Underpinning the Y-factor from a transition perspective in the housing sector: a single case study in the Netherlands

Author: C.Y. Cheung

Complex Systems Engineering and Management, Faculty of Technology, Policy and Management, Delft University of Technology, The Netherlands, Date submitted: 7 August 2018

Abstract

CO_2 abatement options have become more important for policy makers in the mission to transition from a high carbon economy to a low carbon economy. The current evaluation methodology for CO_2 abatement options focuses much on economic models. Assuming that CO_2 abatement options are complex, complementary methods are needed for non-economic models. The Y-factor is proposed in literature, with an emphasis on multiple actor complexity, physical interdependencies and behavior factors. However, the Y-factor is a proof of concept and empirical evidence is lacking. This paper aims to give support to the Y-factor from a transition theory perspective and aims to gather empirical evidence by means of a single case study of an abatement option in the housing sector in the Netherlands. Three interviews were carried out to construct the single case study. The Y-factor has been used in the interview as an assessment tool. On the basis of the single case study, the multiple actor complexity factor of the Y-factor has the best fit with the empirical data. The case study contributes by building empirical evidence for the usefulness of the Y-factor as a complementary tool for evaluating abatement options. Directions for research are proposed to further strengthen the Y-factor from a literature perspective, but also from a policy perspective.

Keywords*:* CO_2 abatement options, multiple actor complexity, evaluation method, transition perspective, energy modules housing sector

Introduction

The transition from high carbon economy to low carbon economy is a national concern for many countries after the Paris Agreement on climate in 2015 (UNFCCC, 2015). Low carbon strategies and prioritization of greenhouse gases mitigation options are needed. (Jorgensen & Leszek, 2011). Authors note that Marginal Abatement Cost Curves (MACC) are used often in this policy context (Timilsina et al., 2016). Others notice that the MACC have "attracted a great amount of attention" (Kesicki & Ekins, 2012). The World Bank for example has "widely used the curves to prioritize climate change mitigation options/technologies in various countries" (Jorgensen & Leszek, 2011; World Bank 2014). Private companies have used them as well (Nauclér & Enkvist, 2009). However, Timilsina et al. (2016) note that the CO_2 potential may not be realized even if the marginal costs are negative. There may be "technical, financial and institutional barriers". Other scholars reckon, that the MACC should be interpreted with "caution" and that policy makers need to pay attention to the "underlying assumptions", consider "non-financial costs" and be "aware of the important uncertainties" and "underlying path dependencies". (Kesicki & Ekins, 2012). Furthermore, scholars reckon that sometimes the "most expensive options make sense" (Vogt-

Schilb & Hallegatte, 2011), while others speak of a "failure of MACC" (Ward, 2014). Nevertheless, scholars regard the MACC as useful (Criqui et al., 1999; Kesicki & Strachan, 2011) and emphasize that the economic theory should be clearly separated from the practice. In the endeavor to bridge the gap between economic theory and practice, Chappin (2016) proposed a complementing approach, the Y-factor. The Y-factor is similar to the MACC in the sense that both work with underlying models and present their outcome in a curve. However, the starting point of the Y-factor is the idea that policy makers should embrace complexity and path dependencies. In an initial proof of concept of the Y-factor, the author showed that the alternative method matter, but empirical evidence is lacking to underpin the Y-factor.

The research objective for this paper is to contribute to the wider societal problem of transitioning from a high carbon economy to a low carbon economy, by contributing to the body of knowledge of the Y-factor.

Methods

The method is to construct a single case study of one CO_2 abatement option. A case study is an empirical inquiry that "investigates a contemporary phenomenon in-depth and with its real-world context, especially when the boundaries between the phenomenon and context are not clearly evident" (Yin, 1994, p.13). The single case study should give more insights about why abatement options may not behave in an economically traditional way. For constructing the case study, the scope is set on the Netherlands for practical reasons, and data collection method is done through semi-structured interviews. The Y-factor is based on four categories and thirteen subfactors, the subfactors are used as an assessment framework in the semi-structured interviews. For the selection of the abatement option, the Dutch

cabinet's agreement of November 2017 (Tweede Kamer, 2017) is used. To underpin the Y-factor, transition theories are used to interpret and create expectations for the outcome of the interviews. The main research question of this paper is as follows:

> What empirical evidence from a single case study through in-depth interviews in the Dutch context, may underpin the Y-factor from a transition theory perspective?

