Incumbents in transition: How the natural gas regime accelerates radical innovation in the gas supply

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Abstract

A common perception in the field of societal transitions is that large, incumbent firms rarely introduce system innovations. Incumbents tend to consolidate their market positions with relatively small incremental innovations. They may even turn away entrepreneurs who come up with radical innovations. As a result, radical innovations tend to come from small firms, the new entrants.

In 2004 the Dutch government initiated a national public-private partnership called Platform New Gas to sustain the Dutch natural gas system. The Platform consists mainly of incumbents. The central element in this paper is to understand the role of incumbents in the Dutch energy transition. Will they inhibit or champion change in the Dutch natural gas supply?

To monitor the effect of the incumbents we use the Technological Innovation Systems (TIS) framework. This framework was first used to map the dynamics in the biogas innovation system between 1974 and 2003. We mapped the dynamics and the actors involved between 2004 and 2011.

This resulted in a better understanding of the role of incumbents in the transition of the natural gas system. Together with new entrants and (local) government focused on a sustainable (new) market for digestion: the substitution of natural gas by green gas. Thus, legitimising the Dutch government's support with new institutions. These institutions will provide a structural change in the Dutch innovation system on biogas.

1. Introduction

In 2001, the fourth Dutch National Environmental Policy Plan (NMP4) adopted a transitions approach aiming at 'system innovation' in important societal domains like energy. The NMP4 proclaimed that persistent environmental problems like climate change cannot be solved by intensifying current policies. Instead the plan argues, 'solving the major environmental problems requires system innovation;…a long drawn-out transformation processes comprising technological, economic, socio-cultural and institutional changes' (VROM, 2001, p. 30).

Transitions are co-evolution processes that require multiple changes in socio-technical (innovation) systems. Transitions involve both the development of technical innovations and their use in societal application domains. Transitions can also be described as long-term processes with a radical shift in the system configuration and as multi-actor processes, which entail interaction between social groups such as firms, user groups, scientific communities, policy makers, social movements and special interest groups (Rotmans & Loorbach, 2010). Innovation is a key process in transitions, as transitions require the development and diffusion of a wide range of new technologies alongside the development of new institutions and practices (Geels, Hekkert, & Jacobsson, 2008)

In 2004, the Ministry of Economic Affairs started the Energy Transition Platform initiative by involving participants from government, business and civil society (Smink, Hekkert, & Negro, 2011). Members of the platforms were predominantly organisations from business and academia that were explicitly active in the areas at hand. They were selected for their potential contribution to the development of new technologies or markets (Rotmans & Loorbach, 2010). Their task was to develop shared visions, transition paths and transition experiments (MinEZ, 2010).

Transition scholars argued that the Dutch Energy Transition policy did not succeed in increasing societal transitions because of the dominance of incumbent regime actors (Smith & Kern, 2009). This is in line with the common perception in the field of innovation (Negro, Alkemade, & Hekkert, 2011).

The central element in this paper is to understand the role of incumbents in the Dutch Energy Transition. Will the incumbents inhibit or champion the change in the Dutch energy system? To answer this question we examine the substitution of natural gas by green gas in the Netherlands.

Green gas is defined as bio-SNG or upgraded biogas (ECN, 2006). Bio-SNG is produced from dry biomass such as wood. Biogas, which is essentially methane together with about 30-40% carbon dioxide, can be produced from landfills, digestion of sewage sludge, or digestion of wet biomass from agriculture, the food industry or manure.

Green gas is essential for the substitution of 8-12% of the annual use of natural gas within the next 10 years (PNG, 2007). This substitution can be seen as a radical (product) innovation. It needs a substantially different core technology and provides higher customer benefits relative to the previous product generation in the category (Chandy & Tellis, 2000).

Negro, Hekkert & Smits (2007) used the Technological Innovation systems (TIS) framework to map the dynamics in the biogas innovation system between 1974 and 2003. To provide complementary insights to this previous work (S Jacobsson & Johnson, 2000) we used it to map the dynamics for the period 2004 – 2011.

The paper is structured as follows: first a short overview of the role incumbents play in transition and innovation system literature. In section 3 we describe the methodology we used to map the actors and dynamics in the Dutch biogas innovation system. In section 4 we describe the effect incumbents had on the dynamics in the Dutch biogas innovation system over the period 1975 – 2011. Finally in section 5, we will discuss the role incumbents have in the substitution of natural gas by green gas in the Netherlands.

2. Theory

Transitions and technological innovation systems: basic concept and system functions

Transitions are co-evolutionary processes that require multiple changes in socio-technical (innovation) systems. Transitions involve both the development of technical innovations and their use in societal application domains. Transitions are also long-term processes with a radical shift in the system configuration and as multi-actor processes, which entail interaction between social groups such as firms, user groups, scientific communities, policy makers, social movements and special interest groups (Rotmans & Loorbach, 2010).

