UNEP DTU PARTNERSHIP

TRANSFORMATIONAL CHANGE FOR LOW CARBON AND SUSTAINABLE DEVELOPMENT

UNEP

International Partnership on Mitigation and MRV

NAMA PARTNERSHIP

United Nations Climate Change Secretariat

Perspectives series **2015**

UNEP DTU PARTNERSHIP

TRANSFORMATIONAL CHANGE FOR LOW CARBON AND SUSTAINABLE DEVELOPMENT

UNEP

International Partnership on Mitigation and MRV

NAMA PARTNERSHIP

United Nations Climate Change Secretariat

TRANSFORMATIONAL CHANGE FOR LOW CARBON AND SUSTAINABLE DEVELOPMENT

Print and layout: Phoenix Design Aid A/S

Editors: Karen Holm Olsen & Jørgen Fenhann

Reviewers: Claudio Forner, Victoria Novikova and Sven Marc Egbers

Acknowledgements: *Perspectives 2015* is published in context of the research project titled 'Indicators of transformational change for MRV of NAMAs' jointly undertaken by the NAMA Partnership Working Group on Sustainable Development (WG-SD) and the International Partnership on Mitigation and MRV. The publication is the second output of Phase 1, the first output is a concept paper titled 'From theory to practice: Understanding transformational change in NAMAs'. The financial contributions from the UNFCCC, FIRM project and UNEP DTU Partnership to this publication are acknowledged.

For more information on the research project visit www.namapartnership.org.
For access to the *Perspective Series*, please visit www.unepdtu.org/PUBLICATIONS/Carbon-Market-Perspectives-Series

May 2015

ISBN: 978-87-93130-27-2

DTU

Table of Contents:

Foreword

The Intergovernmental Panel on Climate Change (IPCC, 2014) clearly documented that if the current global carbon intensive development path is continued, it will lead to unprecedented levels of global warming and cause severe climate impacts. Transformational change within our economies is therefore required to move countries towards a low-carbon and sustainable development model.

Although the IPCC-assessments have documented that climate change is a well-known threat to sustainable development, the necessary political action to keep global warming below the 2°C target is still lagging behind. Since 2010, the United Nations Environment Programme (UNEP) has documented in its annual Emission Gap Reports the large gap that exists between the emission levels projected for 2020 – assuming countries meet the greenhouse gas emission reduction targets they have pledged to the United Nations Framework Convention on Climate Change (UNFCCC) – and emission levels consistent with the 2°C target.

In the run up to the Conference of Parties in Paris (COP 21), where a new comprehensive global climate agreement will be negotiated, Parties are in the process of preparing and submitting their Intended Nationally Determined Contributions (INDCs). All countries are expected to participate in this global effort in line with their respective capability and responsibility, as well as in relation to what they perceive as equitable and fair. By 5 May 2015, 37 parties had submitted their INDCs to the secretariat of the UNFCCC.

To meet the below 2°C objective, both developed and developing countries need to qualitatively change their development pathways and a real paradigm shift towards low-carbon societies is required.

Development and climate finance institutions are now increasingly aware that investments need to be directed towards initiatives with the greatest transformational impacts, supporting sustainable low-carbon development efforts. However, the comprehension of transformational change is still emerging, and there is growing need to understand how paradigm shifts can be supported and managed in practice.

Responding to this challenge the United Nations Framework Convention on Climate Change (UNFCCC) Secretariat and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) commissioned UNEP DTU Partnership (UDP) to produce Perspectives 2015. The aim of this publication is to contribute to the understanding of how transformational change towards low-carbon development has already taken place or is being planned in five developed and developing countries. Informed by theories of sustainability transitions, country experts from Brazil, Colombia, Denmark, Germany, and South Africa reflect on the dynamics and challenges of processes of transformational change in the sub-sectors of wind power, renewable energy, deforestation, transport and state-owned companies.

