (Albaek, 1998). The recognition that political interventions intended to produce progress may fail, realized the need for policy evaluation. Research-based investigation is what we call evaluation, with in this research 'policy' as object of study. How can policy evaluation be conducted?

Policy evaluation as a field has developed many different approaches and methods to evaluate policies on. Dahler-Larssen (2012) explains three imaginaries that define the purpose and meaning of evaluation practices. Firstly, *performance measurements* were developed, based on modernist ideas of rationality, procedures, oversight and predictability (Owens *et al.*, 2004). Evaluation under this imaginary incorporates a technical form of thinking; 'the idea that certain areas under evaluation can be controlled, ordered, regulated or fixed through manipulation of relations between abstract components' (Dahler-Larsen, 2012 p.101). Examples are randomized experiments, or goal-oriented evaluation, often indicator-based (Crabbe and Leroy, 2008). Indicators are used to reduce the complexity and presented as 'objective' scientific tools. In doing the evaluation, the evaluator directly adopts the complexity reduction made by the policy-makers (Dahler-Larsen, 2012).

However, many criticize the idea of positivistic, e.g. objective and generalizable scientific methods, and argue that knowledge is socially constructed, meaning shaped by power, values and preferences (Latour, 1987). *Constructivist approaches* are grounded in this idea and seek to capture many perspectives of stakeholders on a certain policy programme by doing responsive and participatory evaluation (Dahler-Larsen, 2012). In contrast to performance approaches, it breaks with the conventional idea of progress, but instead promotes reflexivity in policy planning and implementation and recognises the different perspectives on the policy (Crabbe and Leroy, 2008). By reflexive modernisation, the process is meant in which the side effects of the policy are continuously reflected upon (Presskil and Torres, 1999).

Recently, the idea of rationality and control are brought back in our present day 'audit society' (Power, 1997). *Evaluation machines* are permanent standardised evaluations with abstract and generalised coverage (Dahler-Larsen, 2012). Evaluation machines use well-defined indicators and procedures to break down complex problems in manageable and measurable small parts. Evaluation in this sense gives a feeling of control. Where from reflexive modernisation the evaluation process became increasingly complex, in this approach rationality, control and predictability are brought back in standardized machine-bases evaluation approaches. Evaluation activities are planned in advance in standardized methods and directly linked to budget processes. Evaluation machines concentrate a large amount of data into data with less complexity often in terms of short statements and figures (Dahler-Larsen, 2012).

Elements of the first, performance measurements and the third, evaluation machines, can be found in how the *top sector policy energy* is evaluated by the actors in the *top sector energy*. To justify spendings and ensure budget for the next year, actors have to write annual reports as well as retrospect by filling in a standardized form, which can be seen as an evaluation machine. In this way, evaluation becomes a decontextualized activity, independently of accompanying sector structure and maturity of the technology. Next to that, technical aspects can be found in the evaluation, since evaluation happens in a goal-oriented way by using indicators. Evaluating in this way can be problematic for a few reasons. Performance approaches and evaluation machines assume that certain areas under evaluation can be controlled or fixed through the manipulation of relations between abstract components (Dahler-

Larssen, 2012). This way of evaluating is methodologically contested since impacts of the policy instrument cannot with complete reliability be measured by certain indicators (Dahler-Larsen, 2012). Next to that, the choice for indicators is taken for granted by the researcher in the technical approach. External evaluations also mostly have a technical character. Within the Ministry of Economic affairs there is a very strong tendency to use merely quantitative indicators to measure direct impact of policy instruments, clearly visible from the letter of the Minister of Economic Affairs to the Parliament (Kamp, 2012). Moreover, many evaluations on the *top sector policy energy* conducted by external organisations can be classified as performance approaches.

This research aims to provide a useful contribution to the already used evaluation methods by taking a constructivist, reflexive approach. A constructivist approach is especially suitable because the *topsector policy energy* involves many different actors from different backgrounds on all levels with divergent ideas on what innovation means, what the goals of the policy should be and how to reach them. Those actors all have a certain amount of power in the form of political power or budget to shape, push and direct the policy from their beliefs in a certain direction. Therefore, a type of evaluation that recognizes the social complexity behind the outcomes of the policy is highly relevant. Next to that, since we use a different approach to innovation than the approach mostly used in policy documents, we do not want to take the choice of indicators for granted like in performance evaluation approaches, but make them part of the evaluation and evaluate their effectiveness.

2.2 Innovation policy content (from an evolutionary perspective)

The research takes an evolutionary approach to innovation and innovation processes. Evolutionary theory emerged from systematic criticisms on neo-classical economic theory in the mid 70s (Boschma *et al.*, 2002). One of the strongest critiques on neo-classical economic theory is the assumption of rational choice, which assumes that economic agents choose the alternative with the highest economic benefits based on the assumption of full information and the perfect capacity to absorb information and adapt to it (Faber *et al.*, 2005). In addition, neo-classical economic theory assumes static economic equibilibrium, which means it does not incorporate time and assumes changes are reversible (Nelson and Winter, 1982). Also, neo-classical theory views technology as exogenous and handles it as a 'black box' (Rosenberg, 1982). As Dosi (1982) explains: 'Orthodox theory is mainly concerned with questions of instantaneous adjustments instead of problems of long-run transformation of the economic and institutional environment'.

However, transforming the energy system is typically a process of long-run transformation in which choices in the past affect possible options today. For example, choices in the design of the electricity grid can, because of practical and financial reasons, not be changed in any point in time. Therefore, it involves path-dependent processes, which are irreversible. Different alternatives have to be selected, like windmills or solar panels, but under the conditions of uncertainty and incomplete information about the technological and financial potential in the future and possible negative side effects (Faber *et al.*, 2005). While technological innovation is an important key to decrease the impact of industrial society on the environment, the understanding of sustainable innovation is still limited from a neo-classical perspective, since the outcomes of inventive activity cannot be foreseen, not even in probabilistic sense (Faber and Frenken, 2008).

For these reasons, innovation from a neo-classical economic approach is limited in its applicability to study long-term processes of change (Mulder and van den Bergh, 2001) (Clark et al, 1995). Evolutionary theory takes innovation out of the black box to acknowledge the multiple paths to possible futures (Faber and Frenken, 2008). Therefore, an evolutionary approach offers a vocabulary suitable to engage with complex dynamics and can provide refreshing perspectives on public policy (van den Bergh and Kallis, 2013).

Evolutionary theory uses metaphors from evolutionary biological theory and is best described as a theory of change and adaption (Boschma *et al.*, 2002). From biological theory, random mutations appear leading to diversity in individuals. Some fit well in the existing selection environment and therefore have a higher chance on being replicated. In evolutionary economics, routines are similar to genes in biological evolution. Evolutionary economics describes the decision making of economic agents, by the concept of bounded rationality (Boschma *et al.*, 2002). Bounded rationality implies that agents rely on routine behaviour, which means that agents use heuristics and experience to make a decision and do not have the time, access or capacity to decide based on full information (Faber *et al.*, 2005). An important result of bounded rationality is heterogeneity in economic strategies of economic agents. This translates to the central concept of diversity.

From evolutionary theory, an increase in diversity relates to an increase in fitness of the system as Fischer (1930) explained; ‘The greater the genetic variability upon which selection forces fitness may act, the greater the expected improvement in fitness’. Diversity creates fitness of the system in terms of robustness and resilience. Applied to the electricity system, diversity in sources provides greater strength in guarding against unforeseen events, which it does by reducing the impact of interruptions in any single source and by providing different options for replacement (Stirling, 1994). Also, diversity of knowledge and technological options is beneficial to increase the chance on new combinations, called recombinant innovation (Faber *et al.*, 2005) (van Rijnsoever *et al.*, 2014). Recombinant innovation creates links between industries that were previously far from each other (Zeppini and van den Bergh, 2011). Integrated or crossover research at the boundaries of traditional disciplines may lead to spill overs and recombinant innovation. In the long run, investments in recombinant innovation and diversification can be a cost-minimizing strategy, because potentially better performing technologies are able to develop (Safarzynska and van den Bergh, 2012). Subsequently, complex challenges can be addressed by the single operational strategy of diversity creation (Stirling, 2015).

Innovation represents the mechanism of diversity generation (Safarzynska and Frenken, 2012). Innovation may be incremental improvements in already existing designs, the introduction of radically different solutions and new technology systems (Freeman and Perez, 1988). Incremental innovations are improvements of existing products and processes. Radical innovation, by contrast, is the introduction of completely new products or processes. Some radical innovations created a whole new industry like television that not only introduced a whole manufacturing industry but also programming and broadcasting services and the advertising industry, which can be called system innovations.

Systematic research (R&D) is a method to increase the chance on innovations (Faber *et al.*, 2005), but is only one among several ingredients of successful innovation. Advanced science and technological research can help drive and enable innovation, but science is only one of the several ingredients of successful innovation (Stirling, 2015). Studies in Science and Technology (STS) found out that traditional ‘linear models’ that focus narrowly on generating novel technology artefacts and knowledge are no longer seen sufficient to achieve successful innovation (Williams *et al.*, 2005). This appeared from problems with unintended and undesirable consequences of technology and problems with achieving successful innovation. The latter driven by the increasing realisation that technological supply was not by itself sufficient to achieve technological advantage, let alone its application to achieve improvements in economic performance and societal well-being (Williams *et al.*, 2005). Therefore, socio-economic aspects of technologies are very relevant to research.

Diversity is narrowed down by selection, which, in evolutionary biology, is defined as the process of survival of sufficiently adapted species to a changing selection environment. Selection acts a short-term adaptive force, which reduces diversity based on the conditions of the moment (Rammel and van den Bergh, 2003). The selection environment consists of market mechanisms as well as governmental regulations and social norms. The selection process is path-dependent in the case of increasing returns (Arthur, 1989). Increasing returns lead to a process in which a choice at a certain point in time, increases the benefits to make the same choice in the future. Increasing returns are caused by scale advantages, learning-by-using, network externalities, information effects or technological complementarity. Subsequently, repeated selection can reap the benefits of increasing returns. However, it can also lead to a lock-in of a suboptimal technology by competing out potentially better alternatives on the long term (Arthur, 1989).

Choices in the balance between diversity and selection, also called diversity management, are often not made explicit (van den Berg, 2008). Once made explicit, they are usually posed as conflicting. Market mechanisms tend to focus on economic efficiency and profitability, which means incremental innovation in existing trajectories, exploiting the advantages of increasing returns by learning and scale advantages (Rammel and van den Bergh, 2003). Such a perspective, however, neglects the economic benefits of diversification in terms of recombinant innovation or spillovers between different options, which contributes to long term efficiency (van den Bergh, 2008). Moreover, when uncertainty about the future potential of a technology is high, it is better to maintain diversity, to prevent lock-in of a technology, which appears to be suboptimal in the future. Strategies to create diversity of alternative options increase the chance of moving away from large, unsustainable systems like fossil fuel car use. Innovation strategies related to the evolutionary approach thus involve portfolio investment in different alternative innovations and the creation of protected niches outside short-term market selection mechanisms.

The last mechanism in the evolutionary process is the retention of routines that are well adapted to the selection environment. Retention happens both horizontally as vertically. Horizontally, other organisations imitate 'well-performing' behaviour through learning and capacity building. In addition, vertical retention happens by the creation of spin-offs of firms with 'well-performing' routines (Faber and Frenken, 2008).

2.3 Innovation policymaking process

The concepts of the evolutionary approach are also used by further research to clarify the policy making process. One of the most important ideas on policy making is the idea of 'Muddling through', which explains why in democracies policies only change incrementally (Lindblom, 1959). Because of conflicting values and difficulties in weighing them, the policy maker will simplify the choice by choosing alternatives that only marginally differ from the current policy. This leads to a policy making process in which democracies almost entirely change their policies through incremental adjustments and the chain of successive policy steps has large influence on the next steps, called a policy chain.

From evolutionary theory this phenomenon is called political path dependency leading to a political lock-in. Hay (1999) introduces the concept of 'policy paradigms', perceived as high-level packages of ideas, which constrains policy changes to incremental steps. The high start-up costs that characterize organisations and the critical mass of communicators needed also create path dependency (Pierson, 2000). Next to that, the employment of power is self-reinforcing. Positive feedback loops can act to reinforce the trajectories favoured by the most powerful interests, and exclude others that may be more widely beneficial (Stirling, 2015). Policy-making thus is subject to the possibility of a political lock-in in a policy area where different ideas struggle for survival while power and other factors determine their success (van den Bergh and Kallis, 2013). The capacity to change public policy is much more limited than conventionally thought, but on the other hand it is not necessarily superior in some functional sense (Pierson, 2000).

A similar dynamic is observed in the innovation process. Innovation has long been described as a linear process moving from one step to another once the initial decision is made (Laredo and Mustar, 1996: 146). Recent economic and sociological findings reveal that such a linear model provides a too simplistic model of innovation (van Est, 1999). Many different actors are involved in shaping the innovation process (van de Ven *et al.*, 1999:149). Van Est (1999) derives his idea of 'innovation networks' to describe the dynamics of different actors working on innovation. 'Innovation networks' are derived from the techno-economic network theory of Callon *et al.* (1992), consisting of the political pole, the scientific pole, the technical pole and the market pole. Different types of actors involved in the innovation process are driven by different types of beliefs and speak different languages (van Est, 1999). Their perception of what the innovation activity is, therefore also differs. Engineers may perceive it as a technological development game, policy makers as a political game, with the innovation network as policy network, managers would see it as an 'institutional setting to sustain market development and fulfil consumer needs' (van Est, 1999).

Similar to the policy makers who search for incremental improvements from a certain policy chain, actors in the innovation process are subject to bounded rationality and the direction of innovative search of the involved in the innovation process is rooted in 'technological paradigms' that guide search behaviour of firms as described by Dosi (1982), 'natural trajectories' as described by Nelson and Winter (1977) or 'socio-technical regimes' described by Geels (2002). Although innovations are intrinsically uncertain, it would be incorrect to consider the process of innovation as completely random like in biological evolution processes (Faber and Frenken, 2008). Companies often limit themselves to activities in which they have experience, in which they can re-use their existing routines, leading to incremental innovation.

Both policy makers as well as actors in the innovation process are subject to respectively political or technological paradigms. However, established understandings, motivations and incentives driving the most powerful actors, do not necessarily fully prioritise wider relevant social values and interests (Wyatt, 2000). Policy is often simply stated as 'pro-innovation' – though the policy runs the risk of being captured by the most powerful actors as described by policy paradigms. Innovation policy should more explicitly and transparently acknowledge the inherently political nature of the interests and motivations driving contending possible pathways (Stirling, 2015).

The involvement of diverse actors can open up the discussion, which prevents searching in usual directions, within technological paradigms, but instead enhances innovative solutions and deliberate decision-making. By a diverse group of stakeholders, the discussion can be opened up to different perspectives on for example gas, the environmental perspective and the energy security perspective and inter-linkages between gas policies and climate change (Vasileiadou and Tuinstra, 2013). The higher the diversity of the institutional backgrounds of the actors, the more informed the decision-making is. The participation of civil society, NGO's and consumer organisations brings valuable perspectives and experience and facilitated creative and innovative solutions to complex problems (Vasileiadou, 2012). Next to within the specific projects, Rijnsoever *et al.* (2014) looked at the actor composition of a network of projects, which is relevant for the *top sector energy*. While many shared actors is beneficial for knowledge sharing (Powel *et al.*, 1996), networks with many shared actors may result in homogeneous knowledge and innovation and therefore contribute less to technological diversity (Burt, 2001).

Another argument in favour of diverse actors, is that involving them from the earliest stages of the innovation process gives confidence that the innovation pathways chosen are as appropriate as possible and less subject to powerful actors but increasingly beneficial from a societal point of view (Wilson and Willis, 2004). Although positive, negative and indirect effects are still uncertain, the motivating values and interests that lie behind a particular innovation pathway is typically much clearer (Wynne, 2002). In this way, critical appraisal of the driving forces behind alternative innovation pathways can be undertaken in early stages (Wilsdon *et al.*, 2005).

Lastly, diversity in the involved actors has impact on the retention mechanisms. Networks of broad actors including outsiders provokes more second-order learning. Second order learning enables changes in cognitive frames and underlying assumptions by extending the learning process over the borders of the specific project (Schot and Geels, 2008). To learn about what routines and technologies are desirable from normative goals like fitting a future sustainable energy system, frequent reflection is required which extends the borders of a single project. From our perspective, while evolutionary process does not say anything about the desirability of the process, learning can help to evaluate the outcomes of the evolutionary process on the basis of normative goals.

2.4 Conclusion

The literature review partly gave solutions to the general research aim: how to evaluate the *top sector policy energy*. Taking a constructivist, reflexive approach, fits the structure of the policy instrument best, in which many different actors have power to influence it as well as provide novels insights in comparison to former research and adds by looking beyond the indicators set by participating actors. The evolutionary approach, as explained above, is especially useful in clarifying the dynamics of long-term innovation processes. What should be noted is that the evolutionary approach that is used, is better be called quasi-evolutionary, since search processes are not assumed to be random and selection criteria can be changed on the base of reflection to reach a certain goal. A very relevant contribution is made by Dowding (2002) who states that evolution is an unintended process of selection, but instead, learning is an intentional process of selection. From the literature review the following research question is derived: How does the *top sector policy energy* perform through the lens of the concepts of the evolutionary perspective; diversity of technologies, selection, retention, diversity of actors and second order learning?

3. Method

The research question, refined by the literature review is: how does the *top sector policy energy* perform through the lens of the concepts of the evolutionary perspective; diversity of actors, diversity of technologies, selection and retention? To answer the research question an in-depth qualitative policy evaluation is conducted. Together with a constructivist way of evaluating, a qualitative approach is most suitable since it can grasp the many practices and underlying perspectives and opinions that exist in social reality (Creswell, 2003).

The research is conducted in collaboration with the Advisory council for science, technology and innovation, which provided access to insiders of the *top sector policy energy* and helped conducting the interviews (appendix 1). Interviewees are selected from the idea of the panel of informants, which consists of both people who are especially knowledgeable or experienced with the policy instrument and people who enrich our understanding because they view the topic from a different perspective (Weiss, 1994). The selection of interviewees provides a rich source of divergent ideas, roles and interests (see appendix 1 for an overview of the interviewees). Also, by the collection of interviewees the different parts of the governance structure of the *top sector energy* is covered (see for the governance structure of the *top sector energy* in appendix 4). By the snowball method more interviewees were selected. However, since the interests in the policy are high to some actors, we were cautious with using this method since interviewees can have the tendency to refer to those people that have the same opinion. We stopped interviewing when the generated data became saturated and little new information was added by doing another interview. This resulted in a total of eighteen interviews. The interviews are semi-structured on the basis of the core concepts of evolutionary theory explained in the former chapter; technological diversity, diversity of actors, selection and retention, although the interviewee is free to introduce other, in the perspective of the interviewee, relevant topics (example of an interview guide can be found in appendix 2).

Next to interview data, network data is provided by the Netherlands Enterprise Agency (RVO). Also, observations at relevant open meetings are conducted to enrich the data by observing real life practices. At one of the open meetings observation notes are taken which can be found in appendix 6. The observation notes were taken with the evolutionary concepts in the back of the mind of the researcher. Alongside interviews, network data and observations, annual reports, and policy documents are used to provide more information and compare the information provided by the interviews on. Results are validated by triangulation of the interview data, network data, annual reports and observation data.

