Comparison of energy transition initiatives between Germany and the Netherlands through the Quadruple Helix model

Comparación de iniciativas de transición energética entre Alemania y los Países Bajos a través del modelo de la tetra hélice

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Abstract

Given the global temperature increase in recent years, world leaders are developing climate change control initiatives aimed at achieving an Energy Transition; this means replacing the consumption of energy produced by fossil fuels with an energy consumption generated by renewable sources. In developed countries, it is observed that the collaboration between government, academia, society, and industry has generated more efficient transition processes than in those countries where the quadruple helix model for knowledge transfer has not been implemented. This article compares the energy transition initiatives, through the quadruple helix model, in Germany and the Netherlands because they are considered leading nations in the adoption of clean energy and their experience could be useful for other countries. In both countries, we observe collaboration among the four agents of the quadruple helix model, but also we observe the existence of a leader that boosts energy transition process: the Federal Government in Germany, and the Academy in the Netherlands. Finally, we point out that both countries use natural gas as an intermediate step towards the adoption of clean energy.

Keywords: Energy transition; quadruple-helix, driver intermediary

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Resumen

Dado el incremento de la temperatura mundial en años recientes, los líderes del mundo se encuentran desarrollando iniciativas de control de cambio climático enfocadas a lograr una Transición Energética; esto significa sustituir el consumo de energía producida con combustibles fósiles por un consumo de energía generada mediante fuentes renovables. En países desarrollados se observa que la colaboración entre gobierno, academia, sociedad e industria ha generado procesos de transición más eficientes que en aquellos países donde no se ha implementado el modelo de cuádruple hélice para la transferencia de conocimiento. En el presente artículo se comparan las iniciativas de transición energética, desde el modelo de la cuádruple hélice, en Alemania y los Países Bajos, naciones líderes en la adopción de energías limpias y cuya experiencia podría ser de utilidad para otros países. En ambos países se observa que la transición energética es liderada por uno de los agentes de la cuádruple hélice; el Gobierno Federal en Alemania, y la Academia en los Países Bajos. También se observa el uso del gas natural como un paso intermedio hacia la adopción de energías limpias.

Palabras Clave: Transición energética, cuádruple-hélice, líder intermediario.

1 Introduction

The scientific community points out that the global temperature has risen between 0.4 and 0.8 Celsius degree over the past 100 years (Hansen, 2010). So, Governmental Organizations (GO's) and Non-Governmental Organizations (NGO's) build a shared international agenda to develop and implement international strategies to get control over global warming, with initiatives to move the world energy consumption from fossil fuels to renewable fuels. In other words, the global community pursues a successful Energy Transition strategy (Stocker, 2014).

Given the importance of Energy Transition in fighting against climate change, its achievement requires human and technological resources (Etzkowitz and Leydesdorff, 2000). Empirical and theoretical studies agree that the correct application of such initiatives requires the sharing of technology, and knowledge, between the government, industry, academy and society. In this sense, the Quadruple Helix (QH) Model establishes a theoretical model that establishes strategies to reach technology transference through the collaboration between the previous actors (Yawson, 2009).

Despite the benefits of the QH model, its implementation represents a challenge for decision-makers since sharing property rights over technological patents is not clear when all the QH' agents participate in their development (Stocker, 2014). Even more, aside technology transfer, energy transition processes also require economic incentives to motivate the collaboration of all the QH's agents; particularly, note that the society and industry have economic incentives to leave the energy transition process given the high costs associated with clean energy production (Yawson, 2009; Kitzing and Weber, 2014; Kalkbrenner and Roosen; 2016). Although the implementation of the QH model presents the previous issues, in the international community, we can find success cases such as Germany and the Netherlands, countries where there exist a strong collaboration between the government, society, industry and academy. Even more, both countries are aware that fighting against climate change requires the active participation of the government, society, academy and industry (Emelianoff, 2013; Boon and Dieperink, 2014). So, the central aim of this paper is to develop a comparison between Germany and the Netherlands to understand how the QH model can contribute to reaching a proper energy transition process; we choose these countries given their socio-economic similarities and the fact that both countries fight against climate change via the energy transition strategy. Our analysis focuses on each QH agent to derive differences and coincidences between Germany and the Netherlands in their energy transition processes. By performing an exhaustive literature review, we summarise the best practices and the roles that each actor in the QH model plays in both countries.