In the past decades two strands of literature that seek to understand and analyse socio-technical transitions have been developed: the multi-level perspective (MLP) (Geels, 2002) and the technological innovation systems (TIS) approach (S Jacobsson & Johnson, 2000; J Markard & Truffer, 2008). The MLP distinguishes three levels (niche, regime and landscapes) where changes take place. It emphasizes how the alignment of trajectories within levels, as well as between levels produces transitions (Alkemade, Negro, & Hekkert, 2011). The TIS framework instead conceptualises the transition process as a build-up process of different technological innovation systems (Hekkert et al 2007).

Transition policy has a strong focus on disruptive or competence destroying innovations and on innovations that may contribute to the decline of the current socio-technical regime in the long-run (Alkemade et al., 2011). Innovation policy for economic growth does not necessarily have such a regime shift objective and therefore the focus is on competence-enhancing technologies. These technologies are perfectly aligned with the existing competences of firms and that strengthen the existing regime (Alkemade et al 2011). Competence-enhancing innovations can however also contribute to sustainability transitions when they improve the sustainability of the incumbent regime (Alkemade et al 2011). To study the substitution of the natural gas system by green gas made of biogas we therefore used the TIS approach.

A *Technological innovation system* (TIS) is defined as a 'network of agents interacting in a specific economic/industrial area under a particular institutional infrastructure or set of infrastructures and involved in the generation, diffusion, and utilisation of technology' (Carlsson & Stankiewicz, 1991). The TIS perspective highlights the dynamic of interplay of actors and broader institutional structures in technological fields (Carlsson & Stankiewicz, 1991; Musiolik, Markard, & Hekkert, 2012). The TIS is composed of a set of structural elements identified in literature: actors, institutions, interactions, and technology operating within a specific infrastructure (Wieczorek, 2012).

To define technology we took a theories of design and complex system perspectives. They present technologies are systems built up by sub-systems of lower order, while in turn being sub-systems of higher order systems. These elements are organised in value chains (Sandén & Hillman, 2011). Energy supply systems, such as the natural gas system in the Netherlands, care large technical systems (Hughes, 1987). These large technical systems encompass a capital-intensive infrastructure, a broad range of technical components and technologies and a variety of actors and institutions (Markard & Truffer, 2006).

The prime goal of a TIS is to induce innovation processes (Edquist, 2005). All activities that contribute to the development, diffusion and use of innovations are innovation processes. Hekkert et al (2007) carried out a literature and empirical study and identified seven key sub-processes that are important for the build up and functionality of TIS. These key sub-processes are: F1 – entrepreneurial activities, F2 – knowledge development, F3 – knowledge diffusion, F4 – guidance of the search, F5 – market formation, F6 – resources mobilisation, F7 – creation of legitimacy (Hekkert, Suurs, Negro, Kuhlmann, & Smits, 2007).

It is important that each individual system sub-process is served. The growth of a TIS can be related to the interaction dynamics between the system functions (Suurs, 2009). Positive interactions between system functions could lead to *virtuous cycles* that accelerate the growth of an innovation system and lead to the diffusion of a new technology (Negro & Hekkert, 2008; Suurs, 2009).

The dynamic analysis of biomass digestion in Germany shows that when positive functional patterns occur, and all sub-processes are present, fulfilled and interact with each other, a well-functioning innovation system is created (Negro & Hekkert, 2008).

Actors in innovation systems: incumbents in transition

We know that organisations strategically shape the technological field they are operating in (Musiolik et al., 2012). To clarify the role organisations play in the innovation system, i.e. to assess their contribution to the innovation process we have to analyse the innovation activities of different actors and their effect on the functioning of the innovation system (Jochen Markard & Truffer, 2006). We therefore delineated categories of actors (individuals, organisations and networks) based on the their role in the economic activity: civil society, government, NGO's, companies, knowledge institutes and other parties such as legal organisations, financial organisations/banks, intermediaries, knowledge brokers and consultants (Wieczorek, 2012).

From an innovation perspective, three types of *actors* are particularly interesting: incumbents, entrepreneurs, and the government (Smink et al., 2011). *Incumbents* are actors that mainly have competencies related to the current technological regime, and that (financially) benefit from existing practices. *Entrepreneurs* are individuals who discover and exploit new market opportunities (Shane & Venkataraman, 2000). The existence of entrepreneurs in innovation systems is of prime importance. Without entrepreneurs, no innovation would take place and the innovation system would not exist (Negro & Hekkert, 2008). The government is often confronted with both types of actors and needs to find a balance in dealing with both interests (Smink et al., 2011).