The interviews are recorded and transcribed, where after a qualitative text analysis is conducted on the available data using the codes of evolutionary theory (Weiss, 1994). The network data is put in network graphs with help of the programmes Stata (Statacorp, 2015) and Ucinet (Borgatti *et al.*, 2002). A blank code is used to put in relevant themes not covered by the other codes. Firstly, from the data collected within one code observations and understandings are integrated, called local integration. Secondly, inclusive integration knits the different areas of analysis into a single coherent story answering the research question (Weiss, 1994).

4. Top sector policy energy

The *top sector policy energy* is one of the innovation policy instruments in the field of energy in the Netherlands and subject of analysis in this research. The *top sector policy* emerged as a successor from the 'key area policy' of Balkenende II. The 'key area policy' was aimed at strengthening the innovation capacity of the Netherlands in order to belong to the top five internationally in the fields of higher education, research and innovation (Scheepbouwer, 2009). Initially, the Innovation Platform identified four areas: Flowers and Food, High tech systems and Materials, Water and the Creative Industry. The energy sector was not yet defined as a key area, since the market was arguably not developed enough (van Tilburg and Bekkers, 2004). In 2010, the Innovation Platform was considering to put Sustainable Energy forward as a 'growth area and key theme'. Figure 1 shows the investment in general innovation policy (green line), specific innovation policy (blue line) and total spending (black line) in million euros over the years. Where during the 'key area policy' relatively a large amount of money was directly invested in the 'key areas', when the *top sector policy* came into place in 2010, the direct subsidies were argued to be too costly and ineffective and were almost completely abandoned.

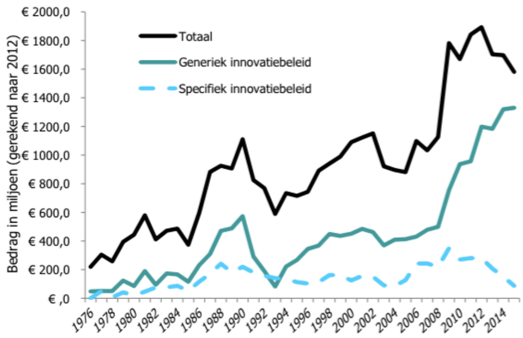

Figure 1: General and specific innovation policy over the years (VNO-NCW/MKB. 2013)

The top sectors were selected by their proven strengths and competitive advantages of the Dutch economy. The nine sectors are strongly innovative, shown by the fact that more than 95% of the private R&D investment is in these sectors in the Netherlands (VNO-NCW/MKB, 2013). Nine sectors are selected: Agri & Food, Horticulture and propagation materials, High Tech Systems and Materials, Water, Chemistry, Energy, Life Sciences and Health, Logistics and the Creative Industry. The goal of the *top sector policy* is 'to strengthen the innovative capacity of the Dutch economy' with three subgoals; 1) to belong to the top five knowledge economies of the world in 2020, 2) to spend 2,5% of the GDP on R&D and 3) to spend 500 milion euros on the Top consortia for Knowledge and Innovation (TKIs) with 40% invested by the private sector.

From the establishment of the *top sector policy*, the financial resources from the FES (fund to strengthen the economic structure) were eliminated and the financing of existing research institutes and programmes decreased. Instead, the government chose for general fiscal innovation policy like the WBSO (Wet Bevordering Speur en Ontwikkelingswerk), the RDA (Research Development Aftrek) and the 'Innovatiebox'. For SMEs (small and medium entreprises) specifically, the fund 'Innovatiefonds MKB' provides loans and venture capital. Next to these general innovation-stimulating instruments, the *top sector policy* has some specific innovation stimulating instruments, available within the top sectors. The TKIs who organise public-private partnerships in the field of research and innovation get 25% of the total amount of invested money in the public-private partnerships (pps) added by the government to the TKI budget (40% for small companies over the first 40,000 euros). The available amount of money for this instrument increased last years and is 200 million euros from 2014 on (AWTI, 2014). Overall, evidence shows that the total budget for innovation policy decreased since the implementation of the *top sector policy* (AWTI, 2014) (VNO-NCW/MKB, 2013) (Rathenau, 2015).

In addition to these innovation stimulating instruments, the Netherlands Organisation for Scientific Research (NWO), the Royal Netherlands Academy of Arts and Sciences (KNAW) and a federation of six Dutch research organisations for applied research (TO2 institutes) have to direct part of their budget to research in the top sectors. The innovation contracts describe how much money is invested by the knowledge institutes as well as the private sector distributed over sectors and topics. The research agendas are set by a close collaboration of the private sector, knowledge institutes and the government. NWO as well as the TO2 institutes adapt their agendas to the agenda of the top sectors. The contracts together encompass a contribution of 1.8 billion euros of the private sector with 1 billion euros of the knowledge institutes to be invested in innovation in the top sectors (AWTI, 2014).

The *top sector energy*, one of the nine top sectors, was established in 2011 when the first top team was formed and published a vision on the strengths and barriers of the energy sector (van der Veer *et al.*, 2011). At the time, the *top sector policy* was private sector policy with the aim to exploit economic opportunities, within the context of energy policy, consisting of goals like CO_2 reduction, renewable energy production and energy reduction. The overall goal, which did not change over the years, is to realize a transition towards a more sustainable and CO_2 poor sector and at the same time transform it to a structurally higher income potential (van der Veer *et al.*, 2011) (Topsector energie, 2013). The role of innovation is argued to make renewable energy technologies more competitive, make the use of fossil fuels more efficient and save energy (van der Veer *et al.*, 2011).

The *top sector energy* consists of seven TKIs: Offshore Wind, Gas, Smart Grids, Solar Energy, Energy saving for the build environment (EnerGO), the Biobased Economy and Energy Saving in the Industry (ISPT). The TKIs Solar Energy, Smart Grids and EnerGO are in the process of merging to one TKI called Urban Energy. Their agendas are already merged to one, but the formal merge will be around January 2016 (interview 6). There are two crossing themes: the programme System Integration and the programme STEM (collaboration of the *top sector energy* and society). The first one is established to develop technologies that enable integration of the energy system and the latter to do research on the societal aspects of renewable energy technologies.

Appendix 4 shows an overview of the governance structure of the *top sector energy*. The daily management of the *top sector energy* is in the hands of the top team, which is supported by the management team (regieteam). The top team consists of someone from the government, someone from a knowledge institute, someone from the private sector and a chairman (boegbeeld). The control team consists of 'movers and shakers' (interview 1, 18) from the sector who are distributed over the different TKIs in advisory and evaluation teams (AET) to monitor them and provide feedback to the top team. From this feedback, the top team makes the decisions on the portfolio of energy themes and programs (Topsector energie, 2013).

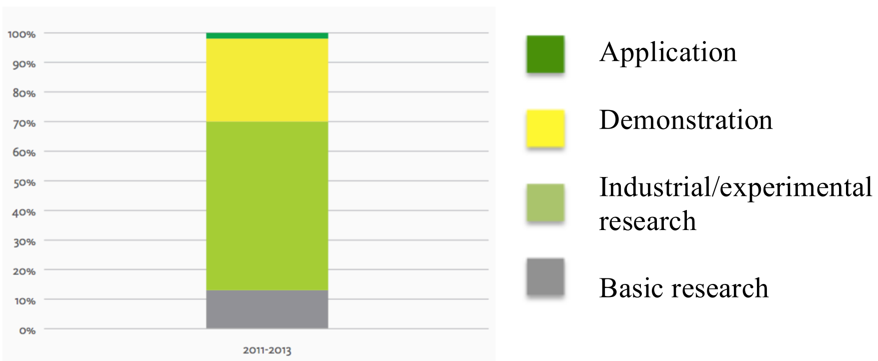

figure 2: allocation of financial resources of the top sector energy over the different phases of the innovation process (ECN, 2014)

Like in the general *top sector policy*, the TKIs of the *top sector energy* gain TKI addition, which they can distribute over self-chosen topics. Also, NWO contributes to basic research in the *top sector energy* and ECN and TNO contribute to the industrial and experimental research in the *top sector energy* (Topsector energie 2013). The *top sector energy* is a special top sector, since it also receives innovation resources from the Ministry of Economic Affairs (further called EZ innovation resources) that are distributed by the top team. Separate from the control of the top team, the projects within the *top sector energy* can apply for financial resources from the energy agreement[2]; the subsidy scheme called Demonstration Energy Innovation (DEI), and financial resources from the Stimulation Energy Production scheme (SDE+), which have to be used to increase the cost efficiency of a technology to save costs of renewable energy production in the long run.

Figure 2 shows the distribution of the financial resources over the different innovation phases in percentage of the total over 2011-2013, which shows that most of the resources are directed to the industrial/experimental innovation phase. Figure 3 shows the distribution of the different financial resources over the TKIs in million euros over 2011-2013. One can see from the figure that private sector investment and investment from the government are well aligned within the TKIs. This is the result of the obligation for projects within the TKIs to have 40% financial contribution of the private sector. As one can also notice, the difference is big between the amount of funding the different TKIs receive.

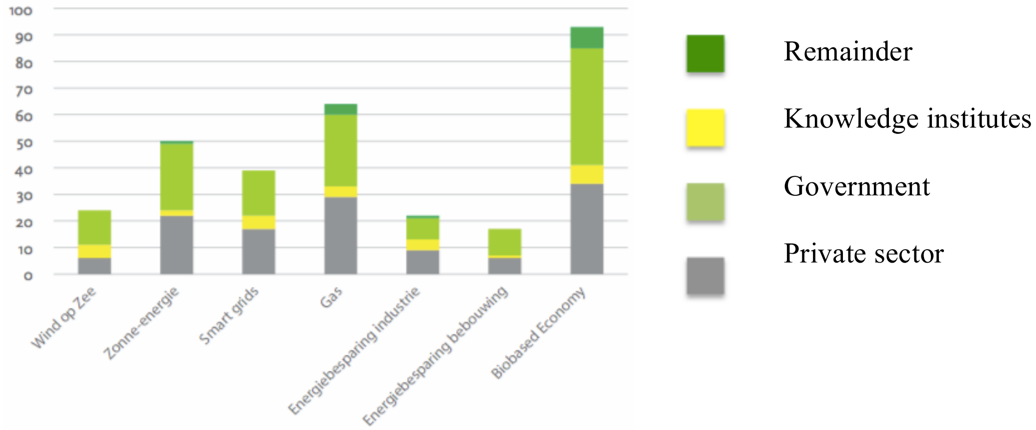

figure 3: Distribution of the financial resources over the TKIs from left to right; Offshore Wind, Solar Energy, Smart Grids, Gas, Energy Saving in the Industry, EnerGO and the Bio-based Economy (Hekkenberg and Verdonk, 2014)

5. Analysis

The analysis part is structured on the base of the concepts of evolutionary theory: technological diversity, innovation, selection and retention. Following from the constructivist evaluation method, the analysis provides different perspectives and practices on the concepts. The analysis of the available data is conducted on two levels. The first level analysis looks at the concepts of evolutionary theory within the *top sector policy energy*. On the second level, the impact of the *top sector policy energy* on the outside energy innovation system is analysed.

5.1 First level analysis

5.1.1 Technological diversity

The creation of diversity as a policy goal in itself is not referred to by any interviewee of the high level governance[3]. Creating focus, which can be defined as the opposite of diversity, is argued to be very important (interviewee 3, 4, 5, 9, 18). Interviewee 3 explains that focus is important to accelerate the energy transition and to reach the goals of the energy agreement. Therefore, there is a drive to incorporate fewer topics than there are now. Interviewee 5 explains: ‘Motivated by policy, the driver is to decrease the amount of topics’. Moreover, interviewees give the spread of financial resources as an important motive to not have many technological options. Making a ‘difference’ on the chosen topic is

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[2] Information about the energy agreement can be found in appendix 3.

[3] A definition of what is meant by the high level governance can be found in appendix 4

not possible when there is not enough focus on some topics, because resources will be spread too much (interviewee 4, 5, 9). By focusing on fewer topics, relatively more 'mass' can be created per topic which is seen as important to really reach something in the world (interviewee 4). For these reasons, tightening the portfolio is the predominant motto in the highest level of the top sector. For example, the TKI offshore wind proposed the topic tidal energy, but this topic was rejected by the top team because it is yet another option and there are enough options already (interviewee 5). On the question, where would you spend it on when you would be able to spend another 100 million euros, interviewee 4 answered: 'I would not go any broader'.

While the highest level of the top sector all agree on the policy goals focus and mass, others have different perspectives on it. Interviewee 12, when referring to a report of the Netherlands Environmental Assessment Agency (PBL), claims: 'We need everything; nuclear energy, offshore wind, more efficient use of geothermal energy, sweet-salt power plants'. Interviewee 13 confirms this by stating that it is maybe not the most efficient, but it is effective to bet on several horses. It is feasible, but it is a political choice interviewee 12 explains. He[4] argues that once the Netherlands chose to invest in natural gas and now there are legitimate reasons to invest in all possible sustainable options, which he considers himself a very controversial answer in comparison to the conventional line of thinking. As a solution to reach this, he proposes to invest in innovation in a sustainable direction, but to not predefine to what options, since otherwise some options will fall between two stools (interviewee 17). Interviewee 15 has a similar idea by proposing not to choose for specific options, but to set a goal, for instance the energy neutral city, and give all sorts of initiatives a chance to apply for funding. In addition, interviewee 12 proposes that the government could take responsibility for these options, that the private sector is not interested (yet). The exact gaps cannot be identified according to interviewee 12, since he describes it as looking for the 'unknown unknowns'. However, the reason for the top sector to not fill the gaps is that the *top sector policy* is 'no energy policy', but it is about earning money, which is shown by the budget overview of the Ministry of Economic affairs, which does not show a contribution to societal challenges (interviewee 1).

Within the TKIs, the different financial resources are distributed over the programme lines. In the case of the EZ innovation resources, the top team decides how to distribute it and on what programme lines of the TKI. The TKI is allowed to propose new topics, but the top team will make a final decision (interviewee 3). In the case of TKI addition, the TKI can decide itself how to distribute it over the programme lines or even add more topics. From the available numbers on spending and interviews, one can determine different views by actors powerful to shape the policy instrument on the creation of technological diversity than earlier seen in the high level governance of the *top sector energy*.

The TKI Urban Energy acts from the idea that all technological options of the decentralized energy system should be able to receive support (interviewee 6). Before the merge some technologies did not logically belong to one of the three TKIs, which is solved by merging. The interviewee explains: 'The most important thing is that the five programme lines cover the whole width'. As examples he gives a battery to charge solar power on and PV systems combining power generation with heat (PVT). The TKI ISPT also has a future energy system in mind by saying: 'In working towards a circular economy the aim is not to reduce on fossil fuel use, but to transform the process to one based on electricity instead' (TKI ISPT, 2015). Another example of the creation of technological diversity is the programme system integration which is explicitly set up to broaden the range of options stimulated by the *top sector energy*, but not merely for the goal of diversity creation, but for the creation of a reliable energy system in the future (TKI System Integration, 2014). It is interesting that, while focus and mass are clearly the most important policy goals of the high level governance, they did agree on having this new programme system integration. Another reason given to invest in different options is the suitability of different technological options in different applications (interviewee 8). Although interviewee 8 argues no use of gas would be the best option, not in all applications this is possible, for example in historical city centres. Therefore, investment in the development of green gas is important to fulfil this function. The same goes for heavy transport. Electrical engines or fuel cells are suitable

[4] To all interviewees we refer as 'he'

for person transport, but for heavy transport like ships and trucks, LNG should still be seen as an important alternative and therefore be part of the range of technological options stimulated in the *top sector policy energy* (interviewee 8).

From data on how the different financial resources are spent within the TKI and from interviews, one can determine differences in opinions between the high level governance and the TKIs. Two examples are Carbon Capture and Storage (CCS) and upstream gas. Figure 4 shows data from the annual report of the TKI Gas about the distribution of financial resources within the TKI. Note that the column 'top team budget' is the reserved budget from the top team and the column TKI addition spending, is the final spending of the TKI addition. As can be noted from these numbers, there are different opinions on where to invest. For example, the top team does not want to invest in Carbon Capture and Storage (CCS), since the carbon price is not high enough (interviewee 8), there are historical problems with the societal acceptation of it (interviewee 8) and there are not many new businesses in it (interviewee 1). However, the TKI Gas does argue CCS 'belongs to their portfolio' (interviewee 8). Therefore, the TKI Gas decided to spend TKI addition on this topic. The same goes for the topic of upstream gas. While from the top team's vision this topic is disputable (interviewee 1), the TKI Gas itself invests a relatively high amount (compared to the TKI addition spending on other programme lines), 0,9M€ on this topic (figure 4).

programme line	Top team budget	number of appliances	accepted appliances	TKI addition spending	number of projects
upstream gas	0,8 M€	7	6	0,9 M€	10
small scale LNG	1,4 M€	15	6	0,4 M€	2
Green Gas	13,4 M€	47	10	0	0
System intergration	2,8 M€	18	11	0	0
CCUS	0	0	0	0,7 M€	unknown
CSER	0	0	0	0,2 M€	unknown

figure 4: distribution of the financial resources within the TKI Gas (TKI Gas, 2014)

5.1.2 Innovation

The way the process of innovation is organised has large impact on the outcomes of innovation, products, processes or technologies. We define this concept as the character of the inflow of new knowledge and innovation which has its impact on technological diversity. From the literature review, we can characterise innovation by looking at opportunities for recombination, the integration of social aspects, the nature of innovation in terms of incremental and radical innovation and the distribution of resources over de different innovation stages.

Integrated and cross-over research

Many topics transcend the boundaries of one TKI or one top sector. Therefore, crossovers can be made between TKIs or top sectors to work on these topics. The TKI Urban Energy determines many possible crossovers with other top sectors and TKIs (TKI Urban Energy, 2015). It is unclear to what extent the crossovers are already working out. The TKI Gas is working on cross overs with the TKI maritime on the use of LNG in ships, with the top sector Agro and Food on CO_2 use for fertilization, with the top sector Water on sustainable use of the North Sea and with the TKI offshore wind on how to organise activities on the North Sea (interviewee 8). The collaborations of the TKI gas are argued to work well but are still on an early stage (interviewee 8). Next to that, the TKI offshore wind is working together with the programme system integration, the TKI maritime on tidal energy to share knowledge and infrastructure and on ships to transport the wind mills with (TKI Offshore Wind, 2013). From these examples, one can conclude that TKIs are active in finding relevant crossovers.

However, people struggle with where to place certain topics when they do not logically belong to one TKI or top sector and next to that, how to organise it administrative and financially. An example is in the TKI bio based economy, which is funded by both the *top sector energy* and the top sector chemistry (TKI Bio-based Economy, 2014). However, the *top sector energy* is struggling with how much money to invest in it, since only a small part of the material chain, the low quality materials, is used to burn and generate energy from. Another issue occurs in the collaboration between the top sector chemistry and the TKI Urban Energy on the topic solar PV. This topic is covered at both organisations. The interviewee recognizes a high potential in increasing the efficiency of a solar panel when combining the two technologies, which are each based in a different TKI, since both technologies are near their physical efficiency ceiling (interviewee 6), we defined this as the benefits of recombination in the literature review. He views the spread of the topic over the two top sectors as an obstruction to organise the crossover (interviewee 6). He explains this obstruction by the different pots of money available and the 'decision tree' behind each pot. An example of such a decision tree is the TKI addition, which is generated by investment of certain companies in certain projects and therefore those companies want to be able to say something about the destination of this money. Interviewee 6 describes the problem by saying: 'When you both put a million euros in a fund, then who is going to decide what to do with it'.