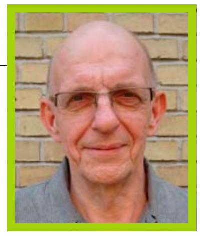
Perspectives 2015 is a result of collaboration between the NAMA Partnership Working Group on Sustainable Development (WG-SD) and the International Partnership on Mitigation and MRV. The objective of these partnerships is to enhance collaboration and the complementarity of activities by multilateral, bilateral and other organizations to accelerate support to developing countries in preparing and implementing their Low-Emission Development Strategies (LEDS), NAMAs, measuring, reporting and verification (MRV) systems and INDCs. For more information on these partnerships, visit www.namapartnership.org and www.mitigationpartnership.net.

Donald Cooper
Coordinator, Mitigation,
Data and Analysis Programme,
UNFCCC

Klaus Wenzel
Head, Support Project for the International
Partnership on Mitigation and MRV

John Christensen
Director
UNEP DTU Partnership

Karen Holm Olsen
Jørgen Fenhann
Editors
UNEP DTU Partnership



Editorial

The need for transformational change for a paradigm shift to low-carbon and sustainable development is high on the international agenda, as the urgency to avoid dangerous climate change and to transform development pathways rapidly in order to be in line with the 2°C target becomes increasingly evident. The United Nations High-Level Panel on the Post-2015 development agenda has identified five transformative shifts to a green economy. In agreement with the Post-2015 development agenda, the Rio+20 process aims to define global Sustainable Development Goals (SDGs) in the form of a new global partnership to eradicate poverty and transform economies for sustainable development.

Under the United Nations Framework Convention on Climate Change (UNFCCC), in 2007 the Bali Action Plan agreed that enhanced action on mitigation would include Nationally Appropriate Mitigation Actions (NAMAs) by developing countries in the context of sustainable development (SD). Co-benefits for development are recognised as a primary driver of strategic, policy- and action-based mitigation actions, though questions of how SD impacts and transformational change (TC) through NAMAs are to be integrated into national development planning frameworks and how to monitor and assess the positive and negative impacts for greenhouse gas reductions, SD and TC remain open questions. The understanding of transformational change is still emerging among NAMA practitioners, and there is a need for innovative approaches to monitoring and measuring activities leading to lasting transformational impacts. Finance mechanisms such as the Green Climate Fund (GCF) and the NAMA Facility have a mandate to facilitate a paradigm shift in the way climate finance for low-emission and climate-resilient activities is governed and delivered. However, the criteria and indicators for monitoring and measuring the process and outcomes of interventions for transformational change need to be developed and integrated into the design and implementation of support programmes for sustainability transitions.

The NAMA Partnership Working Groups on Sustainable Development and Monitoring, Reporting and Verification (MRV) and the International Partnership on Mitigation and MRV are conducting a research project titled ‘Indicators of transformational change for MRV of NAMAs’. This project aims to contribute to the understanding of transformational change and of how to use MRV to ensure that NAMAs facilitate a transformation to low-emission and sustainable development and thus achieve the 2°C target. *Perspectives 2015* is part of this project and contributes with five case studies in order to share experiences of how transformational change for low-carbon and sustainable development has already happened or is being planned. The case studies are informed by a theory-based concept paper ‘From theory to practice: understanding transformational change in NAMAs’ (Mersmann, Olsen et al. 2014), developed as the first output of the research project. The project is being implemented by the UNEP DTU Partnership (UDP, formerly known as the UNEP Risø Centre) in collaboration with the Wuppertal Institute and sub-contracted country and sector experts, and it is being supported by the United Nations Framework Convention on Climate Change (UNFCCC) Secretariat and by the German Federal Ministry for the Environment, Nature Conservation Building and Nuclear Safety (BMUB).

Perspectives 2015 presents five case studies that explore a diversity of success factors and indicators of transformational change across countries and sectors. The cases were selected in order to learn from the most successful examples of transformations that have happened or that are planned to achieve low-carbon development (LCD). Transformations may have emerged for other reasons than responding to climate change concerns, and the choice of cases is not limited to NAMA interventions, but seeks to learn from broader transformations of sectors and sub-sectors towards low- or zero-carbon development at the country level. A balance is kept between the choice of developed and developing country cases. Developed countries have a longer history of twenty to thirty years since starting their transitions to LCD, whereas most developing countries have started recently within the last five to ten years. Cases are chosen to maximize the diversity of sectors and to learn from the most ambitious GHG reduction goals, with a clear link to the hypothesized success factors according to the theoretical approaches presented in the concept paper.