We find that most of the German initiatives come from the Federal Government, who incentives the participation of the other agents in the adoption of renewable energies. In the case of the Netherlands, the Academy sector plays a major role in motivating the collaboration from the other actors in the QH model to adopt clean energies. Thus, although both countries base the development of energy transition initiatives on cooperation between the QH members, we show that their collaboration mechanisms differ given the presence of a "Driver Intermediary" in the energy transition process.

This paper is closely related to the literature that suggests the prevalence of a Driver Intermediary, an agent who leads the definition of strategies to reach a common objective, in the application of the QH model (Matschoss and Heiskanen, 2017). Moreover, in both countries, the driver intermediary first suggests the adoption of an intermediate energy source, like the natural gas, to compensate the fact that clean energy production does not satisfy the demand for energy.

The present paper is organized into four sections. Section 2 gives a general context of global warming, and the initiatives developed by the international community to fight against it. Section 3 analyses how the QH model performance in Germany and the Netherlands by summarising the activities of each agent that collaborates in the energy transition process. The last section, Section 4, presents the discussions and conclusions.

2 Contextual frame

In this section, we discuss international initiatives that pursue the transition from the use of energy generated by fossil fuels to energy produced by renewable energy sources. Moreover, we explain the role of the QH model in the energy transition process.

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2.1 Transition Energy

The Energy Transition refers to a long-term strategy for the development of political, social, academic and businesses structures that facilitate the adoption of clean energy. As we mentioned before, its successful implementation implies the adoption of clean energy, those produced with renewable sources, by all energy users in a country (Marchetti, 1977; Marchetti, 1980; Marchetti and Nakicenovic, 1979). The main problem in the energy transition process relies on the fact that clean energy production requires a high investment from producers that imply the imposition of high market prices; in other words, consumers and producer do not have economic incentives to transition from fossil fuels to renewable fuels (Guidolin and Guseo, 2016).

Despite the efforts made by the international to diminish oil energy consumption, Figure 1 illustrates that such energy covers a significant portion of the energy demand in the period 1990 to 2040. However, the Energy Information Agency (EIA) projects that renewable energy will have a growth spike, by the year 2020, as many energy producers are investing in the development of renewable energy and will smoothly move to replace fossil sources. Figure 1 also shows a decline in energy consumption coming from coal, a primary form of energy, and a steady trend in nuclear energy (EIA, 2016). It is worth noticing that natural gas energy presents a similar trend than renewable energy; the EIA expects that it will become the second source of global energy consumption by the year 2030, which makes it a definite mid step towards the fulfilment of the energy transition.

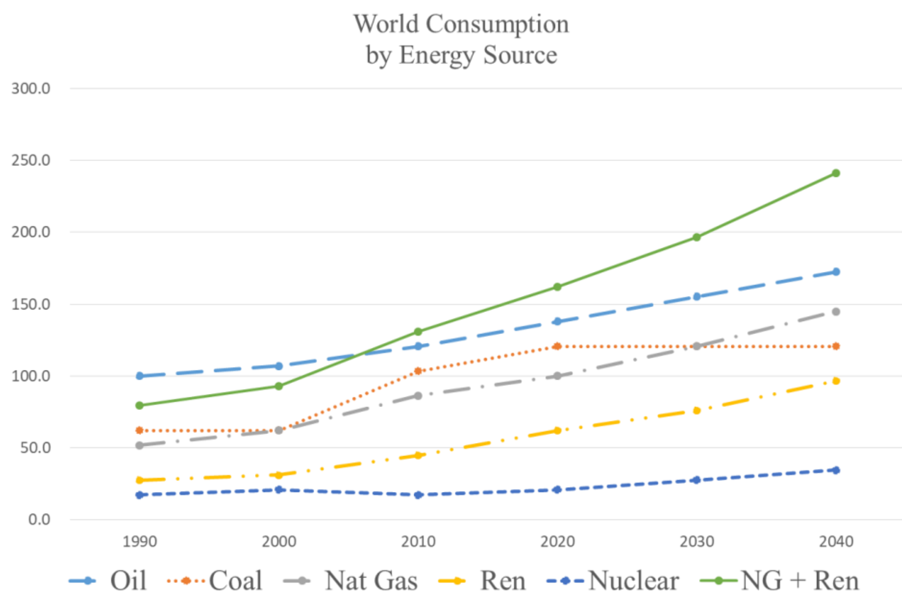

Fig. 1 Own elaboration with data from (IEA, 2016) (Indexed data, 1990 Oil source is base 100).