Social aspects

Within the *top sector energy*, social issues related to new energy technologies are financed through the STEM scheme, which is a separate scheme financially. The STEM scheme receives 1,5M€, which is relative to the TKIs (aprox. 20 M€) a small amount. One of the reasons to make it a separate scheme, instead of a programme line is according to one interviewee because within the portfolio management framework used by the top sector energy, each program line should contribute to the policy goals such as CO_2 reduction and employment. Social issues are therefore not a separate program line, but should be an integral part of each program line (interviewee 5). Interviewee 5 explains that TKIs can integrate social aspects in their program and use the fund related to the STEM program (interviewee 5). However, the same interviewee acknowledges that this does not happen: 'It creates two separate worlds, the TKIs about technological innovation and everything social at STEM, but that is not how it is intended'. Interviewee 10 confirms this by stating:' Within the TKIs the engineers want to create solutions by only wearing their technical glasses'. This is also shown by observing the public consultation of the Knowledge and Innovation Agenda of the TKI Urban Energy (TKI Urban Energy, 2015). The chairman leading the meeting told the attendees that social aspects cannot be researched within the TKI, since it should be done within the STEM programme. Interviewee 5 views this as a problem, since he thinks technological and social innovation belong together, but he struggles with how to organise it. This is confirmed by interviewee 10 who tries to integrate the social aspects more in the TKI programmes, but finds out that TKIs do not know themselves which questions on the border between technological and social innovation are relevant to research.

Because the STEM programme is a separate programme, this may result in a situation in which social aspects are not integrated in the innovation process from an early stage, but left to the moment when the product is fully developed and problems with societal acceptation appear (interviewee 10). Some statements confirm this signal: interviewee 8 frames it as 'which societal deals to make to deal with societal support', interviewee 3 frames it as 'we need to convince people that they want it', the annual report of the TKI Gas frames it as 'it should deal with the question of acceptation of broad energy developments'. Some actors do not agree on working on societal aspects in a late phase of the innovation process (interviewee 10, 11, 13). Interviewee 10 states: 'It is often framed as acceptation, while it all starts much earlier. It is important from the very first beginning to get to know the consumer very well, or involve the consumer, until the consumer really wants to have it.' Interviewee 11 agrees on this by explaining that innovation projects should integrate aspects of the final consumer environment. Consumers should be part of the project (interviewee 11).

Nature of innovation

When looking at the character on innovation in a sense of radical versus incremental, many emphasize cost reduction as a goal for technological innovation. Innovation in this sense is merely seen as increasing the efficiency of the technology, which can be defined as incremental innovation, aimed at increasing financial feasibility. While solar panels currently have an efficiency of 20%, an increase to 30% or 40% will make the solar panels half as expensive, since more energy can be generated from the same square meter (interviewee 6). Also in observing the public consultation of the TKI Urban Energy, cost reduction is a very important theme to many present stakeholders (appendix 6). In addition, in the TKI offshore wind there is a tendency to take an incremental path towards bigger windmills and cost reduction (interviewee 7) (TKI Offshore Wind, 2013). Interviewee 17 observes that the top sector starts from the current situation and from there, defines steps. The energy agreement strengthens the focus on short-term solutions (interviewee 17). This incremental way of thinking may be explained by the private sector demand-driven approach in the *top sector energy*. The Ministry of Economic Affairs leaves the innovation portfolio to the market, from a deeply rooted fear to choose wrongly (interviewee 4). The current private sector can increase their competitive position by increasing the performance of the already existing technology, which can be called incremental innovation.

Some criticize the emphasis on incremental innovation. Interviewee 17 thinks from a long-term perspective the *top sector energy* should already start with developing innovation for 2050 to apply those technologies that still have to be developed (interviewee 17). He aims for a greater emphasis on radical innovation by referring to a citation of Henry Ford saying 'If I would have asked people what they wanted, they would have said faster horses.' When only optimising the current and not investing in diverse innovative pathways, the trajectory between 2030 and 2050 can become very costly (interviewee 17). When you leave this to the private sector, nothing will happen (interviewee 17). Interviewee 12 agrees by stating that optimising the current is not enough to reach climate goals as they are formulated now. However, interviewee 17 recognizes this is a very tedious realisation, that you cannot solve everything from profit making and the creation of employment. Interviewee 14, scholar in the field of socio-technical transitions has a more nuanced position by explaining that incremental innovation can lead to a transition, but you will only know when looking backwards. He gives a more important role to re-combination, since a transition is often a re-combination of existing elements.

Distribution of resources

Opinions on the distribution of financial resources over the different innovation stages differ. Some argue that the last innovation stage is strongly represented in budgets, which is partly due to the energy agreement (interviewee 2). While the interviewee recognizes a need for basic research to work on innovation on a longer term, he does not see a role for the top sector in it, since *top sector policy* is private sector demand driven. Another interviewee is worried about the relative amount spent on basic research and cautiously mentions that he struggles with this question (interviewee 4). In contrary, interviewee 9 thinks that the resources for basic research have been stable, while a lot of savings are on the middle range of innovation chain, meaning everything in between basic research and demonstration. Interviewee 4 agrees on this and observes that the appliance for the EZ innovation fund always largely exceeds the available budget.

5.1.3 Selection

After exploring how actors deal with technological diversity and how the innovation process is organised, this part of the analysis is about how selection is made among the different topics. Many different views exist on it, from different rationales and on different levels of the governance structure. The selection process mainly takes place at the highest level of the top sector. The persons in the portfolio team, the top team and the secretary have differing ideas on how to select. From the available interview data and policy documents, one can observe that there is a very strong emphasis on organising the selection process on the basis of indicators, or key performance indicators (KPI).

Two main goals can be identified from the interviewees and policy documents, which are used to create indicators from. The first one is strengthening the Dutch economy by innovation and the second is the goal to contribute to a more sustainable energy system (interviewee 3, 5, 9). Interviewee 18 even states that the goals of the energy agreement are leading. The goals are translated in measurable indicators. CO_2 reduction is an important prerequisite according to many interviewees, where after within what is left the choice is made on the basis of the strengths in both industry and knowledge institutes in the Netherlands (interviewee 1, 2, 5). 'The *top sector policy* does not look at the solution in the future but looks at where are we good at and strengthens that (interviewee 5, 17).' One interviewee measures the strengths of the Netherlands by looking at the performance of the innovation system, a concept developed by prof. dr. Hekkert (interviewee 5). Employment is another important indicator (interviewee 18). The programme lines are directly linked to the indicator, for instance this programme line contributes this to CO_2 reduction (interviewee 5).

But how do you know the employment contribution of solar panels in ten years? The contribution to the different goals should be made plausible (interviewee 18), since it is 'no rocket science' (interviewee 2, 4, 5). To make contribute to the goals, the TKI should be able to set up successful projects. Private sector investment is a prerequisite to receive funding for the projects in the *top sector policy* (interviewee 4, 9). Underutilisation of budgets could be a signal that there is not enough private sector interest in the programme line. Subsequently, the chance that the technology is interesting to invest in is used as a way to make plausible that the goals can be reached (interviewee 2). Some research areas are not represented because the industry is not interested yet (interviewee 10). For example in CCS there is no business case yet and it therefore not represented (interviewee 1). Therefore, it is not supported within the *top sector energy* (interviewee 4). According to interviewee 5 especially the management team often looks at market opportunities, since a large proportion is, or has been working for a company in the Netherlands. Interviewee 9 even states that the policy is purely based on supporting the private sector and that nothing else matters substantially.

The indicators however, are sometimes conflicting meaning choices have to be made and indicators have to be weighted. One interviewee explains that four sections are made; with up right meaning it contributes to both goals and bottom left meaning it does not contribute to both goals. The discussion is about the two other quadrants (interviewee 4). On that basis, the resources are distributed according to interviewee 4. The discussion takes place along the secretaries and the top team on the basis of the different indicators (interviewee 18). They examine whether the amount of money asked for by the TKI is 'defendable' (interviewee 18).

While there is a strong emphasis on measuring effects and using indicators in the *top sector energy*, not all topics directly fit the indicators set by the people in the high level governance. Examples are the programme line upstream gas, the TKI smart grids and programme lines of energy reduction. In the interviews, the interviewees explain why these topics, although not fitting the indicators, are still selected. The TKI Gas experiences uncertainty of its existence. Every year the top team decides whether the TKI can continue their work (interviewee 8). To some, the gas sector is still important to support to do the things the sector itself will not take on, like the transition to green gas. Another reason is the reliability of the energy source as a back up to the more fickle renewable energy sources. Others provide historic reasons like the origins of the *top sector policy* as private sector policy aimed at increasing the competitive strength of the industry, which changed in a sustainable direction (interviewee 1). He thinks however, it is questionable whether the private sector related to fossil fuels should still be supported (interviewee 1). In the case of energy reduction, CO_2 reduction is not a practical indicator; therefore joules are used to quantify it. The topic of smart grids is another disputable topic, which does not pass the indicator test. Interviewees have 'the feeling' it is an important topic to connect everything in the future (interviewee 5, 7). This is made quantifiable by estimating the avoided costs of strengthening the electricity grid (interviewee 18). The same problems appear with the programme system integration, which even decreases efficiency, since it for example transforms electricity to hydrogen and hydrogen again to electricity, which even costs energy and therefore does not fulfil the goal of energy efficiency (interviewee 5). The rationale behind it is the reliability of the energy system and the system balance (interviewee 5). However, this is not an official goal of the *top sector policy*.

5.1.4 Retention

Retention is defined as the spread of knowledge and well-performing practices that lead to imitation (horizontally) and spin-offs (vertically). Within the TKIs retention happens by publishing scientific articles and by patenting (TKI Solar Energy, 2014) (TKI EnerGO, 2014) (TKI ISPT, 2015) (interviewee 9). Next to via the knowledge institutes, the TKI itself spreads knowledge by news articles on the website about results of projects, by emails and meetings (interviewee 5, 7, 8) (TKI

Solar Energy, 2014) (TKI EnerGO, 2014) (TKI Gas, 2014) (TKI ISPT, 2015). Some TKIs organise meetings to share information within the TKI (TKI Urban Energy, 2015) (TKI Offshore Wind, 2014). Interviewee 7 explains that to reduce the workload for companies, companies provide just once a year on a marginal scale information on the progress of the projects.

Learning processes along the different TKIs is slightly harder to organise according to interviewee 5. Organising meetings for all TKIs only happens occasionally since the people working on the technologies do not see many relations between them (interviewee 5). Interviewee 9 states that this actually never happens. The merge of the three TKIs on a decentralised level results in a fluent knowledge flow between the three topics. However, along the technologies on a larger scale, the TKIs offshore wind, gas and ISPT knowledge exchange is much harder (interviewee 5). This can be explained by the difference in energy markets and technologies needed to sustain their part of the energy system (interviewee 5).

Social aspects of the technologies could be a topic to discuss with all TKIs, since it is relevant to all technologies, but interviewee 5 explains that the people in the TKIs 'speak a different language' which makes it hard to discuss social aspects (interviewee 5).

The STEM projects could provide interesting research results to the TKIs about the implementation of technologies. To make use of this potential, one of the prerequisites of the projects within STEM is a shared actor with a TKI. However, it is the responsibility of the project itself to share the learning experiences. A disadvantage of this way of organising learning processes, is that people working on heat pumps will share knowledge within their own world of heat pumps, while the same knowledge could be interesting for the acceptance and installation of solar panels (interviewee 10). There is not much space for the people working on STEM to invest in sharing results and knowledge. While firstly slightly more full time employees (fte) were devoted to organise STEM, currently there is a tendency to cut hours, which has a direct effect on the ability to spend time on organising knowledge sharing activities (interviewee 10).

While learning plays a role especially within the TKIs, it is unclear whether reproduction takes place of well-performing innovations and practices.

5.1.5 Diversity of Actors

From theory, it seems that the composition of a group of actors can have an important impact on the innovation process as well as on the selection mechanism. Different groups of actors exist in the *top sector energy*; the top team, the management team, the TKI boards and the TKI participants.

The Minister of Economic Affairs formally appoints the top team. Appointing people to other positions like the board of the TKIs and the management team, seems to happen by looking in the network of the already involved actors. The boards of the TKIs are according to interviewee 10 also formed by personal contacts with people in their networks who are hired as a consultant. Also, when there is a vacancy in the management team, new people are found by looking in the network of the already involved people (interviewee 3). The top team consists of a representative from the government, a representative of the industry, a representative of the knowledge institutes and a representative of the SMEs (Topsector energie, 2013). The management team consists of representatives of the energy sector, so-called ambassadors (interviewee 1). They are described as 'movers and shakers', people that can make a difference (interviewee 1, 18). People should be able to bring in expertise on the specific technologies or on the knowledge or industrial sector and should have the capacity to help reaching the goals set. Tjerk Wagenaar[5] is mentioned as the one that can give a completely different perspective on issues (interviewee 18). Although this could be helpful, maybe one person with a completely different perspective is too little to substantially influence the process (interviewee 14).

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[5] Tjerk Wagenaar is director of the NGO 'Nature and the Environment'

The Ministry of Infrastructure and the Environment is not involved (interviewee 9, 12, 17). According to interviewee 9, this shows that CO_2 reduction is not as important as many actors argue it is. Currently, the Ministry of Infrastructure and the Environment does not have the human and financial resources to invest in it, relatively to the impact they think they can have (interviewee 12). That the Ministry of Infrastructure and Environment is not involved is a sign that the societal goal is not the primary goal (interviewee 12). This is part of a larger problem that climate is an overall issue not belonging to a certain sector, which is the reason that the Ministry of Infrastructure and the Environment always considers where to put effort in (interviewee 17). Within the Ministry of Economic affairs, diverging interests can be recognized according to interviewee 4.

The boards of the TKIs all consist of representatives from the industry and from the knowledge institutes (interviewee 6, 8). For example the board of the TKI Gas consists of people from the current gas sector and the knowledge institutes. Also, the board of the TKI Urban Energy consists of people from both knowledge institutes and the private sector. The TKI boards are responsible for building up the eco-system. Appendix 5 shows the network graphs of the TKIs. The nodes represent the actors that are coloured by type of organisation or by the first year of participating in the TKI. The graphs of the TKI Offshore Wind and the TKI Gas also consist of one graph including the programme line the actor is participating in. Appendix 5 also shows a table with some basic network characteristics of the different TKIs.

First of all, the diversity of actors, distinguished in large companies, SMEs, NGOs, governments and knowledge institutes is limited. The emphasis is very much on companies, while NGOs and governments only encompass a few per cents of the total amount of actors. A systems thinking seems to increase the diversity of actors in the TKI. The annual report of the TKI Energo of 2013 explicitly placed different technological options in a future energy system and describes that having such a vision works very inspiring to involve companies in different projects (TKI EnerGO, 2014), which is confirmed by the relatively large proportion of NGOs and governmental organisations in the network data (appendix 5). Also, the TKI Smart Grids (confirmed by interviewee 5), System Integration and STEM show a relatively higher proportion of NGOs (appendix 5). The STEM programme recognizes a whole new range of actors participating (interviewee 10). According to the interviewee, those are companies that were never involved in governmental subsidy projects (interviewee 10). One TKI explicitly mentions attracting diverse actors in the innovation process as a goal. The TKI states: ‘Broad involvement of stakeholders is, because of the scope and diversity of the sector, a serious challenge. Although, this involvement is very relevant for the innovation process and the translation of innovations to applications.’ (TKI Urban Energy, 2015)

As explained in the literature review, when there are many shared actors along projects, also called redundant links, this provides trust and creates knowledge sharing, but may be a sign that the projects to not contribute much to technological diversity. The reasoning behind it is that the same actors can use their knowledge in many projects, which means the projects do not differ much from each other. The table in appendix 5 shows one network characteristic calculating the division between the number of links and the number of nodes, meaning on average, in how many projects each actor is participating. The TKI Solar Energy has a relatively high number (2,47), while other TKIs show a smaller number; the TKI Gas (1,6), the TKI Smart Grids (1,6) the programme System Integration (1,48), the TKI Offshore Wind (1,67) and the STEM programme (1,05). The relatively low numbers can partly be explained by the not fully connected network of the TKI Offshore Wind and the TKI Gas. The dense network of the TKI Solar Energy may be a risk for technological diversity creation. The TKIs with a broader topic than just one technology, like the TKI Smart Grids and the programme System Integration show less redundant links, which would imply they have a positive impact on technological diversity.

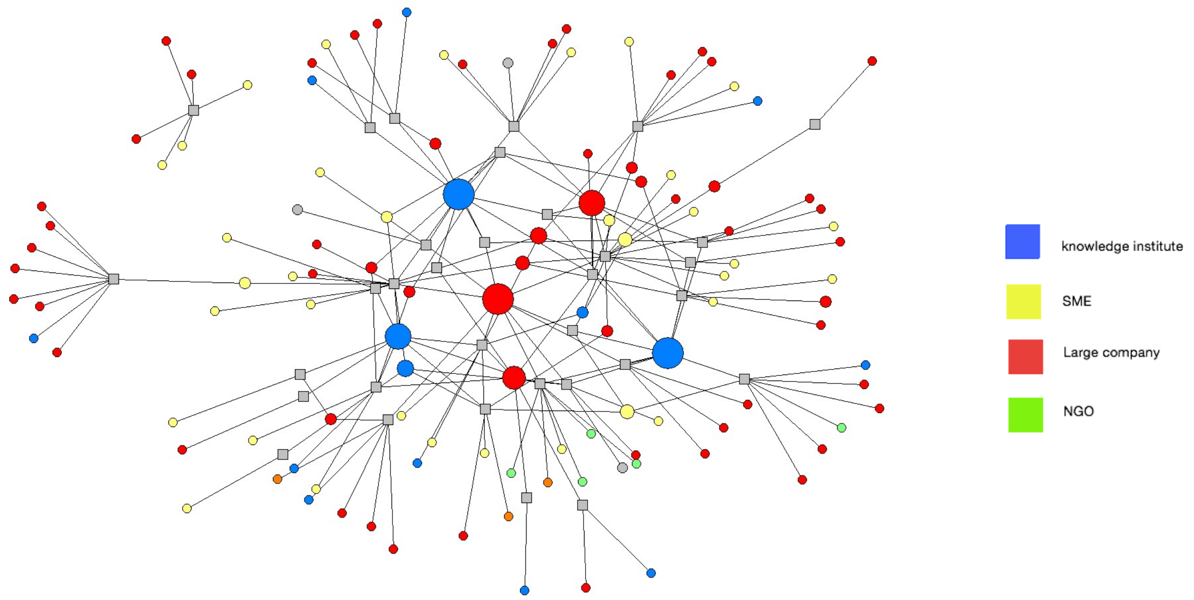

Figure 5: Network graph of the TKI smart grids with data of 2012, 2013 and 2014. Size of the node proportional to the degree (number of projects the actor participates in)

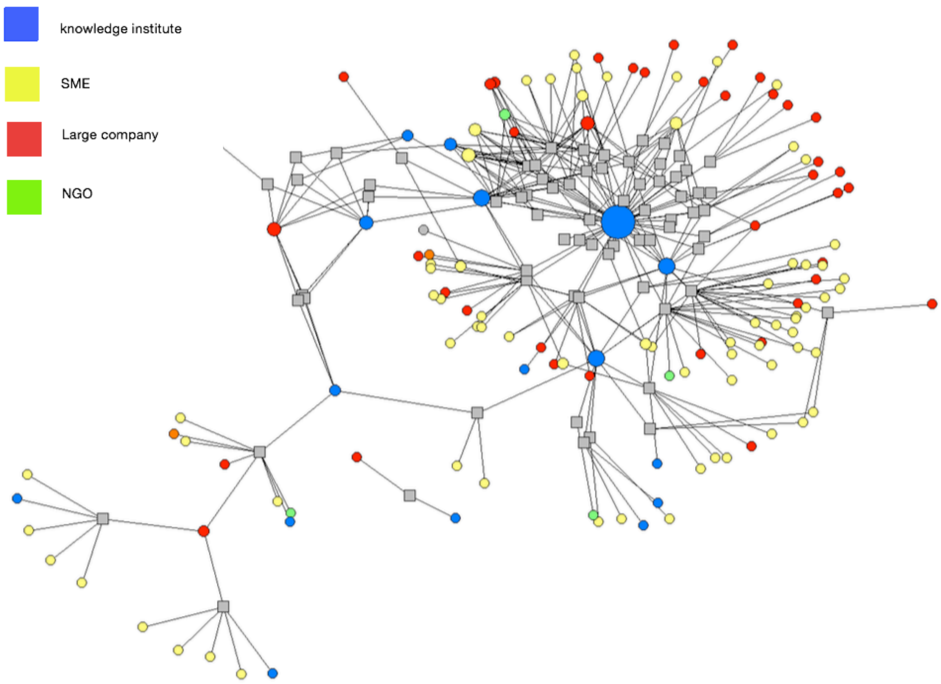

Figure 6: Network graph of the TKI solar energy with data of 2012, 2013 and 2014. Size of the node proportional to the degree (number of projects the actor participates in)

The network graph of the TKI Gas as well as the network graph of the TKI Offshore wind is not fully connected. To show how the different programme lines are embedded in the network, we created network graphs with the shape of the node representing the programme line the actors is participating in. One can recognize the concept of technological relatedness from the network graph of the TKI Gas, which shows that the vested companies on natural gas diversify towards the related technology of small-scale LNG, which uses the same natural resource (figure 5). The graph also shows that actors working on fossil fuel projects (upstream gas and LNG) are different from companies working on green gas technologies. And many companies working on green gas are not connected to the rest of the network. However, some actors, active in both fossil fuel related technologies and green gas, create connections between them. These actors allow knowledge sharing over the borders of the two technological fields, which may be beneficial for retention mechanisms to occur.