Innovation theory strongly suggests that incumbents are less likely to introduce radical innovations (Utterback, 1994) than non-incumbents. Incumbents tend to consolidate their market positions with relatively small incremental innovations. They may even turn away entrepreneurs who come up with radical innovations (Chandy & Tellis, 2000). Chandy and Tellis (2000) showed that this so called 'Incumbency curse' may apply in previous economic periods and for the United States, but no evidence has been found to suggest that small firms and non-incumbents are marginally more likely to introduce radical innovations than larger firms and incumbents. Perhaps a co-evolution of “Emerging Davids” and “Greening Goliaths” is more likely to result in sustainability than either of the two alone (Hockerts & Wüstenhagen, 2010).

Firms who wish to successfully commercialise sustainable innovation need to devote considerable attention to convincing customers that the product they are offering is not just good for society, but also good for themselves (Hockerts & Wüstenhagen, 2010). For radical innovations, new markets co-develop with new technologies (F. W. Geels et al., 2008). *“Without the presence of a niche market, system builders would get nowhere…..they [are] building a constituency behind a new technology”*(Kemp, Schot, & Hoogma, 1998). Market creation; however is a major challenge given that fields typically consist of constituents with different interests and more advantageous positions (Brint and Karabel 1991 in Vermeulen et al).

The *Government* is a central player in market creation (Vermeulen, Buch, & Greenwood, 2007). Its role is to establish basic institutional structures – property rights, rules of exchange – that prescribe how actors will function within the market setting (Campbell & Lindberg, 1990; Dobbin & Dowd, 1997). Singular attempts at market creation are likely to lead to failure, even where regulatory agencies impose legal requirements on field constituents (Tolbert & Zucker, 1983). An alternative is to join forces and establish coalitions in formal networks. In this way, firms and other actors can establish or change institutional structures at the level of innovation systems (Musiolik & Markard, 2011).

3. Methodology

In this paper, we use an actor-oriented innovation system analysis to clarify the role incumbents play in the substitution of natural gas by green gas in the Dutch energy system. This task can be translated into an analysis of the actors involved and the effect their activities have on the functioning of the innovation system. Using empirical data as the basis, the effect of actors on the interactions between the system sub-processes can be assessed to determine whether a positive or negative cycle takes place (Negro & Hekkert, 2008).

Firstly we delineated categories of actors (individuals, organisations and networks) based on their role in economic activity (Wieczorek, 2012). We define actors in civil society/NGO's, government, companies and knowledge institutes.

To measure *incumbency* we firstly identified the product generation that preceded the radical innovation, in this case natural gas or electricity produced out of coal or natural gas. We then defined a firm as an incumbent if it manufactured or sold products that belonged to the previous product generation on the introduction date (Chandy & Tellis, 2000). We defined it as *new entrant* if it did not.

For *entrepreneurship* size matters. The most common measure of the size of the firm in the innovation and evolutionary economics literature is the number of employees (Chandy & Tellis, 2000). We defined a firm as small if it employed fewer than 50 employees, medium if it employed 250, and large if it employed more than 250 employees (EU recommendation 2003/361).

To monitor the effect of the incumbents and new entrants on the functioning of the innovation system we used the functions or sub-processes[1] of innovation (M. P. Hekkert et al., 2007; Negro & Hekkert, 2008). To map the dynamics in the innovation system between 2003 and 2011 we used the same historical event analysis and process analysis used by Negro et al (2007) as deployed by Poole et al (2000).

Table 1. Indicators for measuring innovation processes (Negro, Hekkert, & Smits, 2007)

Innovation process	**Indicator**
F1 - entrepreneurial activities	Project with a commercial purpose started/stopped
F2 - knowledge development	R&D projects, Investment in R&D, desktop/feasibility studies
F3 - knowledge diffusion	Network, coalition *Brochures, instructions, Best practices*
F4 - guidance of the search	Positive/negative expectations Regulations by the governance Expressed deficit of regulations
F5 – market formation	Specific favourable tax regimes and environmental standards Expressed lack of favourable tax regimes and environmental standards
F6 – resource mobilization	Subsidies, investments Feedstock allocated to the project Expressed lack of subsidies, investments Shortage of biomass streams allocated to the project
F7 – advocacy coalition	Support by government, industry Expressed lack of support by government, industry, dissent

For the period 2003 – 2011, we used the Innovation Sensor database (NL Agency, 2011). NL Agency developed this sensor to monitor the energy transition in the Netherlands since 2004. It contains project, application, actor and organisational information on more than 80 digestion innovation projects, more than 120 production plants, feasibility studies, desktop studies and other activities undertaken by actors to diffuse knowledge on the digestion of biomass in the Netherlands. These activities were classified and systematically allocated to the specific innovation processes (see Table1) and the actors involved.