2.2 Global warming

The world population growth also has increased the rate of energy consumption, whose current supply mainly comes from fossil fuels. Among the negative consequences of supplying energy through the use of fossil fuels, the most problematic is the increase of Green House Emissions (GHE), which are the main factors associated with global warming (Mackay, 2008). So, over the last twenty years, the international community has invested a lot of time and resources to develop initiatives to control GHE (Klein et al., 2017).

Renewable energies, also known as the *Golden Energies*, are considered the ideal solution against climate change since they bring benefits for the environment and the society. The rise of the *Green Industries* will diminish the GHE via the creation of new jobs through the establishment of environmentally friendly firms that use golden energies in their production activities (Poltronieri, 2016).

Despite the positive externalities that the energy transition may generate on GHE mitigation, it faces financial and social challenges. Nowadays, and in the midterm, the fossil energy industry represents a significant source of employment, income, and profits for many countries; and it is also the cheapest and most accessible energy source for a big share of the global population.

Some authors suggest that it is not clear how the green industry may overcome such aspects given the high cost associated with its initial investment (Fagerberg, Laestadius and Martin, 2016). Moreover, even though there are efforts to replace energy coming from fossil fuels with renewable energy, the energy transition strategy, there is no general framework that indicates how to succeed in the diminishing of GHE and consequently how to slow/stop climate change (Zimmerman and Faris, 2011). Backstrand (2017) and Geels et al. (2008) indicate that reaching a total energy transition may take decades as the current state of renewable sources development does not fill the existing gap between consumption and production, see Figure 1 (EIA, 2016; Aleklett, 2009; Aleklett et al., 2010).

2.3 International initiatives on climate change

International efforts on climate change policies began in the early '90s when the United Nations (UN) adopted the *United Nations Framework Convention on Climate Change*, and the establishment of the *Kyoto Protocol*, an international agreement to diminish GHE (UN, 1992). Later, the Berlin Mandate, signed in the spring of 1995, follows to the Kyoto Protocol; its primary objective was to reach consensus over the stabilisation of GHE in the atmosphere (Mane and Richels, 1996). The Berlin Mandate clear the mechanism to diminish GHE by setting emission targets for the next 20 years in all developed countries. However, no specific objectives were specified for developing countries, which cause criticism around the mandate that caused the negative of countries like the United States to cope with the agreements on it (Depledge, 2005).

Although alliances between government and private organisations emerged to mitigate the industrial impact on climate change, these were not enough to build international synergies in the first decade of the 2000 years (Zimmerman and Faris, 2011).

In 2015, at the *Conference of parties 21* (COP 21) in Paris, a multi-national agreement over climate change was reached, namely *The Paris Agreement.* Its primary objective is to pursue and align different regional and national efforts to set and update targets to control global warming; specifically, the Paris agreement also establishes to keep the increasing on temperature below two Celsius degree (EIA, 2016). This conference brought an international hopeful spirit that a paced and structured transition from fossil to renewable energy is reachable since countries engage in developing a global collaborative framework that will not have social and financial affectations (UN, 2015).

The *Paris Agreement* was ratified during the COP 22 in Marrakech during November 2016, where the slogan *Together now!* was presented. This meeting reinforces the core message that we are all working along for effective actions to mitigate climate change; also, such slogan boosts the idea that everyone's collaboration is necessary for the *2050 Pathway Platform* (UNFCCC, 2016). The new mandate pretends that renewable energy sources will become the primary source of energy production/consumption, around the world, by the year 2050. At the same time, the UN is searching for developing a *hybrid multilateralism collaboration* agenda to develop different dimensions of collaboration such as multi-country; multi-region; GO's and NGO's, public and private industries, multi-university and civil society collaboration. In other words, the UN recognises the necessity of implementing the QH model to cope with COP 21 objectives (Backstrand et al., 2017).

Aside the international agreements, there exist regional efforts to diminish GHE and control climate change. Kelemen (2010) considers that the Europe Union is the leader on the implementation of an efficient energy transition strategy since it plays a significant role in leading global warming initiatives that motivate other European countries to change energy production processes and consumption (Backstrand and Elgstrom, 2013; Andersson, 2016). Notably, the region is an example of climate control since it has set setting challenging targets on GHE (Heidrich et al., 2016). The European Union calls them the *20-20-20* target (European Parliament, 2009), which consist of 20% decrease in GHE, 20% increase in energy coming from renewables and 20% improvement in energy efficiency. Given the differences among European Union members, these countries individualise the 20-20-20 strategy according to their features and capacity to reach the regional targets (European Commission, 2015). The region pretends to fulfil these goals by the year 2020.