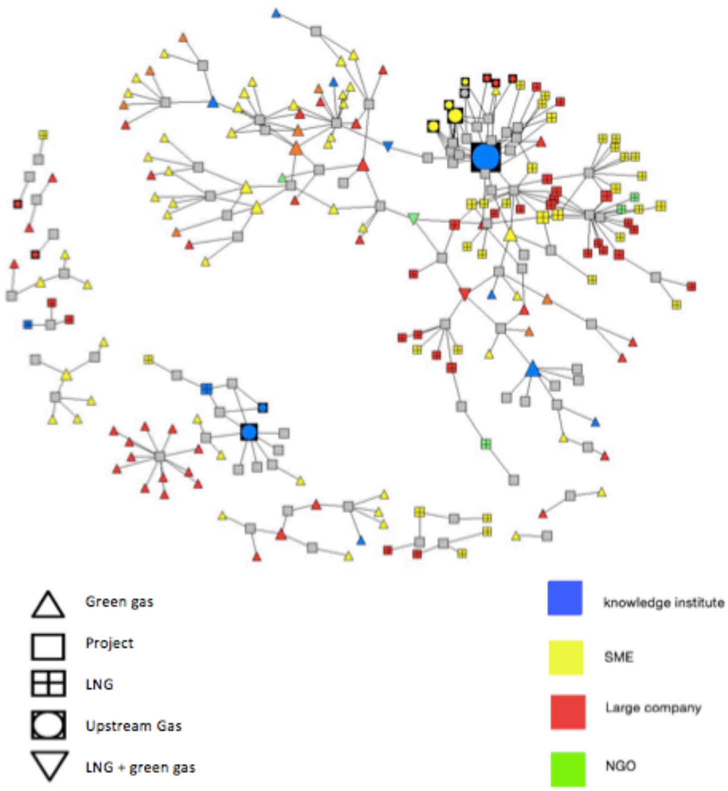

Figure 7: Network of the TKI Gas with data of 2012, 2013 and 2014. Size of the node proportional to the degree (number of projects the actor participates in)

The challenge of the TKI offshore wind is to connect the two eco-systems of the offshore industry and wind mill engineering. Connecting those two sectors is argued to be hard, since the offshore sector is traditionally about incremental innovation, learning by doing, scale advantages, very competitive (interviewee 7), while the wind sector has different ways of creating an industry by focusing on subsidies, policy and politics (interviewee 7). This is confirmed by the network graph of the TKI Offshore Wind (figure 8), showing that mainly actors from the programme line ‘wind turbine and wind power station’ are not connected to the rest of the graph. This may be at risk for retention and re-combination. An explanation is given by interviewee 7, stating that linking those two cultures is challenging because the industry is very competitive, since in the end just one project developer will be the one to build the offshore wind park, in contrary to the market of urban energy, which is much more distributed (interviewee 7).

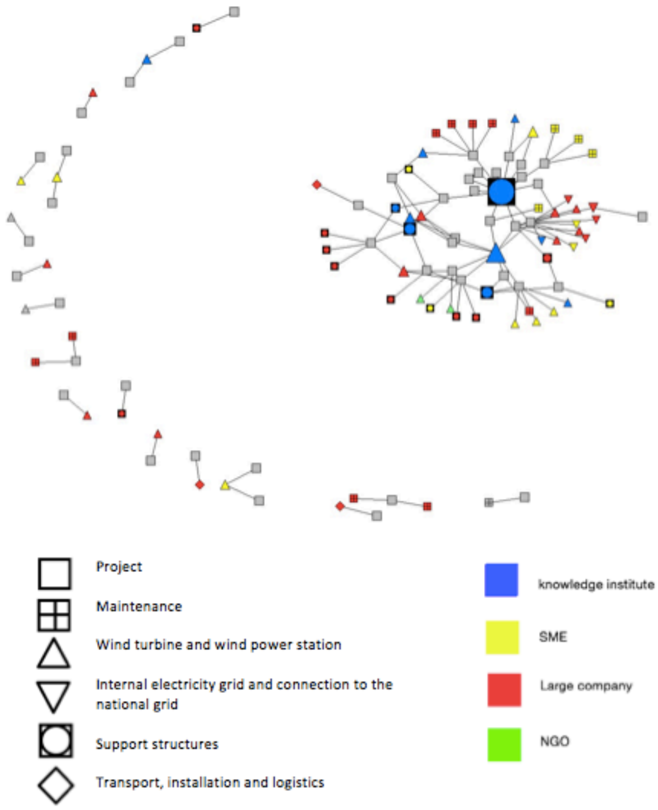

Figure 8: Network of the TKI Offshore Wind with data of 2012, 2013 and 2014. Size of the node proportional to the degree (number of projects the actor participates in)

When looking into the sorts of companies involved, interviewees as well as policy documents emphasize the importance of involving SMEs, which are according to many important to bring in new knowledge and innovation and because they have the highest growth potential (interviewee 18). However, only the TKI Gas, the TKI Solar Energy and the STEM programme have more SMEs in their network than large companies (appendix 5). Interviewee 5 emphasizes the connection between large companies and SMEs to combine innovative capacity of SMEs with the possibility of large companies to develop it and enlarge the scale. Especially in capital-intensive industries, large companies play an important role in the deployment of the technology (interviewee 5). Some TKIs report difficulties in involving SMEs because of the long-term investment required to take part in a project (TKI Bio-based economy, 2014) (TKI Offshore wind, 2013). While some TKIs have problems with involving SMEs, according to interviewee 5 never before so many SMEs were involved in innovation policy. Others are satisfied with the amount of SMEs involved (TKI Urban Energy, 2015) (TKI Gas, 2014) (TKI ISPT, 2015). Interviewee 10 criticizes the composition of companies involved by stating that we should be aware of the fact that it is just a small part of all Dutch companies and that the same companies are involved each time over the years (interviewee 10). 'It is a bit of an internal clique' (interviewee 10). While the interviewee cannot provide names or sorts of companies that are not involved, he thinks that the point is that you do not know who is missing.

The people involved in the innovation projects of the TKIs are merely engineers according to interviewee 10. Obliging the TKIs to involve social scientists would solve the merely technological character of the innovation process. It would be a good thing to also involve social scientists more in the other TKIs like solar panels, where aesthetics of the solar panel is an issue (interviewee 5). Next to that, consumers are not involved in the innovation processes. Interviewee 15 argues the importance of involving consumers by stating that you can only commercialize when consumers are involved. While for example solar panels are technologies, which will directly be bought and used by individual consumers, the consumer is not involved in any of the projects or at the public consultation (appendix 6). Also, the discussion on ventilation systems is about the missing of consumers in the projects on this technology, since feedback should be given in a right way to provide consumers information about the air quality (appendix 6). In addition to social scientists and consumers, some other actors are missing. Interviewee 14 explains this by describing that the energy sector will more and more relate to other fields and therefore diverse actors have to get involved. In the programme line on multi functional building parts, actors are missing who can work on insurances and certificates of the technology (appendix 6) Also new ICT services companies are missing in the programme line (interviewee 6).

5.1.6 Second order learning

From the results on retention, one can recognize that learning within the TKIs seems to happen mainly first order. Certain paths are chosen, defined by the TKIs and within the TKIs the paths are followed. Learning happens within the TKIs and is mostly based on financial and technological feasibility of the different technologies (interviewee 5).

Although in the management team the different themes are discussed more fundamentally (interviewee 5). A discussion took place on the basis of fundamental statements about the future of the energy system, like: 'Would you keep coal powered plans when all the CO_2 emissions can be captured and it is cheaper than renewable?' (interviewee 3). Which is viewed as a moral discussion on to what extent people are responsible for their own grandchildren, environment and the world (interviewee 3). This type of discussion could extend the role of management team beyond just looking at annual reports of the TKIs (interviewee 18). It is unclear to what extent the outcomes of the second order learning are used to change selection criteria.

According to interviewee 4, the role of the management team is also to challenge the TKIs on thinking about whether they are investing in the right topics. The interviewee thinks that the management team could give this role more weight. Also interviewee 9 recognizes the importance of thinking over the boundaries of specific technologies by saying that many technologies within the *top sector energy* still have issues, for example solar PV with the integration in the build environment and biomass with first, second and third generation resources. However, according to him the top team does not have a leading role in discussing these issues and that they are mainly coming up from the TKIs.

5.2 Second level analysis

The second order analysis researches the impact of the *top sector policy energy* on other energy innovation practices in the Netherlands.

5.2.1 Technological diversity and innovation

Because the *top sector energy* only supports a limited amount of technological options, many options and 'unknown unknowns' fall outside the concrete boundaries of the top sector. The subsidy schemes relevant on the later innovation phases, like the Demonstration Energy Innovation (DEI) and the Stimulation Sustainable Energy (SDE+) are open to all technological options. However, because the narrow range of technological options stimulated by the *top sector policy energy*, options falling outside the *top sector energy* are unlikely to develop and become more cost efficient. Cost efficiency is an important prerequisite to take part in both DEI and SDE+. Subsequently, while DEI and SDE+ leave all options open, which is beneficial for technological diversity, in practice the options falling outside the *top sector energy* have less chance on being able to receive subsidy in a later phase.

Higher in the innovation process, the *top sector energy* influenced the knowledge generated by the knowledge institutes in the Netherlands, since the knowledge institutes are obliged to direct a certain amount of their financial resources to the top sectors. While the causality with the establishment of the *top sector policy* is unclear, an enormous saving on the budget of ECN came into place when the *top sector policy* came into place. The budget decreased from 40 M€ to 16 M€ (interviewee 7), of which 12 M€ is for pps'. A saving on the innovation budget means less creation of technological diversity.

Next to that, while ECN before the emergence of the top sector had the freedom to distribute their resources over self-chosen topics, now the research effort is completely dedicated to the topics of the *top sector energy* (interviewee 7). In addition, while ECN can decide itself on the explorative long term research, these themes are also directed at the *top sector energy* otherwise problems occur in finding funding later in the innovation chain (interviewee 9). Continuously, ECN lost freedom in the choice of topics and the distribution of the financial resources. Also, financial resources of NWO are directed towards the topics of the *top sector energy* with consultation of the TKIs. NWO has directed 275 M€ to all top sectors. Of this 275 M€, 100 M€ should be spent in pps', meaning it should be matched by private sector investment. The *top sector energy* receives 20 M€ for basic research in the TKIs and can apply to receive a part of the 100 M€ by applying project proposals of pps'. Opinions differ about the obligation of knowledge institutes to invest a relatively large amount of their budget in the TKIs. According to some, the topics that NWO spends its money on did not really change, compared to the situation before the top sector, except that currently it has the top sector label on it (interviewee 3). Although many do think that less money is left to spend on 'free research' (interviewee 3). Moreover, the top sector may have an absorbent effect on the knowledge generation in other knowledge institutes like universities, because basic research on topics that are not part of the *top sector policy*, have a harder time receiving funding later on in its development process.

5.2.2 Selection

By selection on the second level is meant the impact of the *top sector policy energy* on the selection environment outside the *top sector energy*. Does the *top sector energy* have a positive influence on the selection environment for renewable energy technologies in the Netherlands? Many observe that problems occur in the deployment phase on issues like hampering laws and regulations and access to finance (interviewee 5, 11) (TKI Gas, 2014) (TKI Bio-based economy, 2014) (TKI Offshore Wind, 2013). Within the TKIs the sectors are better organised and the link with the government has become closer, which makes it easier to communicate about barriers in laws, regulations, social acceptation and the access to finance that can be taken on by the governmental officers (interviewee 18). Interviewee 6 confirms this by telling that for the first time he was invited to talk about policy on solar PV and the identification of barriers for its implementation. Interviewee 5 thinks that the TKIs could use this potential more strongly, by operating as lobbying platforms or making a stronger link with the Green Deals[6].

Next to these signals that show that the route to the government became easier, some still experience a very strong power of vested interests that work against the development of their renewable energy technology like offshore wind. Interviewee 7 describes that the licenses for space given out to the fossil fuel industry on the North Sea, which are according to him unnecessarily extensive, are highly hampering the development of offshore wind parks. Interviewee 3 and 18 confirm this and explains that the top sector can provide a signal to the government official in the top team, but he is subject to all kinds of political forces. A closer link with the Green Deals[6] could provide an opportunity to more strongly address these issues and influence them, which is confirmed by the TKI Energo who signed the Green Deal Smart Energy Cities (TKI EnerGO, 2014). In many TKIs however, the link with the Green Deals is not formally organised but consisting of shared actors (interviewee 3).

5.2.3 Retention

How are learning experiences shared over the whole energy innovation process, from links to basic research outside the *top sector energy* to links with demonstration projects? Shared actors seem to be the link over the different phases (interviewee 5). While STEM research could provide important input for deployment subsidies like the SDE+, those links are not very close (interviewee 10). For the rest, knowledge sharing happens mainly within the TKIs.

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6 By Green Deals the government establishes agreements with external organisations to help executing sustainable plans by changing laws and regulations, facilitating collaboration or with helping to find markets abroad.

6. Conclusion

Innovation is by many seen as an important mean to solve the central, complex and often technology-related problems we face today. The energy system based on energy intensive technologies and polluting resources is an example of a complex, societal problem for which, according to many, innovation can provide transformative strength to realise a sustainable energy transition. However, innovation policies are often framed as ‘pro-innovation’ without paying attention to the many different pathways that can be walked, the challenges ahead and the political contestability of innovation.

The innovation strategy of the Netherlands in the field of energy, had next to strengthening the energy sector, also the aim to contribute to the transition towards a more sustainable and CO_2 sector. The research was guided by the general aim of how to evaluate this innovation policy on bringing about innovation that contributes to a more sustainable energy system in the Netherlands. To solve this aim, the literature review explains that a constructivist, reflexive evaluation method could both provide novel insights as well as fits best with a policy instrument in which many actors share the power to influence the policy but act from different perspectives and opinions. Also, the literature review showed that an evolutionary approach to both innovation and the innovation process could provide useful concepts to clarify the practices and choices made by the actors in the *top sector policy energy*. From these insights, we narrowed down the general research aim to the research question: how does the *top sector policy energy* perform through the lens of the concepts of the evolutionary perspective: diversity of actors, diversity of technologies, selection and retention?

Selection is overemphasized by the policy, while diversity and retention are almost not receiving attention by the high level governance of the *top sector policy energy*. This leaves behind the benefits of diversity of both technologies and actors, also by influencing other research efforts outside the scope of the *top sector energy*. While on the short term selection may be more efficient from an economic point of view, diversity creation provides strong benefits in resilience of the energy system, the prevention of a suboptimal technological lock-in and the chance on recombination and radical innovation. While some actors do see these opportunities, the high level governance of the *top sector energy* does not have it as an explicit goal. Also, the lack of attention to retention encompasses a large missed opportunity. First of all, because of the uncertainty how to balance diversity and selection, learning is important to reflect on it frequently. This speaks in favour of reflexive policy evaluation, as mentioned in the literature review. Secondly, evolutionary progress in some self-chosen desirable direction is about replicating well-performing practices, routines and innovations. Giving more attention to sharing learning experiences is therefore very important. Especially the STEM programme provides a high potential to benefit from learning experiences, since the knowledge created is important for the development of every technology. Having diverse actors and integrate social aspects within the TKIs would help to stimulate second order learning and reflexivity. Next to that, diverse actors can stimulate deliberate decision making about what innovation pathways to take, which would prevent the risk of being captured by the most powerful interests reasoning from the current technological and policy paradigms.

Next to these internal dynamics, the *top sector energy* also has its impact on other elements of energy innovation system in the Netherlands. While the *top sector policy energy* is mainly directed at the middle part of the innovation chain (industrial and experimental research), the other phases are influenced by the innovation strategy of the middle part. Because the subsidy instruments like the SDE+ are strongly emphasizing cost reduction of the innovation, many topics not falling in the *top sector policy energy* scope are less likely to become cost efficient. At the beginning of the innovation chain, basic research is more directed at the topics of the *top sector energy*, since otherwise they will not have a chance on funding at a later stage. Next to this, the *top sector energy* can use the full potential of learning over the whole innovation chain better. To influence the selection environment for renewable energy technologies TKIs can make better use of the short links to the government to lobby for better laws and regulation concerning renewable energy technologies.

Usefulness framework and evaluation method
The constructivist, reflexive evaluation method provided the useful insights it promised. By taking into account the many different actors, acting from diverging perspectives, we saw that, though many policy documents and interviewees speak in favour of focus and mass, some actors are working against that and use their power to broaden the amount of topics. This insight is novel compared to earlier studies on the innovation strategy of the *top sector energy* (e.g. PBL report).

The use of an evolutionary approach gained interesting insights but also had drawbacks and limitations. To start with the latter, the main drawback of the evolutionary approach to evaluate innovation policies is its lack in normative value. An important question that came up is: what is the desirable level of diversity at different points in time and with given aims? Another difficulty with the framework is the distinction between the different concepts. Diversity creation and selection often happens at the same time. Selection does not really act upon different alternatives of which a few are 'well-performing' and reproduced. Instead, some alternatives do not get the chance to develop and be subject of selection forces. Also, former literature on the evolutionary approach has a very narrow definition of innovation. From relevant literature on innovation, we found that innovation can be different in many dimensions. When innovation is incremental, it has less potential to increase technological diversity. Therefore, the concept of diversity of actors added to this research, which is according to the literature important to go beyond policy and technological paradigms. Another observation is that according to the literature an increase in technological diversity may increase the chance on recombinant innovation, this can be hampered by compartmentalisation. Another important point of further research is how to operationalize the concept of retention. Retention is the mechanism that should reproduce the desirable innovations, but there is a lack of an operational strategy to enhance this.