The five case studies are presented in two sections exploring the following aspects of transformational change:

Section 1. Developed country perspectives

- *David Jacobs presents* the example of the transformation of the German energy system – how laws and regulatory frameworks for renewable energy have established a low-carbon pathway towards 80-95% CO_2 reductions by 2050 compared to 1990 levels.

- *Bjarne Gantzel Pedersen* describes the role of wind power development in Denmark in developing an energy system based on 100% renewable energy by 2050.

Section 2. Developing country perspectives

- *Doug Boucher* explains the drivers of Brazil's dramatic reduction in deforestation that dropped by 75% over a decade from 2005-2014 and represents the largest reduction in GHG emissions by any country.

- *Carlosfelipe Pardo* analyses how the transport system in Bogotá, Colombia has been transformed by the political visions of a city mayor and implemented through a technical approach which is now spreading to other cities in Colombia and abroad.

- *Saliem Fakir and Manisha Gulati* argue for the role of state-owned companies in leading an incremental transition from high-carbon lock-in towards a national development pathway in order to reduce GHG emissions by 34% in 2020 and by 42% in 2050 compared to business as usual, conditional on support from the international community.

The common focus of all these case studies is to understand how transformational change for low-carbon and sustainable development has already happened or is being planned in a particular socio-technical system. The aim of *Perspectives 2015* is to share experience and detailed accounts of success stories of transformational change in order to learn from both developed and developing country experiences.

In the context of the research project, another aim of the cases studies is to inform the development of a methodological framework for the assessment of the potential for transformational change in NAMAs based on the sustainability transition theories presented in the concept paper. Evidence of TC analysed in the case studies serves to operationalize the theory-based conceptual framework by identifying indicators and success factors of TC that are context-specific. To arrive at generic indicators that are useful in identifying TC potential and in measuring impacts across a diversity of contexts, more cases and empirical evidence are needed. The five cases in *Perspectives 2015* serve as a starting point in formulating generic indicators.

The next phase of the research project is to propose generic indicators and to test them in the analysis of the TC potential of the 98 NAMAs that were submitted to the UNFCCC Registry by 1 May 2015. The methodological framework will be revised in an iterative process between theory and evidence to arrive at a taxonomy for TC that is applicable to using MRV to assess the potential and impacts of NAMA interventions in contributing towards sustainable and low-carbon development.

Finally, we would like to sincerely thank our partners in the NAMA Partnership and International Partnership on MRV, namely Claudio Forner, Victoria Novikova, Sven Egbers, Sebastian Wienges, Florian Mersmann and Timon Wehnert, for their guidance and support in developing the case studies in the context of the ongoing research project.

UNEP DTU Partnership
Low-Carbon Development Programme

REFERENCE

Mersmann, F., Olsen, K.H., Wehnert, T. and Boodoo, Z. (2014), 'From theory to practice: Understanding transformational change in NAMAs', UNEP DTU Partnership, Copenhagen, pp. 1-24.

Photo credit: Activ Solar

Dr David Jacobs
IET – International Energy Transition

Drivers for transformational change: Empirical evidence from the German Energiewende

ABSTRACT

This paper analyses drivers for transformational change in the German energy sector in order to inform the design of Nationally Appropriate Mitigation Actions (NAMAs) for transformational change in developing countries. We assess the ongoing transformation of the German energy system – the so-called *Energiewende* – from a historical perspective in order to understand the underlying factors that have enabled a paradigm shift in politics, society and business. The analysis focuses on the establishment of a long-term vision, the importance of coalitions of actors and technological innovation.