The *success of the European Union effo*rts relies on setting regional targets and local objectives as well. In the local level, European cities are taking advantage of the *green trend* to speed up the development and implementation of the energy transition promoted by the regional climate change initiatives. Through these actions, local governments attract governmental and private financial resources to generate green industries, which generate benefits for the population (Bergmand and Bylun, 2012; Jonas et al., 2010). So, local initiatives pursue to diminish GHE but at the same time create new jobs, as well they improve environmental education and the image of city authorities (Anderberg and Clark, 2013; Metzger and Rader, 2013).

2.4 The Quadruple Helix model

Setting targets from the global to the regional point of view is the first step to reach the objectives of the *Paris Agreement*. However, given the involvement of different agents with specific objectives, it is necessary to establish a framework that strengths collaboration among them, which requires high tech capital. So, parallel to the energy transition, we have a problem of development and implementation of knowledge. In this sense, Etzkowitz and Leydesdorff (2000) introduce the concept of the Triple Helix (TH), a model that responds to the policymakers requisition for technological transfer, and that enhances the collaboration between the university, government, and industry to spread and apply knowledge.

Therefore, the central aim of the TH model is to implement, in an efficient way, the knowledge generated by universities and industries to increase social welfare. A proper knowledge implementation strength the bonds among all actors and enhances the coordination of the role that each one of them must play (Buehler and Pucher, 2011; Collier and Löfstedt, 1997; Emelianoff, 2013; Hall, 2014). Despite the agents' differences, the TH model emphasises that its agents share structural similarities in the knowledge creation process: universities through academy research, government with public and mission-oriented research laboratories, and the industrials by Research and Development (R&D) departments. (Lawton and Leydesdorff, 2014).

In 2009, the Society was added to the Helix model (Yawson, 2009), transforming it into what is now known as the Quadruple Helix. Cavallini et al. (2016) point out that processes leading technology and knowledge transfer improve with the society's participation since its perspective does not only consider the economic impact, it takes care on the social consequences which make the transfer a process more democratic (Arnkil et al.,2010; Woo Park, 2014). However, the interactions between the four agents are characterised by their complexity which implies the arising of conflict due to the particular objectives of each agent.

To avoid conflicts, Matschoss and Heiskanen (2017) identify that one of the actors in the QH model must act as a leader, an agent that they called as *the Driver intermediary* since it makes decisions on technological transfer that balance other agents objectives. So, this actor leads and sets a common vision that coordinates and balances the efforts of all actors to produce more efficient results (Jacobson et al. 2017; Villani et al. 2017; Gupta, Lasage and Stam, 2007; Lawton and Leydesdorff, 2014; Ranga and Garzik, 2015).

3 Comparison of energy transition between Germany and the Netherlands

In the previous sections, we indicate that the European Union is the leader in the definition and implementation of strategies to fight against climate change via the energy transition strategy. Also, we emphasise on the importance of collaboration among economic agents that participate in the QH model.

In this section, we compare the current status of the climate initiatives that drive the energy transition in Germany and the Netherlands since both countries recognise the importance of adopting new technologies, which also require the QH model implementation to transfer technology that friendly with the environment. So, we compare the initiatives of both countries via the activities that agents, involved in the QH model, perform. It is worth to mention that we choose such comparison given their similarities in climate initiatives concerns, economic development (World Bank, 2017) and similar human development index HDI (United Nations Development Programme, 2016), as the Table 1 shows.

	Germany		Netherlands		
	World Rank	**Measure**	**World Rank**	**Measure**	
GDP	4	$ 3,466,757	18	$ 770,845	US$ Milliion
GDP per capita	19	$ 41,936	13	$ 45,295	US$ Milliion
PPP	18	$ 48,730	14	$ 50,898	US$ per capita
Human Development Index	4	0.93	7	0.92	Out of 1.0

Table 1. Comparison of GDP, GDP per capita, Purchasing Power Parity and HDI.