The rationale for the transition perspective is that transitions may occur on the national and macroeconomic scale (Chappin, 2011, p.11). Transitions may be studied one scale lower, such as the sector scale. This more in-depth view of abatement options may be explored for non-economic insights that could support the Y-factor. Moreover, in analyzing policy problems from a complex perspective, Loorbach (2010) presents "transition management" as an approach. The approach deals with complexity in a governance context and act as the second rationale for exploring the Y-factor from a transition perspective.

In designing the interviews, key notions the handbook of Adams (2010) are used, such as getting the right interviewees, drafting tailored interview guides and preparing probing questions. Three interviews are carried out for three types of interviewees in the pursuit of getting to the right interviewees. The three types are inspired by the Triple Helix concept, which emphasized on the importance of the triadic relationship between the industry, academia and the government in innovative economic development (Etzkowitz and Leydesdorff (1995). The interview guides are composed of an interview specific introduction part, a brief description part of the abatement option in project scope, time and parties involved, inspired by the 10 Project Management Knowledge Areas

(Larson & Gray, 2015). For questions and probing questions, the thirteen subfactors of the Y-factors are used, and each will be accompanied with a few probing questions, such as "could you tell me more about…", "what can be said about", "why do you think that…".

Transition theory

Dictionary definitions of transition explains that transition is "a passage from one state, stage, subject, or place to another". Another definition is that a transition is a "movement, development, or evolution from one form, stage, or style to another". Scholars have similar definitions, such as that transition is a "structural change in the way a societal system operates" (van der Brugge, 2005, p.165). Geels and Schot (2007) define transition as "changes from one socio-technical regime to another" (p.399). Chappin (2011) has proposed the following: "a system transition is substantial change in the state of a socio-technical system" (p. 17). He concluded that in transition literature the concept of "change" is ubiquitous. Changes may come in different sizes, speed, and types. In the many definitions, the following notions are found to be recurring: niches and regimes.

Niches and regimes

Abatement options can be seen as technologies trying to break through. With breaking through, transition scholars are referring to "the process of breaking out from niche to regime level". (Geels, 2002, p. 1262). Niches are active on the lower level and consists of mostly smaller companies or other parties. In this level, inventions and technologies are formed. The regime level is at a higher level, and consists of more parties. Regime represents a set of "dominant practices, rules and shared assumptions" regarding problem and solutions (Rotmans et al, 2001, p.19). Regimes prescribe "how things are done" in the society (Chappin, 2011, p.20. Regimes

are large, slow, relatively stable, and do not create new solutions. A regime is therefore very different from niches. In many definitions of transitions, the "change" in transition is called a regime shift (Holtz et al., 2008). In bringing about or shape a regime shift, a Transition Management Arena (TMA) may be created. Rotmans and Loorbach (2009) describe the TMA as "networks of innovators and visionaries developing long-term visions and transition experiments, involving growing numbers of actors." TMA are generally chaired by around 15 to 20 individuals, each with their network. In the TMA, these individuals are frontrunners and they give vision, direction and knowledge, but also design a process for inviting and preparing experts and other actors. In the TMA, actors, including the frontrunners, have the characteristics of come and go in the TMA. This is because actors may come from various disciplines and levels of the sector and have different agenda's and schedules. The TMA also encourage actors to negotiate and may act as a device for conflict management.

The Y-factor from a transition perspective

The Y-factor is composed of four categories. The first category of the Y-factor is Cost and Finance (C&F). Three subfactors are mentioned, these are investment costs, expected pay-back time and financing difficulties. From a transition perspective, individual business or projects are not the main focus. A transition may entail multiple projects at the niche level. The investment costs would be the accumulation of various transition projects in the sector. Specifics in costs and pay-back times for abatement options will vary much and therefore hard to determine. From a transition perspective, many transition projects would struggle and most projects should therefore have financing difficulties.