4. The development of the Dutch TIS on biogas

The Dutch natural gas system

Since the exploration of the natural gas field nearby Slochteren, Groningen the Netherlands has developed a large and well developed grid for transportation and distribution of the gas to more than 6.5 million consumers.

Large incumbent actors are responsible for the natural gas system in the Netherlands. The Dutch Gasunie N.V. is responsible for exploration and processing of the natural gas for transport. GTS, which is part of Gasunie N.V. is responsible for transportation and storage of the natural gas in the high-pressure grid (67 and 40 bar), and thirteen regional gas distribution organisations such as Stedin, Enexis, Liander etc. are responsible for the distribution of the gas to customers and for grid integrity of the local low-pressure grid. Gas suppliers /shippers such as GasTerra, Essent and Eneco purchase the gas from the producer and sell it to their customers.

Natural gas comes in different qualities. In the Netherlands, almost all customers use G-gas. Large industry and energy power facilities have a special high-pressure grid that contains high caloric H-gas. These two grids are coupled. The quality and safety of the G-gas and H-gas is

1 Since 2012 Prof M.P. Hekkert rather uses sub-processes instead of functions of innovation. Within the Innovation sensor we use functions to define the different energy functions within an energy system such as conversion, distribution or the application of energy.

defined by Dutch law. The G-gas is a mixture of natural gasses from the large 'Groninger' field, gasses from small-scale fields (KV-gas) and imported gas. These natural gases have different specifications in terms of caloric value and Wobbe-index[2]. Gas Transport Services (GTS) is responsible for the quality, safety, transportation, and the specifications of these gasses.

The exploration of the small-scale gas fields will decrease within ten years, the Groninger gas field within thirty years. Dutch law guarantees the quality of G-gas for the next ten years. After that period, the specifications of G-gas will change due to the need to import high volumes of high caloric gas. 'Downgrading' of this high caloric gas to G-gas specifications will be too expensive. This 'transition' in specifications of G-gas will require changes in the applications within the residential, commercial, and small-scale industrial markets.

Gasunie N.V. introduced the gas hub as a new idea for the role of the Dutch gas system in the global gas market in 2003. According to this idea, the geographical location, harbours, extensive gas infrastructure, and use of empty gas fields as storage or seasonal buffer capacity makes the Netherlands the perfect location to become the main Gas hub of North-Western Europe. This new role requires new pipelines, NLG terminals and since 2007 the production of green gas. Digestion of wet biomass therefore, appears essential for the substitution of 8-12% of the annual use of natural gas within the next 10 years (PNG, 2010).

Period 1974 - 2003 based on (Negro et al., 2007; Raven, 2004)

The first experiments with digestion where in the 1970’s. Dutch farmers where faced with rising energy prices in the 1970s and 1980s. In an attempt to use local energy sources, researchers of the Agriculture University of Wageningen began to investigate energy generation from manure (F2). The produced biogas of the first plants was used to heat the farm and the sty. Electricity surpluses where fed back into the grid.

By 1985, 27 plants had been constructed (F1). The plants where vulnerable to technical breakdowns and biogas yields were much lower than expected (-F4). The innovation system for biogas consisted of small new entrants in the production of electricity such as farmers, technology suppliers and one research institute from the agricultural sector. Through lack of guidance (F4), market formation (F5), and resource allocation (F6), these initial experiments were not sufficient to expand the biogas innovation system .

In the 1990s, digestion appeared on the political agenda due to the expectations that much biomass waste would become available in the Netherlands (F4). Due to a limte of capacity for landfills, plans were made to stimulate households to separate organic waste from other waste. This compulsory collection of organic waste, which is an resource for biomass digestion, generated a new impulse for biomass digestion (F6).

Large incumbents from the waste/energy sector entered the innovation system. Between 1990 and 1994, four medium plants where built (F1). Due to government programmes a boost of research and knowledge diffusion activities also were undertaken (F2). To increase demand the government introduced a decree regarding the quality and purity of organic-waste fertiliser (F4).

In 1994, the large-scale collection and separation of organic-waste was introduced (F4, F6). Besides the collection of organic waste, landfill gas installations also were installed. Four of them refined the landfill gas to produce green gas (F1, F6). Large incumbents and green gas producers

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2 The **Wobbe Index** (WI) or **Wobbe number** is an indicator of the interchangeability of fuel gases such as natural gas, liquefied petroleum gas (LPG), and town gas and is frequently defined in the specifications of gas supply and transport utilities.