Besides these drawbacks and gaps in using the evolutionary approach, it also provided some interesting insights. The evolutionary approach made clear that diversity, while given a lot of attention in academic literature, is not acknowledged by policy documents and the high level governance of the top sector as a useful goal. Also, the evolutionary approached showed that a lot of potential is left unexploited in sharing learning experiences and reproducing well-performing innovation practices.

Theoretical contribution
This research contributes to the literature by adding second order learning as a very relevant concept to the evolutionary perspective, since it provides the opportunity to change the undirected theory of evolutionary process, to make it usable for reaching a certain a goal. Second order learning helps to reflect on the usefulness of certain innovations to create progress in a certain direction. This transforms evolutionary theory from descriptive to normative and at the same time enlarges its applicability to both evaluate and inform policies on. The concept of diversity of actors is helpful in enhancing second order learning and therefore a relevant contribution when using the evolutionary approach to evaluate policies on. Further research would be recommendable to confirm these first findings.

Methodological contribution
The method used, combining network data with qualitative interview data worked out well. The network graphs were useful to combine theoretical insights on the innovativeness of networks with the information provided by the interviewees. Although it contributed a lot to the research, many opportunities are left for further research. We would recommend conducting a network analysis more extensively with the use of network concepts proven to be important by former scientific research. Van Rijnsoever *et al.* (2014) already found a relation between the creation of technological diversity and network characteristics. It is recommendable to do a similar network analysis and thereby looking further into network characteristics like cliques and structural holes in the whole network of innovation projects. While a lot of literature is focused on the impact of the network of a specific company on its innovative output, looking at the innovativeness of a whole network potentially

contributes a lot to the understanding of how the composition of a network of should be to enlarge innovative output. This could provide interesting policy recommendations.

Limitations
The AWTI was very helpful to get access to interviewees as well as contribute to conducting the interviewees. It has been experienced to be very useful to conduct interviews with more than one researcher, to be able to reflect during the interviews on the information provided and the gaps in information left. However, the presence of somebody from the AWTI could also have influenced the information given, since the AWTI is an important advisor to the government. We were aware of this, but did not find instances that confirmed this statement. It even seemed to have a positive effect, since interviewees were comfortable talking to a familiar face. A limitation of the method is that companies are underrepresented in the panel of informants. However, participating as well as non-participating companies could have provided useful information about their innovation strategies, the fit with the *top sector policy energy* and the perceived power they have in determining the policy agenda. A limitation of the network data provided was that the companies distinguished by the categories SME or large company. It would be helpful to have more information of the type of company for example what the main activity of the company is, to be able to determine its contribution to the diversity of actors.

Policy recommendations
From the research on the *top sector policy energy*, we want to derive policy recommendations. The first recommendation is to focus more on diversification. This can for instance be reached by having both diverse actors as diverse technologies as a policy goal. One could think of changing the organisation of topics. Less focus on a certain technology and a stronger 'system thinking' can increase the diversity of actors as well as the chance on recombinant innovation (as seen in the TKI Urban Energy). Social aspects should be integrated in technological research better to increase useful innovation and be aware of the societal impacts on an earlier stage. Therefore, increasing the importance of STEM is recommendable. The second recommendation is to focus more on retention. Frequent reflection over the boundaries of specific TKIs is required on both the balance between diversity and selection as well as to reproduce successful innovation practices.

The researcher is aware of the fact that diversity creation acts contrary to the policy goals of short-term economic efficiency. Also, more focus on retention goes against the urge of policy makers and politicians to justify spending on the base of measurable indicators. Problems appear with measuring the direct positive effects of both diversification and retention. Therefore, an overall recommendation this research wants to give is a cultural change of how to think about innovation, how to measure it and how to justify it. In the policy world, there should be more emphasis on organising the innovation process from a well-informed rationale instead of using indicators to justify spending. Embrace the uncertainty of innovation and accept failure inherent to innovation processes. Frequent reflection with diverse actors is an important quality to acknowledge the political contestability of innovation and enhance deliberate decision-making.

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8. Appendix

Appendix 1: Interviewees

Interview number	Kind of organisation	Management/non-management	Interviewers
1	Former participant of the top sector energy	Management	L.J.M. van Son, dr. M.J. Kleijn, M. den Heijer
2	Top sector energy	Management	L.J.M. van Son, dr. M.J. Kleijn, M. den Heijer
3	Top sector energy	Management	L.J.M. van Son, dr. M.J. Kleijn, M. den Heijer
4	Top sector energy	Management	L.J.M. van Son, dr. M.J. Kleijn
5	Top sector energy	Management	L.J.M. van Son, dr. M.J. Kleijn
6	Top sector energy	Non management	L.J.M. van Son, dr. M.J. Kleijn
7	Top sector energy	Non management	L.J.M. van Son, dr. M.J. Kleijn
8	Top sector energy	Non management	L.J.M. van Son, dr. M.J. Kleijn
9	Knowledge institute	-	L.J.M. van Son, dr. M.J. Kleijn
10	Top sector energy	Non management	L.J.M. van Son, dr. M.J. Kleijn
11	Company	-	L.J.M. van Son, dr. M.J. Kleijn
12	Government	-	L.J.M. van Son, dr. M.J. Kleijn, M. de Heijer
13	NGO	-	L.J.M. van Son, dr. M.J. Kleijn
14	Expert in the field of Innovation Studies	-	L.J.M. van Son, dr. M.J. Kleijn, M. den Heijer
15	Expert in the field of Innovation Studies	-	L.J.M. van Son
16	Expert in the field of Innovation Studies	-	L.J.M. van Son, dr. M.J. Kleijn, M. den Heijer
17	Government	-	L.J.M. van Son, dr. M.J. Kleijn, M. den Heijer
18	Top sector energy	Management	L.J.M. van Son, dr. M.J. Kleijn, M. den Heijer

Appendix 2: Example of an interview guide

1) Over de geïnterviewde
    a. Achtergrond
    b. Betrokkenheid topsector energie

2) Topsector energie
    a. Doelen
        i. maatschappelijk (termijn) rol energieakkoord
        ii. economisch (termijn)
    b. Bepaling of project bijdraagt aan duurzaam energiesysteem
        i. rol in systeem
        ii. CO_2 reductie
    c. Bepaling of project bijdraagt aan economische doelen
    d. Overzicht subsidiemogelijkheden binnen topsector energie

3) Innovatieportfolio
    a. Welke technologieën
        i. wie beslist
        ii. hoe wordt er gereflecteerd
    b. Rol in duurzaam energiesysteem, systeem voor ogen?
    c. Afweging: Breedte stimuleren ∨ momentum internationaal opschaalbaarheid
    d. Afweging: versterken waar we goed in zijn ∨ stimuleren nieuwe, onzekere maar potentieel duurzame
    e. Technologieën die niet worden gestimuleerd?
    f. Op een andere manier gestimuleerd?
        i. Kennisinstellingen
        ii. Andere subsidies

4) Selectie
    a. Fase waarin de technologie is
        i. subsidies over verschillende fases verdeeld? Gat?
        ii. Fundamenteel onderzoek ∨ korte termijn exploitatie
            1. Wat vind je van verhouding? Energiebeleid algemeen, topsector energie in energiebeleid
    b. Wet- en regelgeving

5) Actoren
    a. Rol ministeries in energie-innovatie
        i. grotere rol EZ
    b. Verhouding aantallen en macht grote huidige bedrijven en kleinere nieuwe bedrijven
        i. soort bedrijven: energieproducenten/leveranciers
    c. Rol grote bedrijven stimuleren duurzame energie
    d. Rol kennisinstellingen en anderen (netbeheerders…)

6) leerprocessen, organisatie
    a. Alleen binnen project: technische haalbaarheid/financieel
    b. Over projecten heen? Toekomst in bijdrage duurzaam energiesysteem
    c. Leerervaringen gedeeld?
    d. Leerervaringen vastgelegd?
    e. Bijdrage aan doelen topsector energie?

7) Denk je dat de topsector energie de doelen behaald?

8) Gaan de maatschappelijke en economische doelstellingen goed samen, of zijn er trade offs te maken? Moet er iets verbeteren aan de topsectorenaanpak?

9) Weet je nog iemand binnen het bedrijfsleven of algemeen die zinvol is om te spreken?

Appendix 3: Energy sector in the Netherlands

Key numbers

The *top sector policy energy* is aimed to have its effect on the energy sector in the Netherlands by increasing the competitive strength of the energy sector and help accelerating the energy transition. In this section, I will explore the most important characteristics of the Dutch energy sector.

During the years, the total primary energy consumption has been raising in the Netherlands (figure 3). The industry, which is only 4% of the total number of companies, is the largest consumer of energy with 44,6% of the total energy consumption (IEA, 2014). About half of the 44,6% is used as a resource to make products, like plastics (ECN, 2010). The commercial and services sector counts for 19,9% and the transport sector for 18,6% of the total final consumption. The residential sector consumes 16,9% of the total final consumption. The major part of energy consumption happens by the consumption of oil products like gasoline and the use of natural gas for heating. The use of electricity is just a small part of the total consumption of energy, about one fifth.

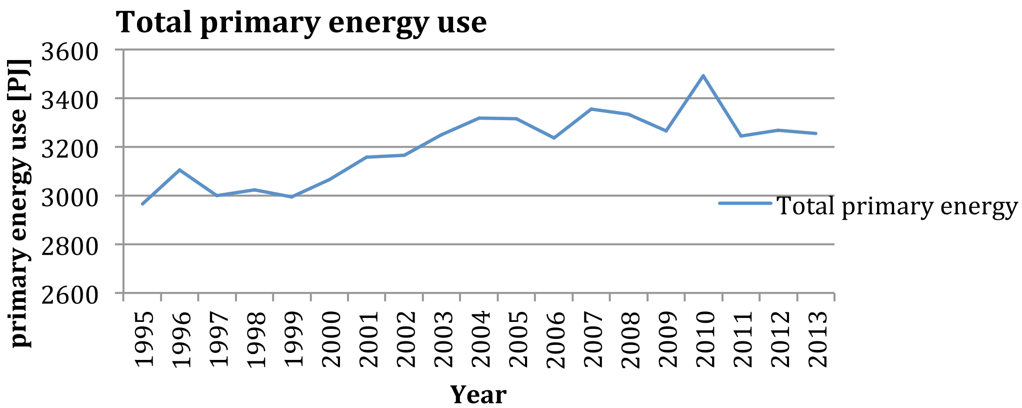


Figure 9: Total primary energy use (CBS, 2015)

The total primary energy supply in the Netherlands is dominated by fossil fuels, representing more than 90% of the total primary energy supply, as shown in figure 4. The part of the electricity generated by renewable sources is slowly increasing and currently about 10% (ECN *et al.*, 2014). Because electricity encompasses only one fifth of the total demand in energy and of the other part only a very small part is generated sustainably, the total share of renewable energy in the Netherlands is 4,5%. The Netherlands has one of the largest shares of fossil fuels in its energy mix among IEA member countries (IEA, 2014). One of the reasons for the low share of renewables in the energy mix is the constantly changing renewable energy policy and policy instruments (van Rooijen and van Wees, 2006).

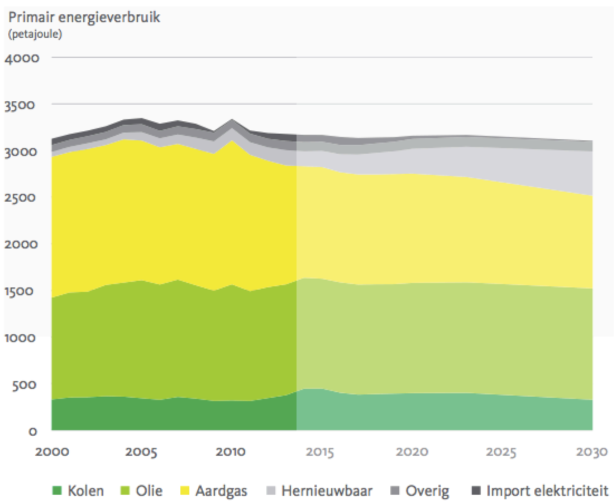


Figure 10: Primary energy use by resource (Hekkenberg and Verdonk, 2014)

Natural gas is an important export product of the Netherlands. The export of natural gas is bigger than the internal consumption (ECN *et al.*, 2014). Also, while the consumption is less than the extraction, there is still import of natural gas, meaning the Netherlands is also an important trader in natural gas. The dense gas distribution network makes the Netherlands important as a European connection point for the transport of internally produced or imported natural gas, called 'the gas roundabout' (IEA, 2008). The stock decreases rapidly resulting in future decreasing export and increasing import of gas.

The energy sector is an important sector in the Dutch economy (Ministry of Economic Affairs, 2015). In 2010, the energy sector reached 5,3% of the Dutch GDP (IEA, 2014). Around 1270 firms were active in the energy sector and 47,000 people working in the sector. Revenues from the gas sector are 13 billion euros and the sector delivers 70,000 jobs (IEA, 2014). The biggest contribution of the energy sector to the economy is originated in oil and gas extraction. Because of the increasing prices for fossil fuels, the value of extracting oil and gas increased and thereby the importance of the sector since 2001.

Renewable energy

This figure displays the share of total energy generation that is generated from a renewable source separated in different renewable energy technologies.

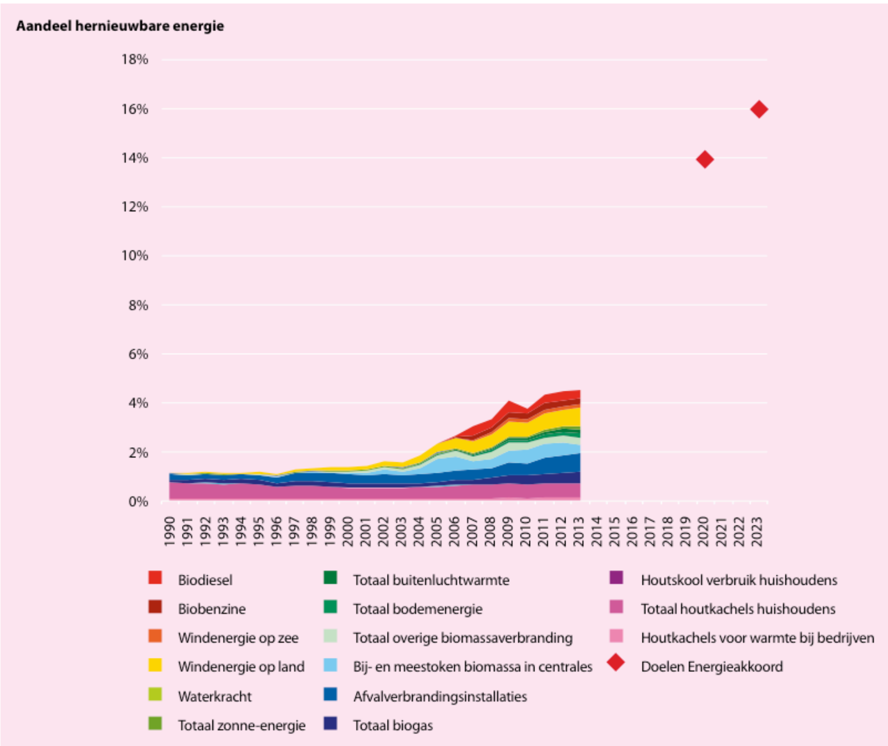


Figure 11: renewable energy in the Netherlands and the goals of the energy agreement (ECN *et al.*, 2014)

The European targets for renewable energy production as well as the demand to decrease geo-political dependency and local air pollution, makes investing in renewable energy production important in the Netherlands. The coalition agreement 'Building Bridges' of Rutte II confirms this and raised the ambition to increase the share of renewable energy to 16% by 2020 (Cabinet Rutte II, 2013). In 2013, the Social and Economic Council (SER) aims to reach this target and prepared the Energy Agreement in an eight-month negotiation along employers' federations, trade unions, government representatives and environmental non-governmental organisations. The following objectives were defined:

- Realize energy savings of 1,5% by 2020 by reinforcing energy efficiency in buildings, industry and agriculture, commercial and transport/mobility sectors;
- Realize a share of 14% renewable energy by 2020, through the SDE+ subsidy and R&D support with a focus on offshore wind and decentralised energy at local and regional levels;

- Realize 60% CO_2 reductions by 2050 and 17% reductions by 2030, compared to the 1990 levels, in transport and mobility sectors. (SER, 2013)

While the horizon of the SER Energy Agreement is 2020, the climate agenda goes beyond that agreement and focuses on 2030 as a reference point towards 2050. The Climate Agenda defines concrete goals and ambitions for 2030 and explores the next steps towards 2030 and 2050 (Ministry of Infrastructure and Environment, 2013). In October 2013, the Climate Agenda commits the Netherlands to achieve a CO_2 reduction of 80%-95% in 2050, compared to 1990 levels. Moreover, the Climate Agenda commits to European Green House Gas (GHG) emission reduction of at least 40% in 2030, below 1990 levels and the reform of the ETS to support these goals.

The short-term targets of the Energy Agreement to increase renewable energy production result in a great emphasis on exploitation of existing renewable energy technologies. The SDE+ instrument financially supports renewable energy technologies to make them competitive in the market. The investment in the exploitation of renewable energy technologies is collected by taxation of the energy price for consumers. In total, 3,5 billion euros is invested in SDE+ in 2014 (ECN, 2014). The 'Energie Investeringsaftrek' (EIA) provides an investment cost reduction of about 10% for businesses that want to invest in renewable energy. In 2014, 111 million euros in invested in EIA. For small consumers there is a tax benefit on the energy small consumers generate with solar panels, which costs the government about 50 million euro (ECN, 2014).

Important actors

Many different actors are active in the energy sector. Starting from the producers of energy, to the suppliers, network operators and the government. In this section, we will outline the most important ones.

The private energy sector is big and diverse with different products and interests. The gas and oil extraction plays the biggest role in the production of energy, 2451 PJ (peta joule final energy). The Dutch Oil Company, owned by Shell and ExxonMobil, does 75% of the oil and gas extraction. The Dutch Oil Company supplies gas to the company GasTerra, which is owned by Shell (25%), ExxonMobil (25%) and the Dutch government (50%). The company Gasunie is responsible for the transportation of gas. Generally speaking the energy market is highly concentrated around the large companies extracting and supplying energy energy.

TenneT operates and maintains the high voltage network. Other important grid operators are Enexis, Liander, Stedin and Delta. The network operator balances supply and demand on the network by adapting the electricity supply. The connection of renewable energy sources to the grid results in a higher fluctuating current and a stronger need for balancing capacity, for example coal fired plants. About 17,000 people work for network operators and yearly investments in extension, changes and maintenance of the grid costs about 2 billion euros (ECN *et al.* 2014). The network operator does not have a commercial interest.

Different Ministries are responsible for different parts of national energy policy in the Netherlands as shown in figure 6 (IEA, 2014). The Ministry of Economic Affairs is responsible for the overall energy policy. The responsibilities of the different Ministries are translated in actions to fulfil them. In these actions, the government takes on different roles, from facilitator, to regulator and from investor to client and on different levels, from local to global.