The second category is Multi Actor (MA) complexity. Four subfactors are composed for this category: number of actors, dependence on other

actors, type of actors involved and responsibility unclear. From a transition perspective, the boundaries between direct and indirectly actors are blurry. Transitions may affect the whole sector or the whole nation. The number of actors seem to be about the population, the demographics, the actors at the niche and the regime level. A useful notion is that of the Transition Management Arena (TMA), as it may explain why high dependencies between actors, many types of actors, and ambiguity between actors may act as barriers to transition. For example, up keeping a network of experts may be difficult as the experts are not necessarily fully committed to the network. As experts in the TMA may produce visions and action plans, stakeholders outside the process may not understand or agree with the vision, and as a result roles and responsibility for actors involved in the abatement option may be somewhat unclear. Abatement options should have high degree of MA complexity.

The third category is Physical Interdependencies (PHI). This category is made up of three subfactors: physical embeddedness, disturbance in regular operation, and technology uncertainty. From a transition perspective, technical systems are important, but it is the interface between the technical and the social system that is important. When abatement options disturb the socio-technical system, this may indicate that changes are on the rise. This could indicate that the regime is made unstable, and that niches may break through in time. High technology uncertainty may indicate the amount of relevant niches in the transition. For embeddedness, abatement options should be slightly embedded, as being strongly embedded means that it may be too entangled into a particular system and therefore be part of the regime, instead of a niche. In any case, abatement options should show a good amount of physical interdependencies.

The last category is Behavior (Beh) and is made up of "thinking outside the scope", frequency of opportunity, and requires changes in behavior. From a transition perspective, transitions are defined using concepts like changing "shared routines", and changing from "one mode of operation" to another. These may be interpreted as lifestyle changes, changes in working habits, and more. Thinking outside the scope should induce such behavior. In the TMA, "thinking outside the scope" seems to be one of the reason why bringing experts from multiple disciplines, levels and phases are thought to be important. The frequency of opportunities may refer to the level of entrepreneurship (Hekkert and Negro, 2009). In the niche level, technologies are developed, but only the ones who venture and take risks in the market may be relevant. If niche-players have the habit of venturing outside their core-business regularly, then the right transition conditions are in place.

Table 1 - The Y-factor from a transition perspective

Category	Explanations and expectations	
C&F (3 sub-factors)	Costs and pay-back time should be hard to specify. Financing should be difficult	? ? High
MA (4 sub-factors)	May affect the whole population, may see sector-wide multidisciplinary teams, and somewhat unclear visions and discussions.	High High High Medium
PHI (3 sub-factors)	May be slightly embedded, many disturbances, and high technology uncertainty	Medium High High
Beh (3 sub-factors)	Unknown result of "outside the scope thinking", and some level of entrepreneur-ship. May see changes in lifestyle, routines, and habits.	High High High

Results from interviews

The constructed single case study concerns the Dutch abatement option of refurbishing houses by means of installing energy modules within the scope of "Nul op de Meter" program. The program is dedicated to realize zero emission for the housing stock in the Netherlands. The timing of the program span multiple decades. The longer term goal is to

renovate 200 thousands houses per year by 2050, and at the end to fulfil the goal of refurbishing 6 million households. For the upcoming four years, the target is to have 30 to 50 thousands houses renovated, a non-linear curve is expected towards the end of 2050. For 2030, this has the abatement potential of two to three Mton CO_2. Municipalities, social housing associations and homeowners and their associations are involved. The installation sector and the construction sector are also involved.