Source: World Bank, 2017; UN, 2016

Both countries also share the vision of developing climate initiatives oriented to reach a smooth energy transition from fossil to renewable energies. They have established private organisations that are in charge of implementing these initiatives to fulfil the objectives derived from the 20-20-20 strategy. Table 2 presents the current stage of Germany and the Netherlands in the Energy Transition process; both countries have established similar target for the reduction of greenhouse emission.

	Green House Emission 2020 target		**Ranking within the EU in Climate**
	2020	As of 2012	
Germany	14%	24%	3
Netherlands	16%	8%	4

Table 2. Green House Emissions GHE targets and currently ranking within the European Commission Source: Own elaboration with data from the European Community, 2012).

3.1 Germany and the Quadruple-Helix

Below, we describe the activities that involved agents in QH model perform in Germany.

3.1.1 Government

Germany's government has boosted the replacement of fossil fuels with renewables for around twenty years. The Federal Government has placed a particular focus on environmental policies and now are in the process of being institutionalised across the country (Monstadt, 2004; Bulkeley and Betsill, 2003; Chmutina, Goodier and Berger, 2012). In this sense, its main climate initiative programme is the *Energiewende*, which means a change in energy.

The Energiewende is a national program that sets targets for GHE for the year 2025 and intends to reach a 100% renewable conversion by the year 2050 (Scholz et al., 2014). One of the strategies of this program has made that the Germany government sold their shares in energy companies to private investors, and now is the market the one that is driving the energy transition

(Heriter, 2002). Stepping out of their shares in energy production has boosted that new industrials and market niches emerge with the creation of new jobs and new educational curricula (Monstadt, 2007). So, Germany has experimented with an *ecological modernisation* of energy systems.

Also, the German Federal Government has shared and partially delegated the responsibility of climate initiatives implementation to the states through a programme named Bundeslander (Bundeskabinett, 2008). The Energiewende and the Bundeslander align GHE targets to the ones agreed with the UN (UNFCCC, 2013).

Germany had a strong push over nuclear energy, but after the Fukushima incident in 2011, the national approach of moving towards a nuclear power generation in Germany has shifted, and there is active consideration of phasing out that energy and look for a substitute. Natural gas technology is being seemed like the path to the future and has received substantial government support to become the intermediate step between fossil and renewables energies (Joas, F., Pahle, M., Flachsland, C., and Joas, A., 2016).

Table 3 describes the growth of consumption of different kinds of energies in Germany and the advance of renewables in the past fifteen years, now representing almost one-third of German supply. We note that German is moving towards its goals since fossil supply (oil and coal) have decreased in the last fifteen years, while renewables together with natural gas are replacing them with an increasing production path from the first ones.

	2000	**2010**	**2015**
Oil	100.0	83.6	79.7
Coal	68.0	63.3	62.9
Nat Gas	57.6	60.8	51.5
Ren	8.8	24.2	33.5
Nuclear	35.4	29.3	19.0
NG+Ren	66.3	85.0	85.1

Table 3. Growth of consumption of different kinds of energies in Germany.
Source: Own elaboration with data from the IEA (Indexed data, the year 2000 Oil source is base 100).

3.1.2 Industry

The German Industry has seen the transition from fossil energy to renewables with particular scepticism given its high costs; at this moment, the industrial sector requires financial support from the government. In other words, firms' efforts depend on the financial support that subsidies provide. Renewable energy depends on a series of interrelated and interdependent legislations and policies that include cross-governmental or direct subsidies (Sturm, 2017). One example is the cross-subsidy scheme that the country uses for the development of solar panels (Sanz-Casado et al., 2014). In the long term, German industrials are projecting that the clean-tech industry will be developed at a quicker phase and production costs will decline, so it can survive without any subsidies or the need to translate higher price to the end-user. Industry research and development departments are also working on developing new technologies for energy storage to stabilise the supply of renewable energy (The Economist, 2018).

From the financial standpoint, Chief Financial Officers (CFO's) in the German industry are performing continuous exercises on Net-Present-Value (NPV) about renewable projects. They need to be sure that, in the mid and long-term, financial results are favourable to attract private investors to fund the green industry, namely *green ventures* (Kitzing and Weber, 2014).