	Ministry of Economic Affairs	Ministry of Infrastructure and the Environment	Ministry of Interior and Kingdom relations	Ministry of Education, Culture and Science
Overall energy policy	Overall energy policy			
Climate/renewable related	Renewable energy, the energy transition and the bio-based economy	Climate and the environment		
Energy efficiency related	Energy efficiency in agriculture and other sectors	Energy efficiency in transport	Energy efficiency in buildings	
Infrastructure related	Large-scale energy infrastructure projects	Transport, water, public works		
Innovation related	RD&D			Fundamental science and research

Figure 12: Responsibilities for energy policy along the different Ministries, information from (IEA, 2014)

The government subsidises energy, with no goal of future financial profits or pay back. An example of the government as a 'donor' is the SDE+ subsidies, in which the government raises tax over the energy price to pay a certain amount of money per kWh generated. This makes the renewable energy technology competitive with conventional energy technologies. In addition, the government also subsidises the use of fossil energy, by for example a reduction of energy tax for large energy consumers. In 2010, large consumers paid 1,8 billion euros less energy tax than the total societal costs for energy generation (CE Delft and Ecofys, 2011).

The government takes on a role as 'investor' in energy, which means the government finances (part of) the investment in energy technology and expects the investment to be paid back including a profit over the investment. This often happens by the provision of cheap loans. Also, the government is the only shareholder of the private company 'Energie Beheer Nederland' (EBN), which has an important role in the search and exploitation of Dutch oil and gas. In 2013, EBN made a profit of 2327 million euros, going to the national financial treasury (EBN, 2014). Moreover, EBN is shareholder (50%) of the company GasTerra and therefore the government is also involved in the sale of gas.

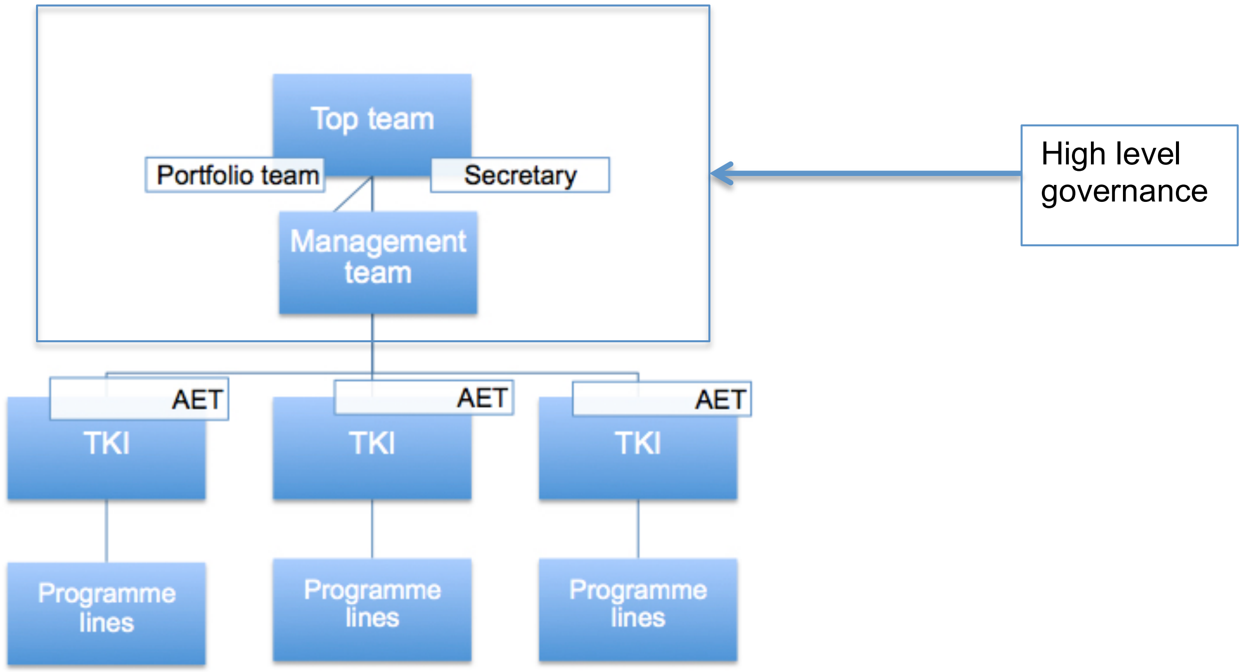
The government is an important client for energy suppliers. The government buys on all levels in total for an amount of 50 billion euros energy. Subsequently, the government as a large consumer has power to influence the market and create a market for energy-innovations. Different purchase programmes like 'innovative purchase' or 'circular purchase' supports this. Also, the government has the power to set requirements on energy characteristics in tenders. (CPB *et al.*, 2014)

The government also acts as the regulator of the market. Besides the financial regulation in the form of subsidies and tax benefits, the government sets rules like standards and norms for instance on energy efficiency of generators. The government also regulates the electricity and gas market under the authority of the Netherlands Authority for Consumers and Markets (ACM), which is part of the Ministry for Economic Affairs.

The government acts as a facilitator in many ways. It can influence other actors in the innovation system, for example knowledge institutes and banks and thereby support research and development, facilitate partnerships and act as a guarantee for banks. In addition, the government can support societal initiatives to give space to changes coming from bottom up. By Green Deals, the government tries to take away barriers in for example law or financing to facilitate initiatives. The government also has an important role in spatial planning which is important in for example wind parks. Goals can serve as an anchor for actors to direct their efforts towards. (CPB *et al.*, 2014)

Other important actors in the energy sector in the Netherlands are: the CBS statistics, who collect and process data; the Energy Research Centre (ECN), which carries out research in the field of energy; the Environmental Assessment Agency (PBL), which monitors the implementation of national energy and climate objectives and the Netherlands Enterprise Agency (RVO), which implements R&D policy and funding programmes with a focus on sustainability and innovation in collaboration with the research institutes and universities (IEA, 2014). In addition, municipalities and provinces are important since the latter gives permission for wind projects and both have subsidy schemes for renewables.

Appendix 4: Governance of the top sector energy



Appendix 5: Network graphs

In this Appendix the network graphs of all TKIs are displayed. The network graphs are derived from the data provided by RVO. The excel sheet provides data on the theme, the programme line, the policy, the tender, the project, the project year (2012-2014), the name of the organisation, the chamber of commerce number (kvk-number) and the organisation type.

The layout is 'spring embedding', meaning the distance between two nodes represents the path length (number of links) between them. The placing of the nodes starts with a random layout and iterates 100 times to improve the placement. 'Equal edge length' is make the distances between adjacent objects similar.

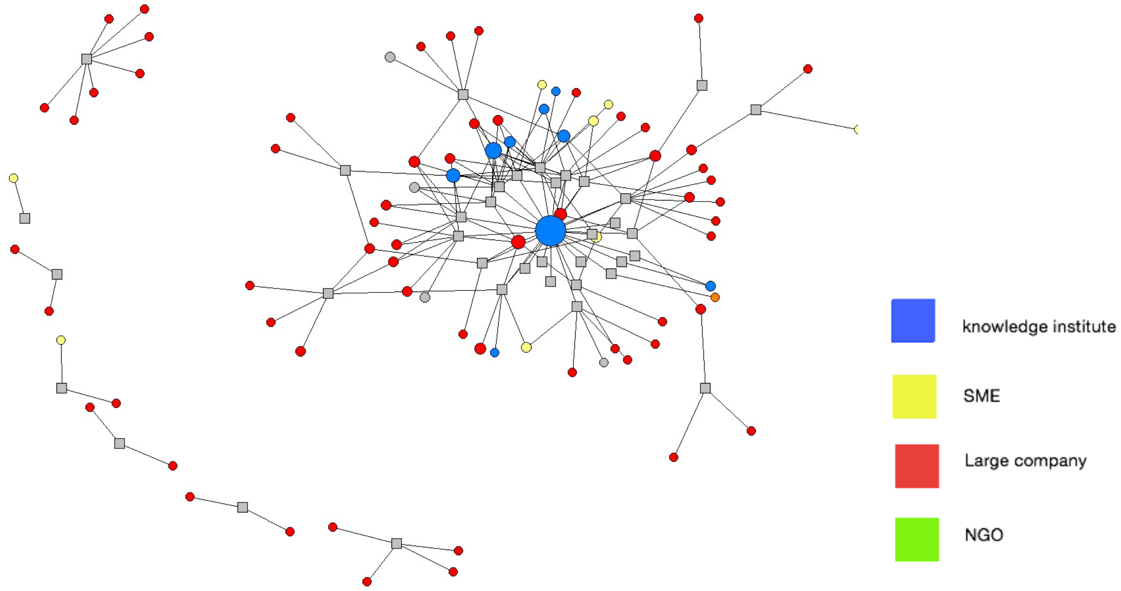
5.1.a: TKI ISPT, nodes by type of actor
5.1.b: TKI ISPT, nodes by year
5.2.a: TKI EnerGO, nodes by type of actor
5.2.b: TKI EnerGO, nodes by year
5.3.a: TKI Gas, nodes by type of actor
5.3.b: TKI Gas, nodes by year
5.3.c: TKI Gas, node colour by type of actor and shape by programme line
5.4.a: TKI Smart Grids, nodes by type of actor
5.4.b: TKI Smart Grids, nodes by year
5.5.a: programme System Integration, nodes by type of actor
5.5.b: programme System Integration, nodes by year
5.6.a: TKI Offshore Wind, nodes by type of actor
5.6.b: TKI Offshore Wind, nodes by year
5.6.c: TKI Offshore Wind, node colour by type of actor and shape by programme line
5.7.a: TKI Solar Energy, nodes by type of actor
5.7.b: TKI Solar Energy, nodes by year
5.8.a: STEM, nodes by type of actor
5.8.b: STEM, nodes by year

	TKI ISPT	TKI EnerGO	TKI Gas	TKI Smart Grids	TKI System Integration	TKI Offshore Wind	TKI Solar Energy	STEM programme
# nodes	80	103	181	115	64	67	136	20
# projects	27	23	64	31	16	32	40	5
# links	168	145	292	187	95	111	336	21
# links / # nodes	2,1	1,41	1,6	1,6	1,48	1,67	2,47	1,05
# central nodes (degree > 3	11	3	12	8	5	4	15	0
% knowledge institutes	11%	17%	7%	13%	17%	16%	13%	35%
% large companies	76%	42%	38%	50%	61%	52%	29%	5%
% SMEs	10%	32%	47%	30%	13%	24%	53%	55%
% NGOs	0%	6%	3%	4%	8%	3%	4%	5%
% government	0%	3%	5%	3%	2%	0%	2%	0%
% unknown	1%	1%	1%	0%	0%	3%	0%	0%
# actors participating in the TKI from 2012 on	26	37	99	61	10	26	69	x
# actors participating in the TKI from 2013 on	4	30	41	36	9	15	35	x
# actors participating in the TKI from 2014 on	50	36	41	19	45	26	32	x

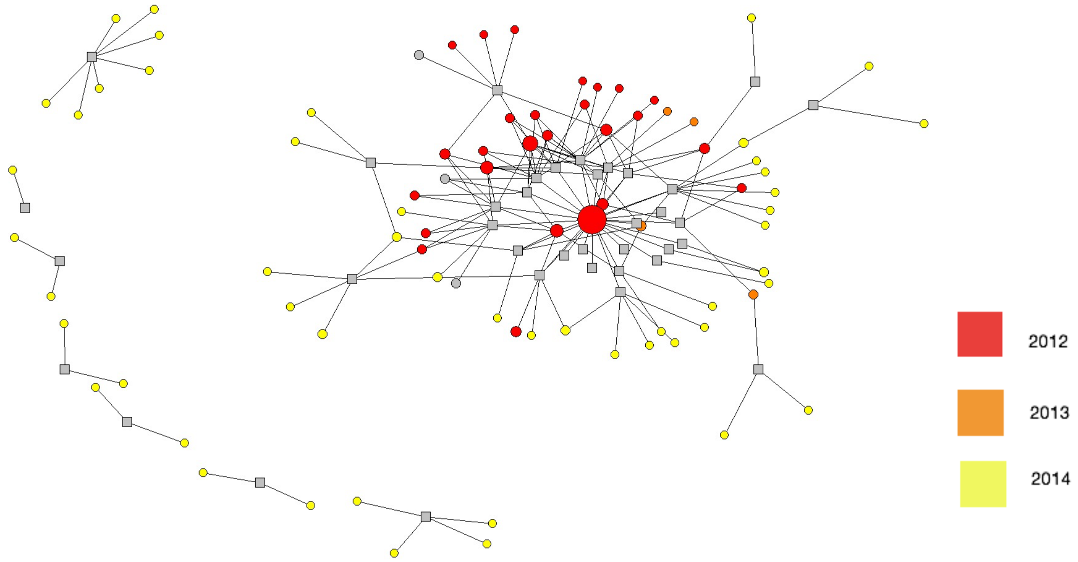
5.1: Network of the TKI ISPT

The square nodes represent the projects and the round nodes represent actors. A link means that the actor is participating in the project. In network graph 5.1.a, the colour of the node represents the type of actor. In network graph 5.1.b, the colour of the node represents the year the actors was involved for the first time in a project. The size of the node represent the degree, meaning to how many projects the actors is connected.

5.1.a Network of the TKI ISPT, node colour by type of actor



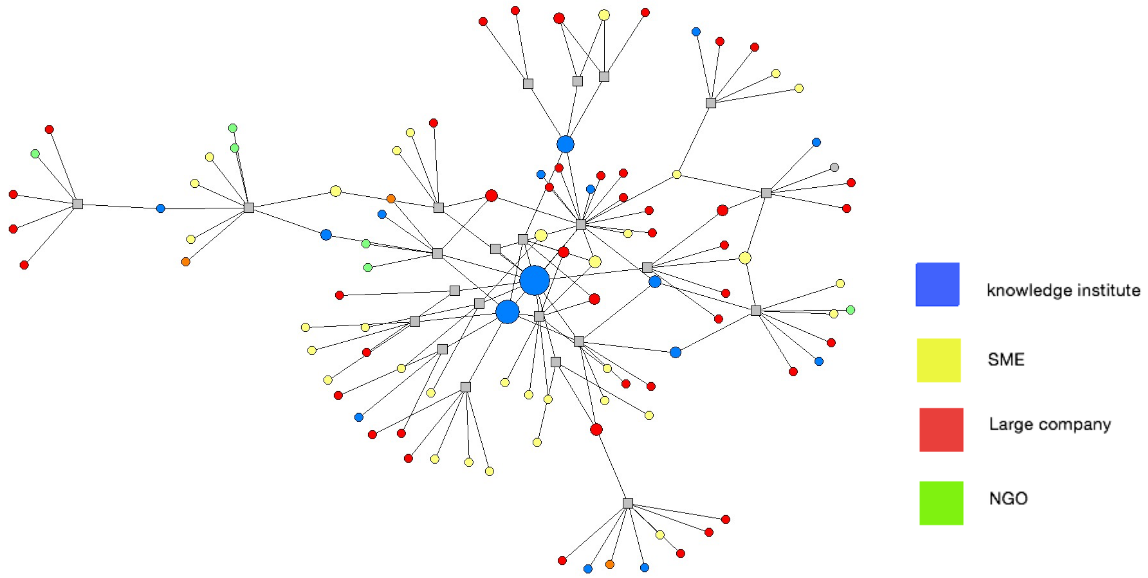
5.1.b Network of the TKI ISPT, node colour by year



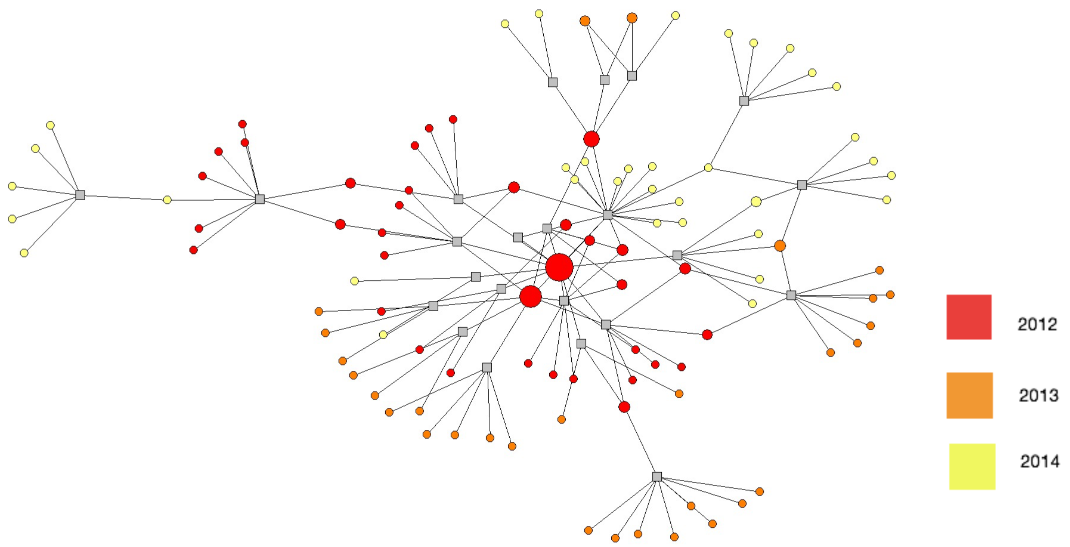
5.2: Network of the TKI Energo

The square nodes represent the projects and the round nodes represent actors. A link means that the actor is participating in the project. In network graph 5.2.a, the colour of the node represents the type of actor. In network graph 5.2.b, the colour of the node represents the year the actors was involved for the first time in a project. The size of the node represent the degree, meaning to how many projects the actors is connected.