Table 2 - Descriptive of the Housing case study

	S	K	G	
C&F	2	1	2	**Investments costs?** [0=Absent,1= medium, 2=large]
	1	1	2	**Payback period?** [<5yr, 5-12yr, >20yr]
	2	1	0	**Finance difficulties?** [0=none, 1=medium, 2=large]
MA	2	2	2	**How many actors?** [0=few, 1=many, 2=millions]
	2	2	2	**Dependencies actors?** [0=none, 1=few, 2=many]
	2	2	1	**Types of actors?** [0=low, 1=medium, 2=many]
	0	2	1	**Responsibilities unclear?** [0=clear, slightly, 2=unclear]
PHI	2	2	2	**Physical embedded?** [0=none, 1=medium, 2=strong]
	2	2	0	**Disturbance daily operations?** [0=none, 1=medium, 2=many]
	1	1	1	**Proven Technology?** [0=proven, 1=small, 2=large]
Beh	2	0	1	**Out of the scope?** [0=not,1=partially,2=outside]
	2	1	0	**Frequency?** [0=often, 1=medium, 2=seldom]
	2	2	2	**Behavioral change?** [0=no, 1=slightly, 2=large]

The S, K and G codes reflect the Triple Helix approach for three types of interviewees.

The three interviews from the perspective of the thirteen subfactors is displayed in table 2. The combined score of each category on the basis of their subfactors are calculated in the next paragraph. A narrative is constructed per category to substantiate the combined scores on the basis of the comments in the interviews. The interviews are summarized; they are not processed with a transcript method.

Table 3 - Combined score and narrative

C&F with a score of 1.3
The investment costs for the case can be very different in absolute terms. It all depends on the characteristics of the building, they vary from several thousands to 80k or more. From the perspective of the tenant or owner, this is generally experienced as high. Long payback period are not accepted. However, some costs for the installations may have very long payback time. The financing part seem both easy as well as very difficult. This depends on the collateral that inhabitants possesses. Housing corporations have more stable cash flows and reserves and for them, the finance is easier. New financial tool in the sector (energy performance contract, EPC) may ease financing

MA with a score of 1.7
Millions are involved in this transition. The most important actors are the municipalities, housing corporations and the civilians. Sometimes there is distrust for housing corporations. Crucial actors are the multidisciplinary professionals, interviewees comment that they are needed due to the fragmented installation and construction actors. For the 2 million households that housing corporation overlook, 300 multidisciplinary teams of 10 experts are needed. Some visions exists, but only for parts of the housing sector. It is not totally clear for example how to bring about mass-production capability within the installation and construction actors to keep up for the ambitions to refurbish the millions of households.

PHI with a score of 1.4
Refurbishing houses can be highly embedded into the housing system. Special construction might hamper the process, and the age of the building might hamper the integrity of installations. Many small problems arise, such as the surroundings of a house, a tree may already influence some installations (e.g. solar modules). The street image, or the neighborhood image is at stake, and at times of the inhabitants sometimes need to be relocated. The technology is proven, but innovations is needed for large scale adoption. Current production techniques may be a factor 10 to 100 too low.

Beh with a score of 1.3
Most housing corporation have experience working with municipalities and the ministry quite closely. The installation and the construction sector, on the other hand are not. They seem to struggle keeping up with the innovation-driven demand from the housing sector. It is not that the installation and construction sector does not have frequent

opportunities, but that they are in smaller numbers and often tend to go for the easier and more profitable new housing. Corporations and some neighborhoods with an entrepreneurial character do experience more opportunities. Large changes can be seen for the occupants, but also the contractors from the installation and construction sector. For them it is a "game changer". The installation and construction sector are required to work differently too: away from a simple product delivery with turn-key contracts, towards a more comprehensive and collaborative project approach with performance-based contracts. For the occupants, the air quality and the sound quality of the installation changes too. This is not necessarily as in lower quality, but it is more of a change of habits. Sometimes, this may even affect the business case of the installation, as energy consumption might go up due to a known "rebound effect".

Conclusion

For comparing the expectations with the outcome of the interviews, the scores of the thirteen subfactors and their comments or narrative are taken into account. For every subfactor, if two of the three subscores are scored two, then the subfactor is considered high, such as for investment costs in C&F, and the disturbance subfactor in PHI. If two of the three subscores are one, or if the average of the subscore is one, then the subfactor is considered medium. None of the thirteen subfactors are seen as low in both the expectation and the outcome.