3.1.3 Academy

Universities play the role of facilitators or brokers on climate change initiatives (Geels and Deuten, 2006; Hargraves et al., 2013). An example of a collaborated work with the Industry was the CLEAN initiative, a pilot project between institutes of science and the industry (Kuhn et al., 2012). This type of coworking complements the Energiewende policy. The long-term goal of universities is to replace the government as the required link between research findings and their implementation within the industry. Universities have the social prestige to educate and guide citizens in the adaptation of climate initiatives and a strong reputation to properly coordinate the collaboration among QH actors, a partnership that otherwise it would not happen (Joas et al., 2016).

3.1.4 Society

German society plays a vital role thanks to the trend of *green projects* (private and public funds, coordinated by a group of people, to develop environmentally friendly *green enterprises*). This kind of projects provides an opportunity for citizens to be part of the energy transition system. Kalkbrenner and Roosen (2016) indicate people should feel that they can influence government decisions and industry initiatives to reach a fruitful collaboration with the society to the QH objectives.

The *Green Cooperatives* demonstrate that social collaboration is possible within the energy transition strategy. In these businesses, the German society is actively involved; their functioning requires excellent communication among them, government and the industry. Moreover, the community is the enabler between the central initiatives and their implementation at a local level for the functioning of green cooperatives, i.e., no other agent can manage a cooperative (Boon and Dieperink, 2014; Geels and Deuten, 2006; Hargreaves et al., 2013).

Citizen groups have been shaped in the country, and now, they are seen not only as an energy consumers both also as active players over the confirmation and transformation of an environmentally friendly energy system (Kalbrener and Roosen, 2016). These groups are educating other members of the society on being more efficient in energy consumption. The essence of these groups is the trust existing among them, as they are part of the same community, and share a common concern of a sustainable environment. Also, their structure comes from governmental policies and funds having the incentive that the community owns the cooperative, or remain in a partnership with public or private institutions (Walker and Divine, 2008; Walker, 2008; Yildiz et al., 2014).

Society faces some challenges as well. Usually, *Green Energy* is more expensive than energy coming from fossil fuels, and the government cannot provide subsidies for all the population to facilitate the consumption of such energy (Sturm, 2017). Hence, in the case of Germany, part of the society is reluctant to speed up the energy transition because they have to absorb some of the transition costs (Kalkbrenner and Roosen, 2016). Given this problem, the German government is working along with private and public financial institutions to solve this situation creating financial and non-financial incentives that are promoted to fund community energy projects, namely *Green investments* (Bomberg and McEwen, 2012; Monstadt 2007). These funds pursue to incentive the adoption of renewable energy in a faster pace creating a virtual cycle in which more users will build large-scale economies that will bring the cost of renewable energy down (Castan, Broto, and Bulkeley, 2013; Kivimaa et al. 2015; Würtenberger, 2011).

3.2 The Netherlands and the Quadruple Helix

Now, we review the activities that QH agents perform in the Netherlands. It is worth to mention that the Netherlands is located below the sea level, which makes them especially sensitive to climate change effects (Kavat et al., 2005).

3.2.1 Government

The Netherlands is one of the first countries, together with Germany, that established national climate initiatives (Gupta, Lasage and Stam, 2007). Thorugh the National Climate Policy (NCP), the central government develops national strategies including national climate goals, while provinces adopt and implement them at a local scale. For example, there are policies like the *Bestuursaccord Nieuwe Stijl* (BANS), and the *Climate Agenda: Resilient, Prosperous and Green* (Den Exter, R., Lenhart, J., and Kern, K. 2015). The BANS programme pursues that public buildings constructions, traffic, transport technologies, housing initiatives and businesses parks have an environmentally friendly design. Also, it actively promotes academic research on sustainable energy (Gupta, Lasage and Stam, 2007).

Netherlands climate initiatives are focused on two approaches that complement themselves: **Climate Adaptation**, which goal is the design of the future living, due to the climate change effects; and **Climate Mitigation**, which its core goal is to reduce GHE emissions (EZ, 2006).

Municipalities are crucial to implement and evaluate any strategy derived from the country's policies. Both government levels have relied on the Academy to get the flexibility for adapting national efforts to a local situation (Reckien et al., 2014).

	2000	2010	2015
Oil	100.0	112.1	98.7
Coal	27.7	26.9	38.9
Nat Gas	124.6	139.6	103.0
Renewables	12.8	15.1	18.5
Nuclear	3.6	3.7	3.8
NG+Ren	137.4	154.7	121.5

Table 4. Path of the oil supply index.