5.2.a Network of the TKI Energo, node colour by type of actor



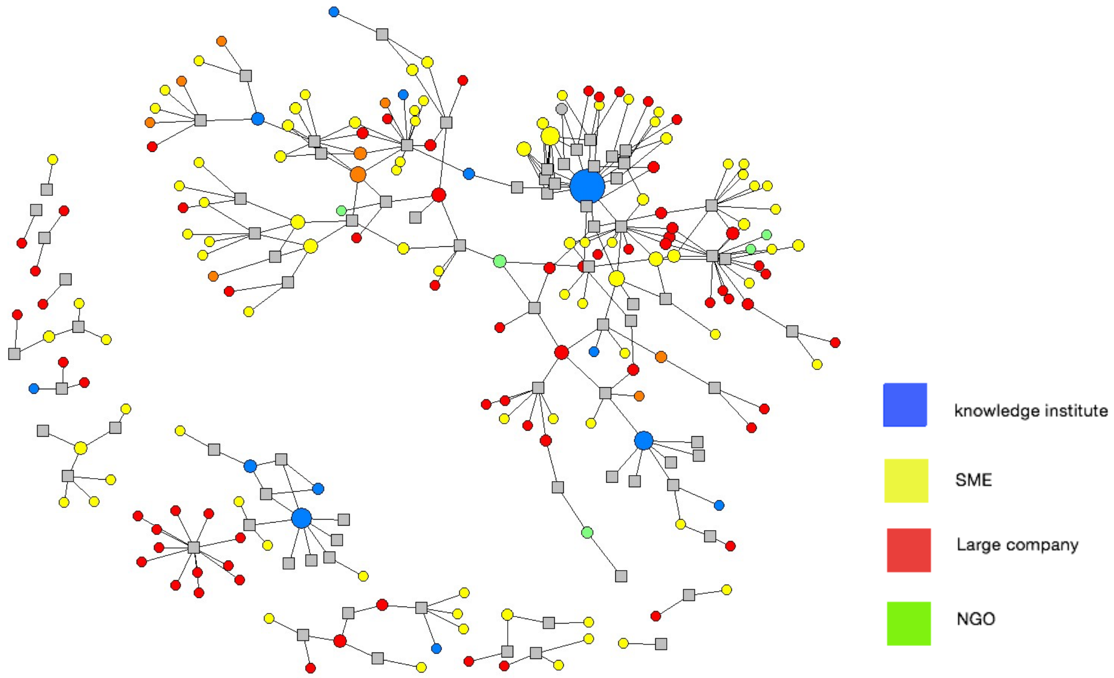
5.2.b Network of the TKI Energo, node colour by year



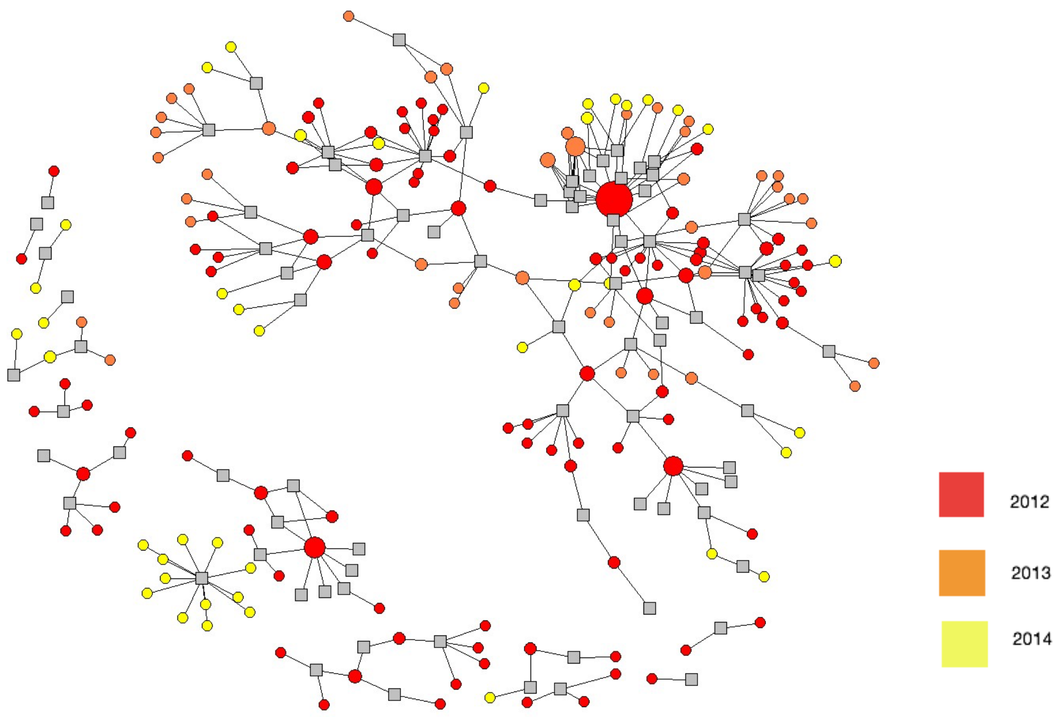
5.3: Network of the TKI Gas

The square nodes represent the projects and the round nodes represent actors. A link means that the actor is participating in the project. In network graph 5.3.a, the colour of the node represents the type of actor. In network graph 5.3.b, the colour of the node represents the year the actors was involved for the first time in a project. The size of the node represent the degree, meaning to how many projects the actors is connected.

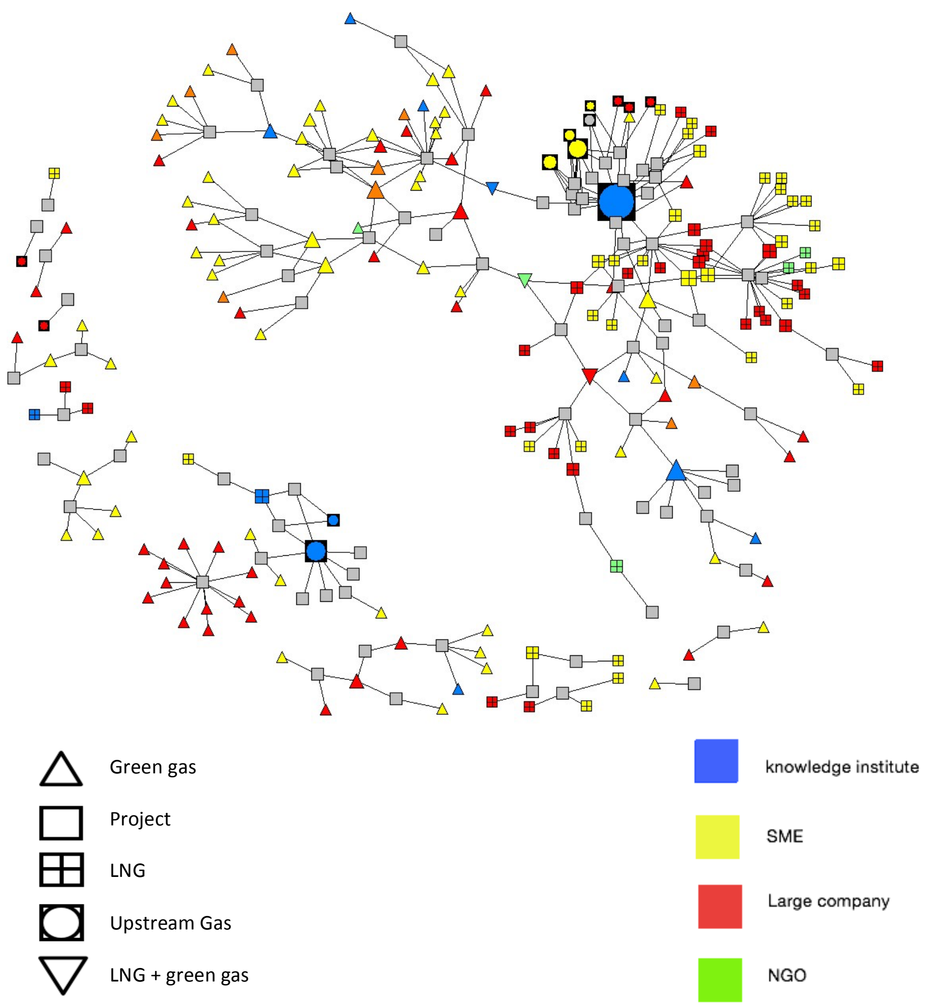
5.3.a Network of the TKI Gas, node colour by type of actor



5.3.b Network of the TKI Gas, node colour by year



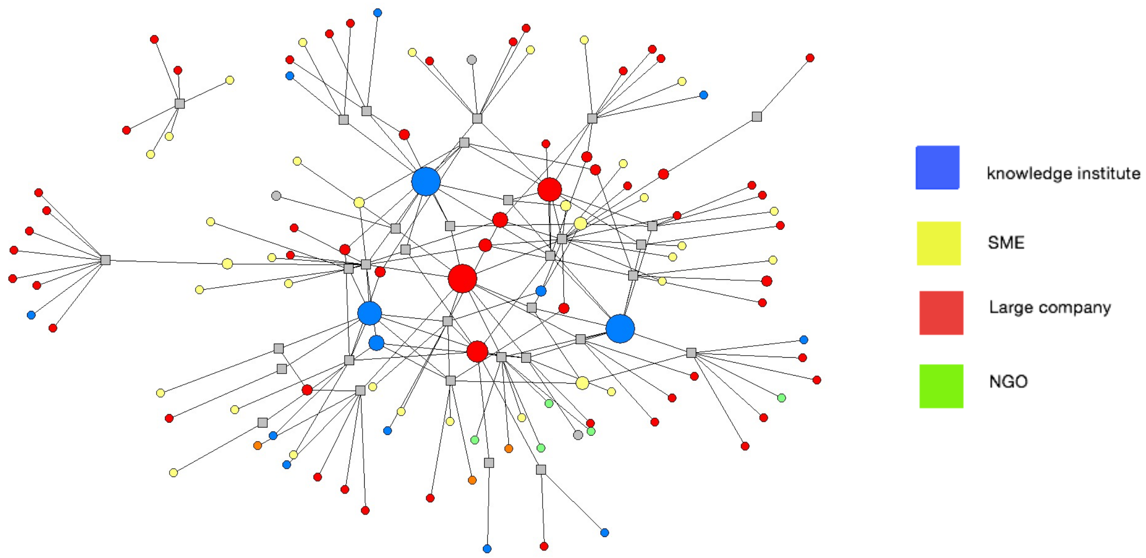
5.3.c Network of the TKI Gas, node colour by type of actor and shape by programme line



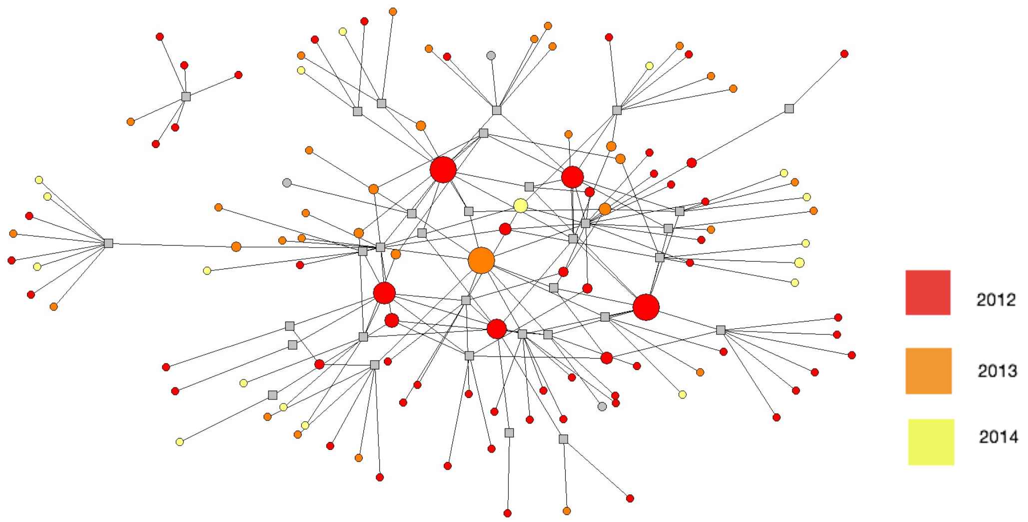
5.4: Network of the TKI Smart Grids

The square nodes represent the projects and the round nodes represent actors. A link means that the actor is participating in the project. In network graph 5.4.a, the colour of the node represents the type of actor. In network graph 5.4.b, the colour of the node represents the year the actors was involved for the first time in a project. The size of the node represent the degree, meaning to how many projects the actors is connected.

5.4.a Network of the TKI smart grids, node colour by type of actor



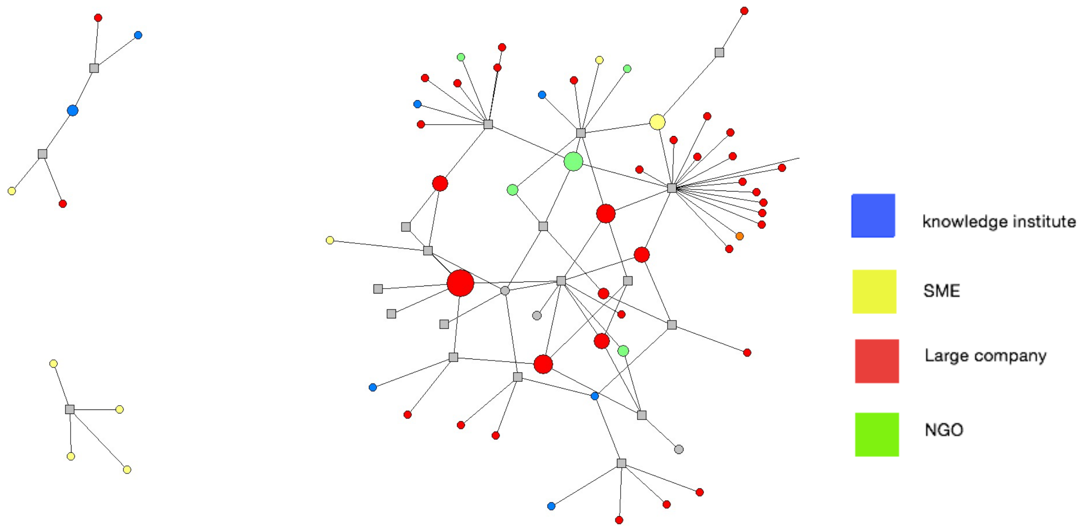
5.4.b Network of the TKI smart grids, node colour by year



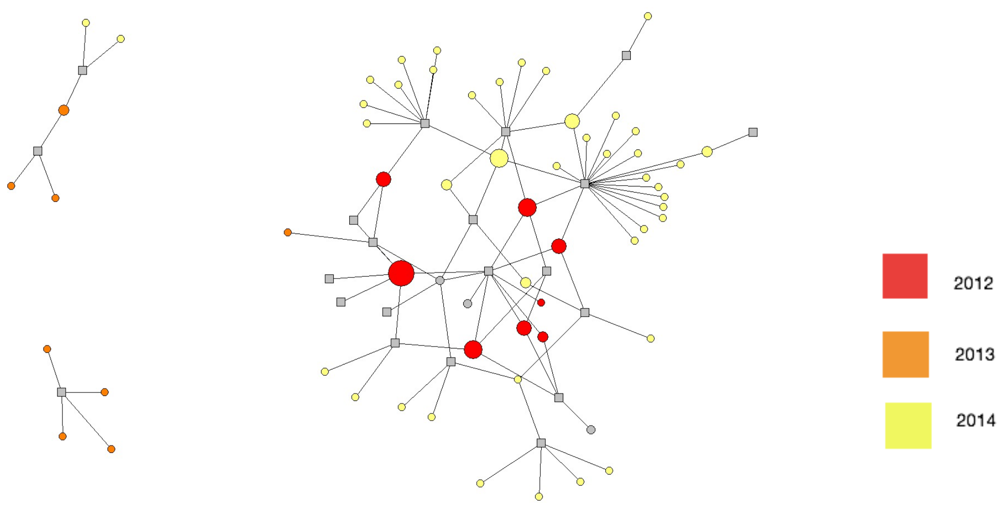
5.5: Network of the programme System Integration

The square nodes represent the projects and the round nodes represent actors. A link means that the actor is participating in the project. In network graph 5.5.a, the colour of the node represents the type of actor. In network graph 5.5.b, the colour of the node represents the year the actors was involved for the first time in a project. The size of the node represent the degree, meaning to how many projects the actors is connected.

5.5.a Network of the programme system integration, node colour by type of actor



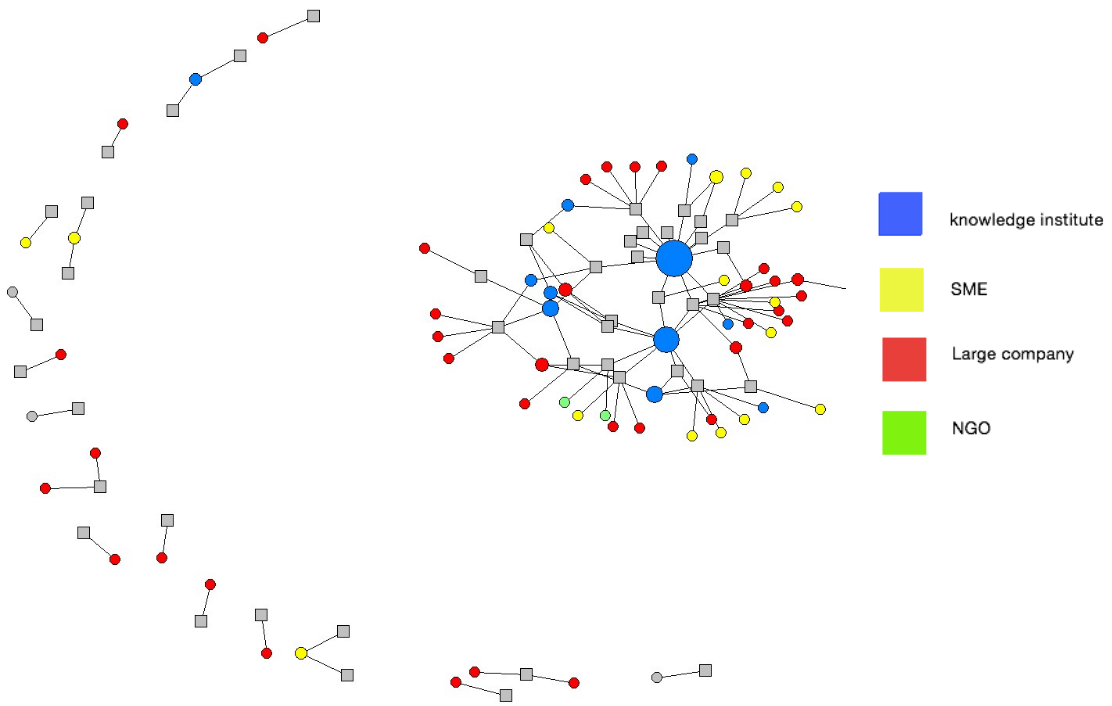
5.5.b Network of the programme system integration, node colour by year



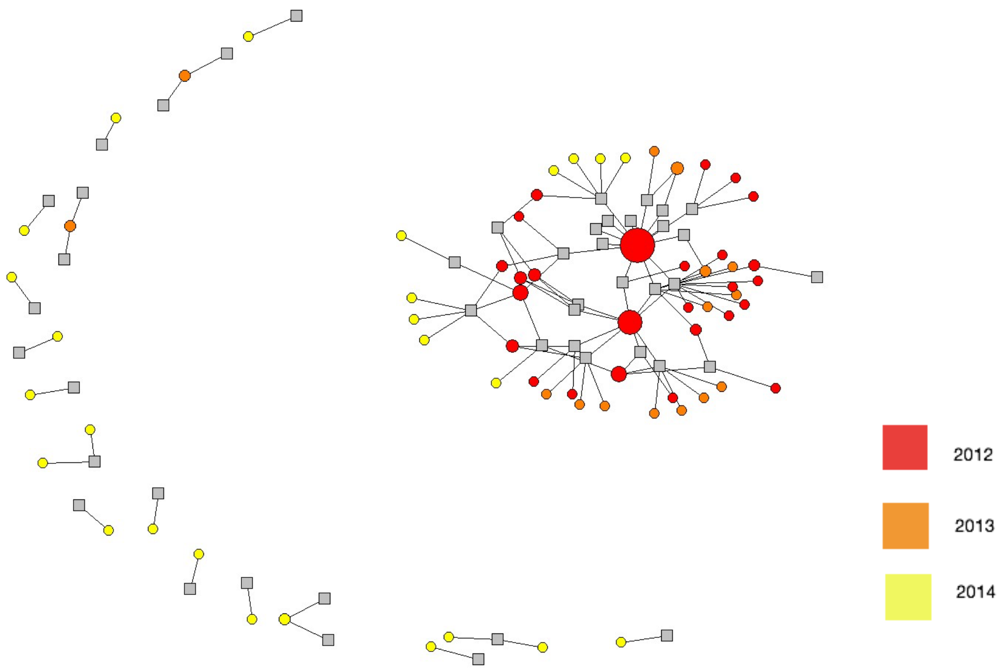
5.6: Network of the TKI Offshore Wind

The square nodes represent the projects and the round nodes represent actors. A link means that the actor is participating in the project. In network graph 5.6.a, the colour of the node represents the type of actor. In network graph 5.6.b, the colour of the node represents the year the actors was involved for the first time in a project. The size of the node represent the degree, meaning to how many projects the actors is connected.