(in) directly owned these four landfill plants (Courage, 2007). Yet, no real acceleration of digestion for the production of green gas and electricity occurred. On one hand, the government openly expressed pessimistm about the technology of digestion (F4), on the other hand the market actors complained about the lack of financial support (F6).

In the late 1990s and early 2000, large incumbents from the energy industry together with technical agriculture knowledge institutes began to experiment with digestion of manure. At the same time large incumbents from the waste/energy industry experimented (F1) with the digestion of organic waste and the production of green gas from landfills.

Renewable energy was stimulated through taxation and grant schemes (F5). The government provided funds for research and experimentation, aimed at reducing agricultural methane emissions (F4, F6). Still the government assessment continued to be pessimistic (F4) along with a shortage of financial resources (F6).

Due to lower energy prices and the lack of a clear market for energy and fertiliser products (-F5) digestion plants where economically not feasible (-F4). The diffusion in the energy and fertilizer market therefore stagnated. Meanwhile, German and Danish actors increased their experiments with co-digestion (F1), adding biomass resources (F6) to manure. This resulted in technically stable, economically more feasible biogas plants, along with higher biogas yields (F1) (F. Geels & Raven, 2006).

Finally, political pressure to improve the circumstances for digestion in the Netherlands succeeded (F7). The Ministry of Agriculture changed the regulations on the use of substrate, which opened possibilities for co-digestion (F6), and therefore higher biogas production. In 2003, the Ministry of Economic Affairs introduced a feed-in tariff to increase investment in renewable electricity. The feed-in tariff (MEP) guarantees the renewable *electricity* supplier 9,7 Euroct/kWh over a period of 10 years (F5). Farmers received 5 Euroct/kWh from the energy companies. This amount was enough to cover the estimated cost of production.

Period 2004 – 2007

The new Cabinet initiated a Biomass Action Plan (F4) in 2003 to increase the use of biomass in the Netherlands renewable electricity market in 2010 and a public-private platform to ‘govern’ it. Members of this Bioenergy Realisation Platform (BERK) came from the Ministries of Economic Affairs, Agriculture and Environment, representatives of the regional government, energy and waste utilities, NGO’s and the largest bank in the agriculture sector (F3). They focused on monitoring the bioenergy projects e.g. permitting period and project development (F2), identifying and diffusion of the lessons learned to potential new entrants (F3). The BERK did not succeed in alignment in the discussion on sustainability (-F7) and availability (-F6) of biomass resources (SenterNovem, 2006).

In 2004, the Ministry of Economic Affairs initiated a new policy on energy innovation (F4) and subsidy programs (F6) to demonstrate innovative renewable energy technology. Another fund, which aimed at reducing agricultural methane emissions (see before) enabled twelve other demonstration projects of co-digestion to monitor the effect on methane emissions (F4, F6). The effect of the feed-in tariff (F5, F6), the demonstration projects (F1, F2) and the activities of the BERK (F4, F2) are shown in Figure 1.

The Ministry of Economic Affairs also initiated the Platform New Gas. Members of the Platform came from government, the natural gas and automobile sector, knowledge institutions, NGO's and sustainable energy. The mission of the Platform was *“..... to be the cleanest and most innovative gas country in Europe”* (PNG, 2008). The Platform focused on three pathways; the use of less natural gas in decentralised gas applications, the substitution of natural gas through hydrogen and green gas and if necessary ‘cleaning’ of the natural gas through capture and storage of CO_2 (F4).

In 2006, a TaskForce energy transition was initiated with 17 high level members from the Platforms and public sector. The TaskForce was chaired by the CEO of Shell Netherlands, who is also an influential member of the largest political party in the Netherlands: CDA. The Task Force formulated a transition action plan on energy themes and a set of recommendations for the new cabinet. The main issues raised by the TaskForce are the need for consistent energy policies that transcend political trends and a substantial increase in government investments in sustainable energy (Rotmans & Loorbach, 2010).

In 2006, due to positive expectations for the realisation of 9% renewable energy in 2010, the new Ministry of Economic Affairs announced the termination of the MEP feed-in tariff. Representatives of farmers successfully lobbied for a temporary feed-in tariff for already planned digestion plants (OVMEP). This succeeded and caused a peak in entrepreneurial activities in 2006 and 2007. In less than three months more than 80 plants where granted for the OVMEP feed-in tariff.

Period 2007 – 2011

In 2007, the TaskForce recommendations were adopted by the newly elected government as central to their energy and sustainability policy agenda “More with less” (Meer met minder) (F4). The Interdepartmental Project Directorate Energy Transition (IPE) was established because of the perceived need for policy integration (Rotmans & Loorbach, 2010). In the IPE, innovative government officials concerned with the energy transition in their domains such as energy, agriculture, mobility, housing and innovation worked together. The Platform published their vision on green gas (F4) in 2007. Substitution of 8-12% of the natural gas with green gas in 2020 is possible, 15-20% in 2030 and up to 50% in 2050 (PNG, 2007) (F4).