Source: Own elaboration with data from the IEA (Indexed data, the year 2000 Oil source is base 100).

Table 4 shows the path of the oil supply index. It shows a consistently increasing trend in renewable energy production in the Netherlands during the last 15 years. Thus, we can say that energy transition policies, in the Netherlands, were in the right direction by combining the production of renewables and the use of natural gas.

3.2.2 Industry

The Dutch industry is aware of the need for reducing their environmental impact in highly populated cities and actively participates in the energy transition process (OECD, 2015). For example, in the transport sector, dutch industrials are moving away from diesel to natural gas engines. National and private vehicle fleets, trains and ships in Netherland ports are examples of how the industrial sectors are moving from fossil to renewable through the natural gas energy (Inoue, 2012). Even more, local industries have joined forces with the municipal government to implement innovative solutions that won't affect the economics of the cities but improve the environmental condition at the same time. Concerning the urban design planning for transport efficiency, the construction sector has adapted its procedures and infrastructure to cope in a better way with environmental requirements (Merk, 2013).

The dutch industrials are working closely with universities and research centres to speed up the energy transition (Fusco, 2013). In general, they work closely with other members of the QH model, mainly with the Academy to be technologically prepared for the future environment condition.

3.2.3 Academy

Knowledge institutions, universities and research centres are working very closely with the other actors of the QH in the Netherlands and have taken the leadership to implement climate change control initiatives. They are commanding the development of technologies on CO2/GHE capture, transport, and storage; searching for energy efficiencies across value chains; and giving advice in developing sustainable entrepreneurship (Castan and Bulkeley, 2013). Schools are integrating knowledge sustainability in all its curricula, and implementing measuring elements that allow auditing the advance over the implementation of these initiatives, in their field and also supervising the implementation of government policies by the industry. One example is the

Audit Instrument for Sustainability in Higher Education (AISHE), instrument that today is used by the majority of schools of higher education in the country. Another example is the INHolland University, in which all their students are engaged in sustainability programs during his career, and their research projects must be related to this topic and practised in the industry at least for one scholar period (RCI, 2016).

Netherlands education system is not only a valuable actor of the QH model; its educational institutions are collaborating as an integrated unit. We could find many examples like the *Holland Program on Entrepreneurship* (HOPE), in which the Erasmus University of Rotterdam together with the Delft University of Technology and the Leiden University have developed an active and innovative centre for green entrepreneurship (OECD, 2010).

3.2.4 Society

Dutch society characterises on focusing on cooperation and innovation, features inherent to the Netherlands culture that has risen in an environment with a lack of natural resources and a complex orography (Backstrand and Elgstrom, 2013). Given the active collaboration between industry and academy and a proper direction set by the government, the Dutch society is aware of the importance of reaching a successful energy transition and have aligned easily with the guidelines imposed by government and academy (Merk, 2013). Dutch society is committed to growth education on sustainability as they understand that the ET will take time they procure to having people more educated on sustainability now and have a better standard of living in the near future (Fenton, 2015).

4 Conclusions

In this paper, we develop a comparison of energy transition strategies between Germany and the Netherlands following the interactions established by the QH model. In this comparison, we have found some similarities, like the establishment of a national energy plan or the use of an intermediate element that compensates the gap between the energy consumption and the current level of energy produced by renewables. But also differences, mainly related to the agent who drives the initiatives, the *Driver Intermediary.*

In the case of Germany, their energy transition is characterised by an active intervention from the government via a centralised climate program that takes care on providing financial support, for the generation of green enterprises and research on sustainable topics, and the adoption of green energy, via subsidies. Also, we note that the society and the industry play a more passive role since their participation depends on government support. Hence, the Federal Government closely watches over the industry, academy and society activities related to climate initiatives, i.e., the government act as the driver intermediary of the QH model in Germany.

Concerning to the Netherlands, we observe that the Dutch academy closely works with the other three members of the QH, all of them have complete trust in education institutions. Moreover, the Dutch academy has set up different programmes to promote knowledge transfer and implementation with the industry to strengthen the energy transition with the supervision of the central government. Hence, the academy is getting more involved to promote the energy transition by including sustainable topics in their curricula, i.e., it influences society by generating a better-prepared workforce on climate issues. Also, its close relation with the industry and the government has boosted the development of sustainable production processes and public policies to get control over climate changes. Given the impact of the Dutch Academy in the actions of the other QH agents, we conclude that it plays the role of driver intermediary.