Table 4 - Comparison expectation and outcome

Category	Expectations	Outcome interviews
C&F	? ? High	High Medium Medium
MA	High High High Medium	High High High Medium
PHI	Medium High High	High High Medium
Beh	High High High	Medium Medium High

For the C&F category, the investments costs and pay-back times are expected to be hard to determine, as there are large differences between the different installations types for a variety of households. These arguments can be found to be supported in the narrative of the interviews. However, the finance part is easier than expected, this can be seen in both the score and in the narrative. In the MA category, all elements were found; interviewees mentions the millions of households, notions of TMA, and different types of actors. Also, important debating points were found. For example, the large gap between what the installation and construction sector can offer and supply, and what the transition requires and demand. The score of MA is the highest among the four categories. While the scores for each subfactor are within expectations, the comments reveal an interesting difference; hundreds of multidisciplinary teams are needed. From a transition perspective, such multidisciplinary teams may be interpreted as a TMA, and only few are needed as suggested in theory. For the PHI category, the only score that matches is that of the disturbance subfactor. The embeddedness factor is high, and in the narrative this is explained by the many physical and social layers. The technology uncertainty score is scored medium, in the narrative, the medium score refers to lack of innovations in production techniques. For the Beh category, the expectation is that the subfactors are all high. This only matches with one of the three scores of the interviews. The "out of the scope" subfactor is scored medium, and in the narrative, the arguments seem to focus on the collaboration between the related parties and that they have a long working history with each other.

The PHI and the Beh categories seem to differ more in expectations than the C&F and MA category. For both categories, some inconsistencies exist in the score and its explanations. Sometimes different notions in explaining the score can be

found. In the PHI category, the technology uncertainty subfactor is scored medium, but the narrative shows that technologies are proven. This is inconsistent with the theory. The embeddedness is scored high, and this was not expected. The narrative shows that various social and technical layers are responsible for the high score. The expectation from theory is somewhat similar but social technical systems instead of layers are expected. In the Beh category, the notions of collaboration for the "out of scope" subfactor are not expected. For the frequency of opportunities, the notion of entrepreneurship is indeed mentioned, but also a certain negative level of opportunism. It seems to suggest that the frequencies are too high, and in scoring the subfactor, this is reflected by a medium grade. This inconsistency in score and narrative is not expected.

To answer the research question of this paper, the comparison of the Y-factor with key notions of transition theory with the housing case shows that the Y-factor can be underpinned by some but not all empirical data from the case. The best support for the Y-factor can be found in the MA category. The MA category shows the best fit in both scores and narrative. The C&F category is generally in line with the empirical data, as the narrative confirms the difficulties with specifying the subfactors. The PHI and the Beh categories show the most differences in practice. Two of the three scores do not align with expectations. Moreover, the narratives shows that there are different notions at play, and that there is some inconsistency with theory.

Discussion and recommendations

It is important to note that the insight drawn from the single case study is limited. For example, it should be noted that while the empirical data of the MA category does support the Y-factor as a complementary tool, it does not provide the empirical evidence that high multi actor complexity could explain why the Housing abatement option does not materialize in practice. In discussing the MA category from a transition perspective, it could be said that high scoring subfactors of the MA category are necessary for a transition. From a transition perspective, large societal change is accompanied with large groups of actors. The high scoring subfactors of the MA category may therefore not act as impediments to the implementation success of the Housing abatement option. The empirical data only supports that the MA category fits well the Y-factor, from a transition perspective. It should also be observed that none of the thirteen subfactors are scored as low. From a transition theory, low scoring subfactors may also hamper implementation, such as low technology uncertainty or behavioral change.