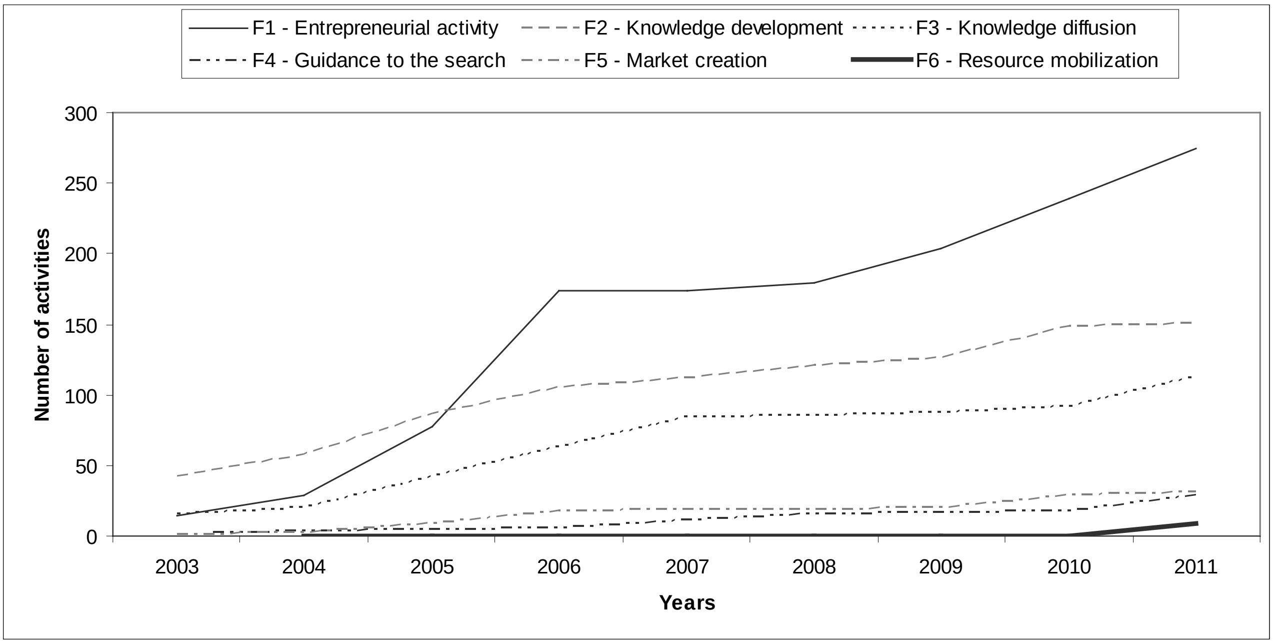

Figure.1 Cumulative number of innovation processes (NL Agency, 2011)

Two major routes were selected: first the production of biogas from local wet biomass, and second the production of large quantities of SNG out of imported wood (F4). The Platform also recommended the government to support their vision through a certification system (F4) and a feed-in tariff for green gas (F5), the development of subsidy programs (F6) to reduce the costs of digestion and to demonstrate the injecting of green gas in the grid (F2, F1) and for driving on green/natural gas (F5) and the formation of an innovation acceleration team on legal issues (F3, F7). (PNG, 2007).

In 2007 most digesters produced biogas to generate power and heat in a co-generation unit that fed electricity into the electricity grid. In only one of 40 biogas powered co generation units was the produced heat used for heating (SenterNovem, 2007). Without the using the heat, the overall energetic efficiency of producing electricity out of biomass is only 36%. In contrast, injecting the gas in the natural gas system is a promising alternative to the generation of electric power. After refinement of the biogas, including desulphurisation, dehydration and CO_2-separation, the gas can be injected into the natural gas system and can be used as a fuel for cars, for heating residential homes, or for power and heat production in industry.

IPE adopted most of the recommendations in their energy innovation policy plan called Energy Innovation Agenda. In 2008, the Dutch government published the Energy Innovation Agenda and the new feed-in tariff scheme for renewable energy (SDE). In 2009, a 30 million euro innovation programme (F4, F6) on green gas was launched. Lobbying (F7) for so-called biogas hubs led to a new feed-in category in the SDE in 2009 (MinEZ, 2010). Due to higher co-substrate prices and lower market prices on electricity not all the granted digestion plants where built (-F1) (Organic Waste Systems NV, 2011). Between 2007 – 2008 more than 20 plants stopped (-F1).