Our paper contributes to the literature by identifying the presence of driver intermediaries in the functioning of the QH model. In other words, the complexity to transit from one type of energy to another requires that some agent leads the efforts by providing clear strategies, support and training and the utilisation of an intermediate energy element to reach a successful and smooth energy transition.

Despite the good climate results in Germany and the Netherlands, and the apparent success of the QH model in the transfer of knowledge and technology to impulse the energy transition, both countries recognise that renewables are not ready yet to take over fossil sources completely. In this sense, we identify that both countries have utilised a common energy transition element, which is the Natural Gas in order to compensate for the existing gap between their energy consumption and renewable production.

As stated before, we observed that both countries share similar climate control actions in order to boost energy transition. However, the implementation differs in Germany concerning the Netherlands. In table 5 we summarised the main practices of each country by each member of the quadruple helix.

	Germany	Netherlands
Government	• The federal government set the rules and gives positive or negative incentives depending on the kind of energy used, fomenting the rise of *Green Industries.* •Also drives the entrepreneurship of the society with subsidies to *Green cooperatives.* • Impulse the use of Natural Gas as the intermediate step for the energy transition.	• It is a facilitator that set the legal framework, both federal and local in order to reach a smooth transition. • It relies heavily on the academy for the implementation of its policies. • They promote the use of natural gas as the bridge from fossil to renewables by being part of climate control initiatives and adopting academic research findings.
Industry	• Industry activities rely on government incentives, or taxes, for using, or not, a different kind of energy. • Strong focus on financial numbers (NPV) of Green projects. • Take advantages of subsidies, especially on natural gas to adopt in a faster way alternative energies	• It is characterised by the fast adoption of new renewables technology •Since the Netherlands do not produce fossil fuels, the collaboration between the industry and academy is close for the adoption of new technologies. • Create synergies between government policies and academy research to implement them as fast as possible. • Uses natural gas instead of oil and coal to reduce cost and complying with federal and local regulations.
Academy	• The academy performs the activities of a broker through technology transfer offices. • It is focused more on research that speeds up new green technologies than coordinating efforts among QH members to reach a successful energy transition. Have a long term vision.	• It takes the lead of driving the ET by supporting federal and local energy policies implementation. • The academy shares new renewable research findings to the industry, and it drives the creation of *Green entrepreneurs* among society. • It develops an educational system that is proactive in the use of renewables. • Strong focus on obtaining a properly phased transition, moving towards renewables by using NG as a transition element.
Society	• Society participation relies on government support, i.e., subsidies and taxes that lead to the consumption of clean energy.	• It uses new energies if they are properly communicated. Such communication mainly comes from the academy. • Given the education system, society

	• It establishes green cooperation to adopt green energy via the government's intervention. • Society is responsible and disciplined when the benefits are clear	believes in creating the world of tomorrow with everyday actions.

Table 5. Main practices of each country by each member of the quadruple helix

Source: Own elaboration based on conclusions.

Finally, the best practices identified in Germany and the Netherlands can be applied to any country. By Table 5, we conclude that QH successful implementation during the ET process requires a driver intermediary under other QH agents can trust. So, each nation needs to define which member of the quadruple satisfies the previous feature. Even more, it is necessary the establishment of an energy fuel that can overcome the gap between clean energy supply and total energy demand.

In future works we pretend to develop a decision making framework that generates the necessary incentives to boost the production and consumption of clean energy. Also, in a companion paper, we are working on how the experience of Germany and the Netherlands can be applied in emerging economies, particularly, Mexico.

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6 Figures, tables and acronyms

6.1 Figures

6.2 Tables

6.3 Acronyms

AISHE	Audit Instrument for Sustainability in Higher Education
BANS	Bestuursaccord Nieuwe Stijl (National Policy Agreement on Climate Change)
BTU	British Thermal Units
CFO	Chief Financial Officer

CCI	Clinton Climate Initiative
CO2	Carbon Bi Oxide
COP	Conference of parties
EPC	Energy Performance Contracting
GDP	Gross Domestic Product
GHE	Green House Emissions
GO	Governmental Organization
HDI	Human Development Index
HOPE	Holland Programme On Entrepreneurship
NCP	National Climate Policy
NGO	Non-Governmental Organization
NPV	Net Present Value
PPP	Purchasing Power Parity
R&D	Research & Development
UN	United Nations