The overall conclusion is also subjected to the limitations of conducting single case studies. The underpinning of the Y-factor on the basis of this study should be taken with high caution. This study has only conducted one case study, in one geographic location, and one housing case within the housing sector. Moreover, only three interviews were carried out. Furthermore, the single case study as a research method is also limited by personal bias in collecting empirical data. Although personal bias is reduced by working with an assessment framework in coherence with the principles of a handbook specific to semi-structured interviews (Adams, 2002), data collection bias may still exists. Another limitation lies in the conceptualization of the Housing case. The boundaries of the single case study were described from a project management perspective. It is unclear if this provides a good enough scope of the single case study, as alternative mechanism for defining boundaries are not evaluated. As a result, the discussed case may be different from what the interviewees are thinking of. The validity of the single case study is also low.

Replication of the interviews could be difficult as projects and people involved will change over time.

In literature, cases of negative marginal abatement costs have been discussed as problematic for the MACC evaluation of policy options. In Taylor (2012), the MACC method has been found to be unsuitable for negative scoring cases, and as a result an alternative method is proposed. The alternative is based on Pareto-ranking, but other Pareto approaches may be used too (Taylor, 2012). Levihn (2016) has reviewed the Pareto approach, and argues that such an approach "is not a good solution" (p.1155) to the negative cost problem, due to "undesirable effects" (p. 1161). When strong interdependencies exists in options, the MACC is not advised. The interdependencies referred to are derived from interdependencies "between discrete abatement options" (p. 1161). This study is limited to one abatement option in one sector, and did not look for interdependencies with other abatement options in other sectors. Moreover, Levihn (2016) also note that for "most firms (and nations) climate change abatement is not the primary concern or core business" (p.1160). Multiple goals may cause negative marginal costs to be problematic to work with. This observation by Levihn (2016) may support the finding of this study, assuming that multiple goals are derived from multiple actors. In van den Bergh & Delarue (2015), "interaction effects between fuel switching and renewables deployment" are mentioned as influencing the MACC results. In this case, van den Bergh & Delarue (2015) policy options for power plants are analyzed using the MACC, and interaction effects could be interpreted as specific interdependencies between abatement options. In another study (Ponz-Tienda et al., 2016), three methods are analyzed as opposed to the MACC method.

This paper research focused on underpinning the Y-factor from a transition perspective using a single case study. Research is needed to further strengthen the Y-factor from a literature perspective and from a policy perspective. First, directions for research from a literature perspective are suggested second directions from a policy perspective are suggested.

Future research should continue to study the Y-factor from within the transition theory, as the conceptualization of the Y-factor in this paper is limited. The larger transition literature may provide more specific context for what instances or parameters of the Y-factor may act as either an impeding factor or as a factor for monitoring purpose. This could be important to bring about or shape the success of the abatement option. It is also recommended to research outside the realm of the transition theories, the single case study shows signs of limitations of transition theory in especially the "physical interdependency" and "behavior" category of the Y-factor. However, more case studies are needed for supporting this recommendation. Conducting more cases is also recommended for the purpose of a multiple case study analysis. Given multiple cases, quantitative outcomes may be possible. Future quantitative research may start with categorical or nominal labels for each of the thirteen subfactors, and with statistical methods such as Factor analysis. This study is limited by one type of primary source, therefore future research should be accompanied with a triangulation of sources.

For a more practical policy context, future research should also compare the Y-factor with alternative evaluation methods. In the few discussed MACC literature, specific methods are proposed for certain limitations of the MACC, it is unclear how these alternative methods to the MACC overlap or differ in what policy context. Last, future research for the Y-factor should be more tied with the complex policy context. The Y-factor may be suitable for acting as key performance indicator for a transition

monitoring system. In such context, research may start by experimenting the Y-factor as a monitoring system in a simulated environment, for example in a serious game.

Acknowledgements

References

Adams, W. C. (2010). Conducting semi-structured interviews. *Handbook of practical program evaluation*, *365*.

Chappin, E. (2016, June). Complementing weaknesses in marginal abatement cost curves. In *Energy: Expectations and Uncertainty, 39th IAEE International Conference, Jun 19-22, 2016*. International Association for Energy Economics.

Chappin, É. J. L. (2011). *Simulating energy transitions*. Next Generation Infrastructures Foundation.