Figure 2 shows the production of biogas in the period 2005 – 2010. Only 10% of the biogas production in 2010 was used for the green gas market.

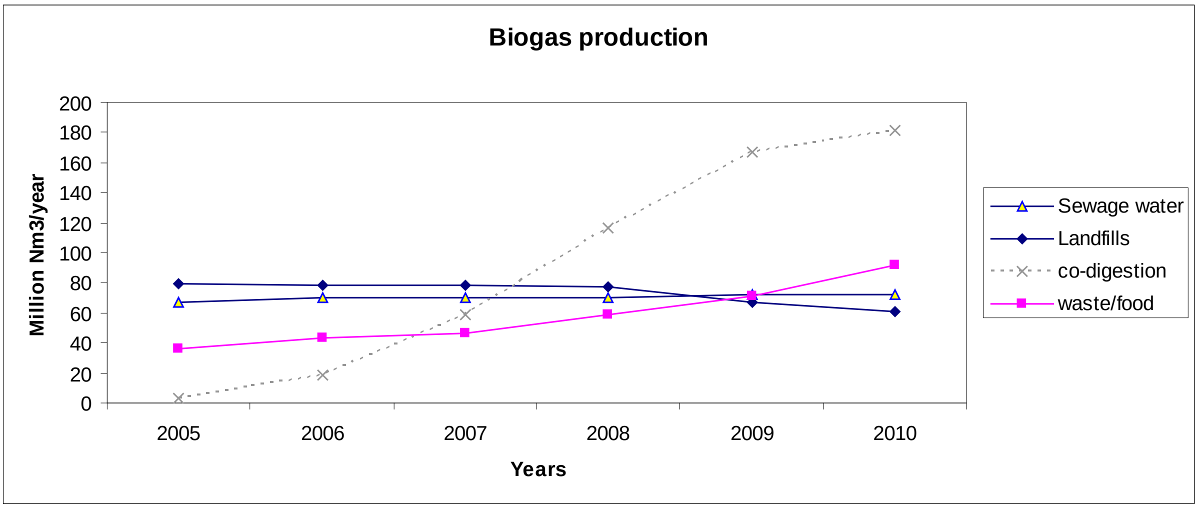

Figure.2 Biogas production in the Netherlands (CBS 2010)

In June 2009, the European Directive for Energy from Renewable Sources (RET) was published with renewable energy targets for the Netherlands. This directive used a different calculation method - the gross energy end-use method – while the Dutch definition is based on the substitution method (NL Agency, 2010). According to gross energy end-use method, the production of biogas for green gas counts equal to the production of renewable electricity. This results in a level playing field between the production of green gas, renewable electricity and heat. In the substitution method, renewable electricity counted almost three times the production of green gas. To realise this level playing field in the SDE feed-in tariff, the government raised the tariff for the production of green gas in 2009. Since then we have seen an increase of entrepreneurial activities (F1), knowledge development (F2) and diffusion (F3), as shown in Figure 1. Table 2 shows the effect of the level playing field in the allocation of the feed-in budget (NL Agency, 2011).

Table.2 Budget assigned to renewable energy production out of biomass[3]

3 This electricity category also contains small biomass combustion installations

Biomass	2008	2009	2010	2011
Electricity(M€)	63.7	569.4	400	100
Gas (M€)	20	236.7	190	1,000

Large incumbents from the energy industry are still rare in the core innovation process (F1). Figure 3 shows how many small, medium and large new entrants and incumbents take part in digestion projects. Small and medium-sized new entrants such as farmers and component suppliers form the 'working force' in the innovation system. They work together (F3) on incremental innovations to increase the performance of the technology and search for new business opportunities (F1).

Large incumbents in the Platform New Gas initiated assessment studies and desktop studies by influential experts on (sustainable) business (F2). They also organised discussions in networks on digestion (F3) to build up a common vision (F4) and were able to influence policy on the role of green gas in the natural gas grid (F7). Together with new entrants and (local) government, they focused on a sustainable (new) market for digestion: the substitution of natural gas (F5).

In this vision, we see a balance in the interests of the entrepreneurs, the incumbents in the natural gas system, and the (local) governments by creating a new market for digestion: green gas. Since 2010, this new business potential is widely accepted in the Netherlands. New large entrants from the food and medium-sized new entrants from the waste industry are planning large digestion plants to produce green gas (F1).