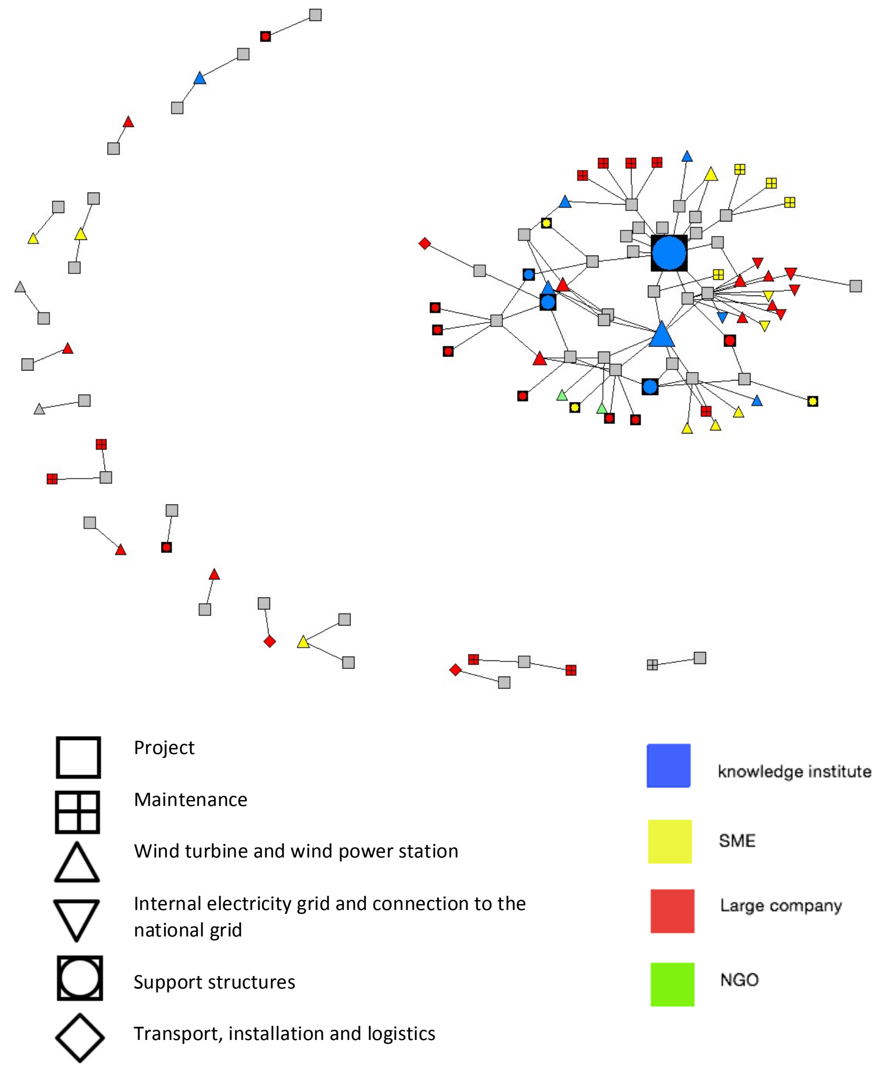
5.6.a Network of the TKI Offshore wind, node colour by type of actor



5.6.b. Network of the TKI Offshore wind, node colour by year



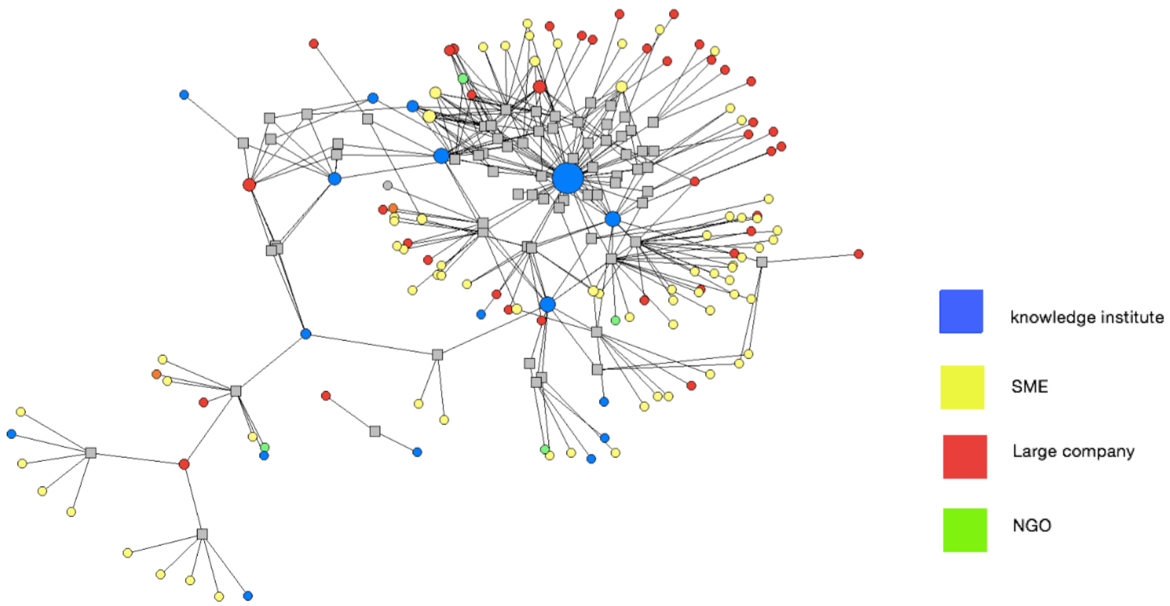
5.6.c Network of the TKI Offshore wind, node colour by type of actor and shape by programme line



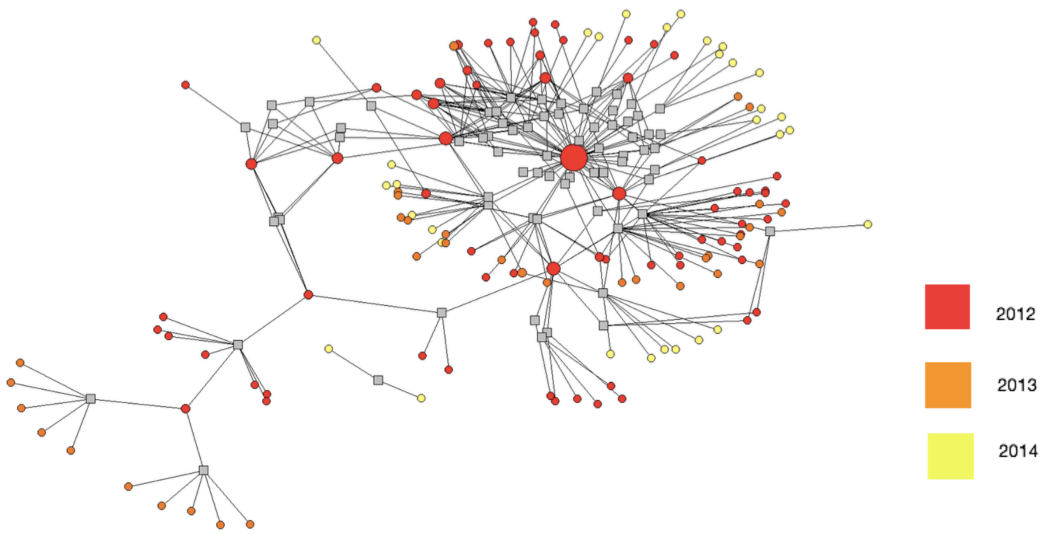
5.7: Network of the TKI Solar Energy

The square nodes represent the projects and the round nodes represent actors. A link means that the actor is participating in the project. In network graph 5.7.a, the colour of the node represents the type of actor. In network graph 5.7.b, the colour of the node represents the year the actors was involved for the first time in a project. The size of the node represent the degree, meaning to how many projects the actors is connected.

5.7.a Network of the TKI Solar energy, node colour by type of actor

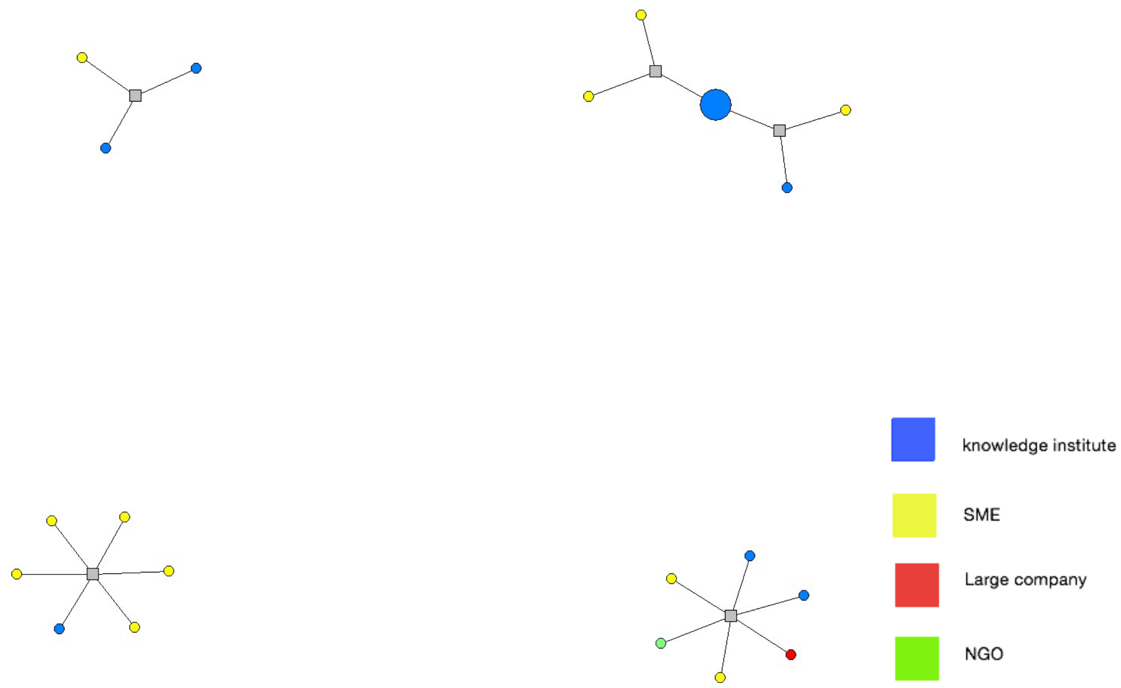


5.7.b. Network of the TKI Solar energy, node colour by year



5.8: Network of STEM

The square nodes represent the projects and the round nodes represent actors. A link means that the actor is participating in the project. In network graph 5.8.a, the colour of the node represents the type of actor. This TKI does not have a graph with colours representing the years, since the database only consists of projects from the year 2014. The size of the node represent the degree, meaning to how many projects the actors is connected.



Appendix 6: Observation notes TKI Urban Energy

Researcher: L.J.M. van Son
30 april 2015
Beatrixgebouw, Utrecht

Evenement: *Samen geven we vorm aan de kennis - en innovatieagenda 2016 – 2019*
TKI's Switch2Smartgrids, Solar Energy, Energo

Startpresentatie:
Vanaf volgend jaar gaan de drie TKI's fuseren en worden ze samen 'Urban Energy'.
Deze sessie is ervoor bedoeld om de programmering voor 4 jaar vast te leggen, 2016-2019.
Er wordt getracht een 'combinatie te vinden' van de energietransitie en waar we economisch goed in zijn.
De scope van de drie TKI's begon veel overlap te hebben. Het is een systeemverandering, cross-overs waren duidelijker.
Daarom is de TKI Urban Energy erop gericht om decentrale energie opwekking, opslag en distributie te stimuleren. De andere TKI's binnen de topsector energie zijn meer centraal.
De tenders van 2015 waren al gebundeld onder de naam Ideego. Dit is 'geen bezuiniging maar een versterking'.
Data wordt als cruciaal gezien in de decentrale netten.
Er zijn vijf programmalijnen:

1. zonnestroom
2. warmte en koude
3. multi-functionele bouwdelen
4. regelsystemen
5. flexibele energie-infrastructuur

1. zonnestroom

Nederland is goed in technologieproductie, apparaten en nieuwe materialen.
De programmalijnen zijn Cr-Si zonnecellen, dunne film, een combinatie van voorgaande twee, andere componenten.

2. warmte-koude

Een aantal programmalijnen waaronder warmtepompen en zonne-collectoren.

3. multi-functionele bouwdelen

Meervoudig gebruik maken van de ruimte. Integreren van de installatie en productie, ook bijv geschikt maken van technologie voor ongeschikte gevels.
In zowel gebouwde omgeving als infrastructuur toepasselijk. De link met de bouwsector is erg belangrijk.

4. regelsystemen

Regelen en meten levert meer data op. Op basis van die data kunnen nieuwe diensten ontwikkeld worden en energiestromen geregeld worden. Daarmee kan duurzame energie optimaal gebruikt worden. Belangrijke andere partijen hierbij zijn ESCO's, energie coöperaties en netbeheerders.

5. flexibele energie infrastructuur

Je kan beter intelligentie inbouwen dan het net verzwaren.

Twee discussierondes aan de tafels:

1. zonnestroom

Er zitten gaten in het vermarkten.

- In R&D wordt er al geen rekening gehouden met vermarkten, waardoor dit later niet mogelijk is.
- Programmalijnen erg gericht op efficiëntie, terwijl opschaalbaarheid belangrijker is.

- Er moet een koppeling gemaakt worden met de omzet van de industrie. Het geld wat je investeert moet in verhouding zijn met de winst die het oplevert.
- Het ministerie kijkt direct naar omzet en arbeidsplaatsen die een investering oplevert.

Moet je een keuze maken of overal op inzetten?

- er is nu geen focus
- er is geen aanpassing aan waar bedrijven mee bezig zijn
- de markt moet richting geven
- TKI kijkt nu sterk naar Nederlandse bedrijven, de eindverbruiker die gaat verbruiken zit niet in de projecten.
- Dingen ontwikkelen voor de markt, dat is de focus!
- Uitgaan van de krachten van Nederland: stimuleren van een technologie omdat Nederland er bedrijfsleven in heeft. Maar heeft een bedrijf niet iets heel anders nodig zoals regelgeving?

Juist de opschaling is lastig om financiering voor te vinden.
Je moet technologie stimuleren op het uiteindelijke potentieel.
Nieuwe technologie heeft niche nodig waarin het kan concurreren.
De rol van de TKI is om innovatie te stimuleren en een brug te slaan naar de volgende stap.

2. multi-functionele bouwdelen

Er wordt een partij gemist in verzekeringen en certificaten op de markt door multi-functionele bouwdelen.
Het gaat om het totale concept van de woning waarin het uiteindelijk gebruikt wordt.
De producten zijn er, waarom worden ze niet gebruikt?

- installatiewereld en bouwwereld losse werelden
- ontbreekt aan een visie
- leren door te doen
- lef om te experimenteren
- de enige manier om de technologie te gebruiken is door de normen aan te scherpen
- maar, als de vraag er wel is, zijn er dan de goede producten?
- Bijna niemand kan de eerste 100 bouwdelen leveren, die zijn veel te duur.
- Waar willen we met de sociale huurwoningen naar toe? Concrete doelen zijn nodig. Industrie/bedrijven kunnen daar dan naar toe werken.
- Focus/alles open houden
    - Alle gebieden zitten nu in de programmalijnen
    - Versnipperd, we hebben directe richting nodig
    - De keten moet georganiseerd worden, zodat je het op grote schaal kan doen
    - Het is een verspilling van tijd om het in zoveel stukjes te hakken
    - Overheid kan niet kiezen voor een technologie, dat is niet goed voor innovatie
    - Betaalbaarheid is de drive bij woningcorporaties, alleen duurzaamheid is niet genoeg.
- Overheid moet normen strakker trekken samen met stimuleringsinstrumenten
    - Overheid moet sterke normen hebben

4. Intelligente energieregelsystemen en ondersteunende diensten

In de definitie zitten geen begrippen van haalbaarheid, schaalbaarheid, en hoe wordt het geaccepteerd door de klant, bijv. de doelgroepen. Ook zitten privacy en security niet in de definitie, of gedragsaspecten.
Gedragsaspecten zou een doel op zich moeten zijn.
Voor wie doen we het en waar toe?
Verschillende doelen conflicteren soms. Gebruiker moet mee kunnen kijken en het klimaat kunnen regelen binnen huis.

Tafelleider antwoordt dat deze sociale aspecten oorspronkelijk bij de TKI's zaten, zoals gelezen kan worden in het innovatiecontract 2012 van de TKI smart grids, waarin expliciet de sociale aspecten genoemd worden. Echter, de topsector energie heeft besloten om alle sociale aspecten te verleggen naar STEM en weg te halen bij de TKI's.

5. flexibele energie-infrastructuur

Moeite met 'op de lange termijn' en berekenen wat de economische voordelen zullen zijn.
De overheid heeft een belangrijke rol in het mogelijk maken van proefprojecten door de regelgeving flexibeler te maken.
Lokale warmtenetten zijn lastig te organiseren door meerdere aanbieders en afnemers

- meer onderzoek is nodig in hoe dit organisatorisch aan te pakken is.
- Wie gaat dat beheren? (zoals een netbeheerder in het elektriciteitsnet).
- Riothermie is warmte halen uit rioleringen, dit kan gekoppeld worden aan het rioolvervangingsplan.
- er moet eerst een student ingezet worden om precieze temperaturen te bepalen etc. en haalbaarheid
- wordt geparkeerd

2. Warmte/koude

We willen meer maakindustrie -> worden ook projecten gehonoreerd die de productie goedkoper kunnen maken?
Lage temperatuurnetten valt nog buiten de definitie.
Ga je de zon gebruiken voor elektriciteit of warmte?
Esthetiek is ook belangrijk voor zonne-collectoren.
De gebruiker is heel belangrijk in ventilatiesystemen, die staat er nu niet in. Ook de feedback die gegeven moet worden aan de gebruiker over de luchtkwaliteit.

- link gezondheid mensen en materialen filters
- filter minder onderhoudsgevoelig maken, omdat mensen hun rooster niet tijdig vervangen

Elektriciteitsopslag zit helemaal niet in de TKI want hier in zijn weinig bedrijven en onderzoeksgroepen, zoals Tesla in de VS.

Eindpresentatie, van iedere tafel geeft de tafelleider een korte samenvatting:
(punten die nog niet genoemd zijn in de voorgaande notities)

1. Solar

De doelstellingen van de TKI moeten meer beredeneerd worden vanuit het hele systeem.

2. Warmte-koude

Laag-temperatuur afgifte staat niet op de agenda van de programmalijnen.
De doelen zijn niet SMART, wat wil je bereiken?
Kostenverlaging is een belangrijk criterium.
Efficient produceren.

3. Multi-functionele bouwdelen

Waarom willen we ze eigenlijk?
Ontwikkelen we wel de goede producten?
Voor een samengesteld product is een systeemcertificaat nodig dat het aan de normen voldoet. Een partij die dit doet bestaat nog niet.
De overheid als inkoper kan ook zorgen voor meer vraag hiernaar.

4. Intelligente energieregelsystemen en ondersteunende diensten

Aansluiting van 4. en 5. verdient meer aandacht.
Hier is certificering ook een issue.
Omdat je ICT implementeert, is er een nieuwe governance structuur nodig. Wie beheert de data?
Overbruggen valley of death:

- Traditionele bedrijven wachten of het ook zonder deze technologieën kan.
- MKB'ers hebben geen 3 jaar de tijd daarvoor

Te technocratische benadering!

5. flexibele energie-infrastructuur

Het belang van gelijkstroom komt nu nog niet genoeg aan de orde.
Ook marktmechanismen belangrijk binnen het net.
Er moet snel nagedacht worden over standaardisatie en wat de privacygrenzen zijn wat betreft open data.
Telecom en netbeheerders moeten sterker aan elkaar gekoppeld worden, dit is een belangrijke rol van de TKI.