Criqui, P., Mima, S., & Viguier, L. (1999). Marginal abatement costs of CO2 emission reductions, geographical flexibility and concrete ceilings: an assessment using the POLES model. *Energy policy*, *27*(10), 585-601.

Etzkowitz, H., & Leydesdorff, L. A. (1995). Universities and the global knowledge economy: A triple helix of university-industry-government relations.

Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Research policy*, *31*(8-9), 1257-1274.

Geels, F. W., & Schot, J. (2007). Typology of sociotechnical transition pathways. *Research policy*, *36*(3), 399-417.

Jorgensen, E., & Leszek, K. (2011). *Transition to a Low-Emissions Economy in Poland* (No. 10083). The World Bank.

Kesicki, F., & Ekins, P. (2012). Marginal abatement cost curves: a call for caution. *Climate Policy*, *12*(2), 219-236.

Kesicki, F., & Strachan, N. (2011). Marginal abatement cost (MAC) curves: confronting theory and practice. *Environmental science & policy*, *14*(8), 1195-1204.

Larson, E. W., & Gray, C. F. (2015). A Guide to the Project Management Body of Knowledge: PMBOK (®) Guide. Project Management Institute.

Levihn, F. (2016). On the problem of optimizing through least cost per unit, when costs are negative: Implications for cost curves and the definition of economic efficiency. *Energy*, *114*, 1155-1163.

Loorbach, D. (2010). Transition management for sustainable development: a prescriptive, complexity-based governance framework. *Governance*, *23*(1), 161-183.

Nauclér, T., & Enkvist, P. A. (2009). Pathways to a low-carbon economy: Version 2 of the global greenhouse gas abatement cost curve. *McKinsey & Company*, *192*.

Ponz-Tienda, J. L., Prada-Hernández, A. V., & Salcedo-Bernal, A. (2016). The problem of ranking CO2 abatement measures: A methodological proposal. *Sustainable Cities and Society*, *26*, 306-317.

Rotmans, J., & Loorbach, D. (2009). Complexity and transition management. *Journal of Industrial Ecology*, *13*(2), 184-196.

Rotmans, J., Kemp, R., & Van Asselt, M. (2001). More evolution than revolution: transition management in public policy. *foresight*, *3*(1), 15-31.

Taylor, S. (2012). The ranking of negative-cost emissions reduction measures. *Energy policy*, *48*, 430-438.

Timilsina, G., Sikharulidze, A., Karapoghosyan, E., & Shatvoryan, S. (2016). *How do we prioritize the GHG mitigation options? development of a marginal abatement cost curve for the building sector in Armenia and Georgia*. The World Bank.

Tweede Kamer. (2017). Vertrouwen in de toekomst. Regeerakkoord 2017-2021. *VVD, CDA, D66 en ChristenUnie. Vergaderjaar*, *2018*, 34700.

UNFCCC. 2015. *Synthesis Report on the Aggregate Effect of the Intended Nationally Determined Contributions*. In Bonn, Germany: United Nations Framework Convention on Climate Change.

Van den Bergh, K., & Delarue, E. (2015). Quantifying CO2 abatement costs in the power sector. *Energy Policy*, *80*, 88-97.

Van der Brugge, R., Rotmans, J., & Loorbach, D. (2005). The transition in Dutch water management. *Regional environmental change*, *5*(4), 164-176.

Vogt-Schilb, A., & Hallegatte, S. (2011). *When starting with the most expensive option makes sense: Use and misuse of marginal abatement cost curves*. The World Bank.

Ward, D. J. (2014). The failure of marginal abatement cost curves in optimising a transition to a low carbon energy supply. *Energy Policy*, *73*, 820-822.

World Bank Group. (2014). *World development indicators 2014*. World Bank Publications.

Yin, R. K. (1994). Case Study Research: Design and Methods (Applied Social Research Methods, Vol. 5). *Sage Publications, Beverly Hills, CA. Rick Rantz Leading urban institutions of higher education in the new millennium Leadership & Organization Development Journal*, *23*(8), 2002.