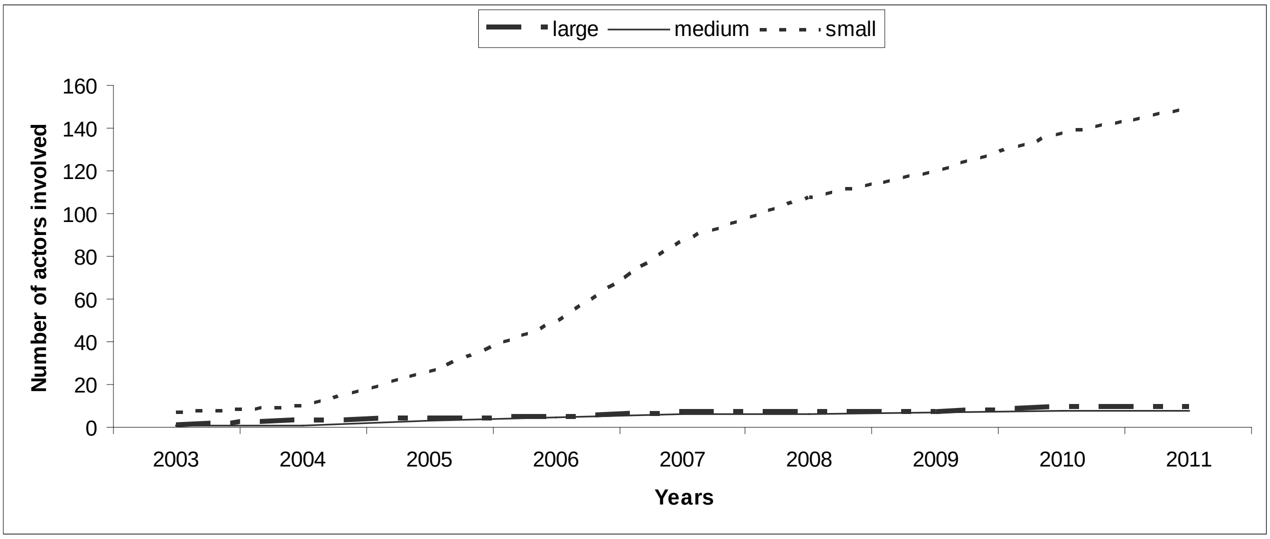

Figure. 3 Cumulative number of small, medium and large actors in digestion projects

In 2011 the SDE+ granted 1 billion Euros for green gas production and injection in the grid (subsidy period is 12 years). This means a potential increase in green gas production of 300 million Nm^3/year! Former members of the Platform New Gas set up a new public-private network called the Green Gas Forum (F3). Together with the national knowledge centre of green gas, they made a green deal (F4) to develop new green gas chains for more than 1.5 – 2 billion green gas in 2030! Besides this national deal, 10 regional consortia of potential large and small producers, local and regional government and intermediaries (F3) also made 'green deals' with the national government (F4) to increase the production of green gas (F1).

5. Analyses and conclusions

So, did incumbents in the Dutch energy transition inhibit or champion sustainable change in the Dutch gas supply?

Until 2003, the role of large incumbents in the innovation system on biogas was limited. In the late 1990s and early 2000, experiments were carried out with digestion and refinement of landfill gas (F1) for the first time. Due to low energy prices, no market perspective for fertiliser products (-F5) and uncertainty about regulations on the use of substrate (-F4,-F6), digestion was not economically viable (-F4). Therefore most incumbents stopped their experiments in digestion. Only five landfill gas plants operated by large incumbents where operational in 2003.

In 2003, only one large incumbent experimented with co-digestion (F1). In 2003 – 2005, large incumbents worked together with the government on the alignment of regulations (F4), informed local governments on legal issues (F3) and stimulated knowledge creation (F2). This resulted in the development of well-functioning innovation systems where all innovation processes were present, fulfilled and interacted with each other.

In order to sustain this build-up process, however, new markets such as district heating, transportation, or green gas are necessary. The energy yield of local electricity production without using the heat is only 36%, which is not sufficient for a sustainable business case on digestion. The large incumbents in the Platform New Gas therefore focused on a sustainable (new) market for digestion: the substitution of natural gas by green gas.

They initiated assessment and desk studies by influential experts on (sustainable) business (F2). Organised discussions in networks on digestion (F3) to develop a common vision (F4) helped influence policy on the role of green gas in the natural gas grid (F7). In this vision on a new market for digestion, we see a balance in the interests of the entrepreneurs, the incumbents in the natural gas system, and the (local) governments. Thus, the Dutch government supported this new market for digestion with new institutions (F6). These institutions will provide a structural change in the Dutch biogas and natural gas system.

The dynamic analysis shows that large incumbents champion change, not through experimenting with the new technology (F1) but through developing a shared vision of a (sustainable) business case (F4) for a 'growth' market (F5). Thus, legitimising the Dutch government support this new market for digestion, which is essential for the ‘take-off’ of the biogas digestion technology.

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