1. INTRODUCTION, THEORETICAL FRAMEWORK AND STRUCTURE

This paper analyses the factors enabling transformational change in the German energy sector. The analysis is intended to inform the design of Nationally Appropriate Mitigation Actions (NAMAs) in developing countries. According to the working definition of the conceptual paper (Mersmann et al., 2014a), transformational change through NAMAs is a change:

I. that disrupts established high-carbon pathways, contributes to sustainable development and sustains the impacts of the change (goal dimension),

II. that is triggered by the interventions of actors who devise innovative low-carbon development models and actions, connect the innovation to the day-to-day practices of economies and societies, and convince other actors to implement the innovation in order actively to influence the multi-level system to adopt the innovation process (process dimension)

III. that overcomes persistent barriers towards the innovated low-carbon development model and/or creates new barriers which push the transformed system to relapse into the former state (sustains 'low-carbon lock-in').

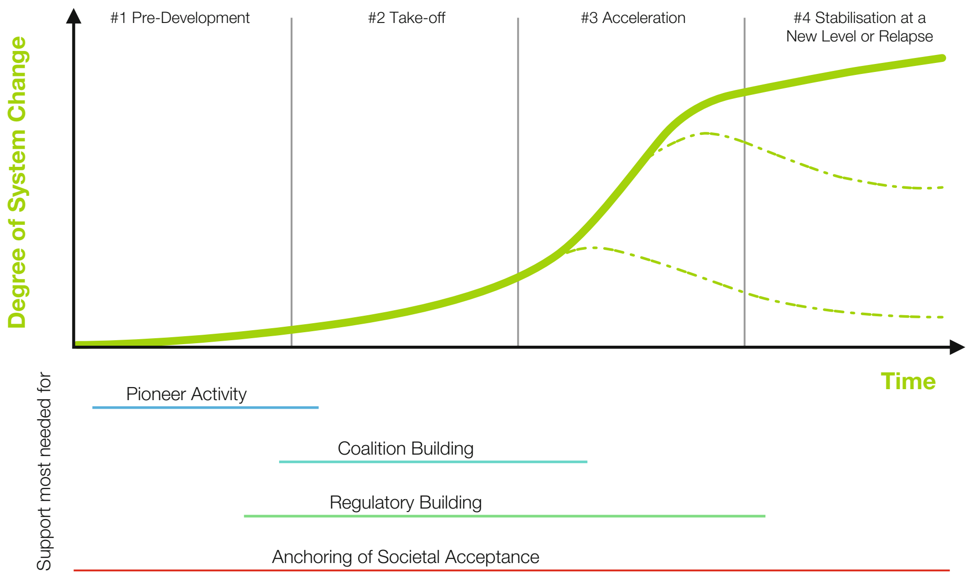
We assess the ongoing transformation of the German energy system – the so-called *Energiewende* – from a historical perspective in order to understand the underlying factors that have enabled a paradigm shift in politics, society and business. The German *Energiewende* currently consists primarily of policies for the transformation of the electricity sector. This will therefore also be the focus of this paper.

The German *Energiewende* is a long-term energy and climate strategy which started in the 1970s and includes targets reaching forward as far as 2050. According to the phase model developed by Rotmans et al. (Rotmans et al., 2001) and Mersmann et al. (Mersmann et al., 2014b), different phases of renewable energy support in Germany can be identified. In the 1980s and early 1990s – the "predevelopment phase" of renewables in Germany – support took the form of investment subsidy programs. The take-off phase started in the early 1990s with the establishment of the first feed-in tariff. Accelerated market growth was triggered by the Renewable Energy Source Act (EEG) in 2000. Although from 2014 the EEG included annual technology targets, the expansion phase of renewable energy technologies in Germany continues though at a slightly reduced speed. These phases will be described further in the following sections.

“We assess the ongoing transformation of the German energy system – the so-called Energiewende – from a historical perspective in order to understand the underlying factors that have enabled a paradigm shift in politics, society and business.

This research paper analyses important factors in achieving transformational change within the Germany electricity sector in recent decades in order to derive conclusions regarding policy interventions in developing countries with the potential to be transformational in achieving low-carbon and sustainable development goals. In line with the conceptual paper (Mersmann et al., 2014a), several theory-based hypotheses regarding transformational change are tested in this paper, namely:

Figure 1. A phase model of transformation processes



Source: (Mersmann et al., 2014a)

I. **The long-term vision.** Transformations require a long-term vision for change supported through the mid-term articulation of transition agendas, sustainability visions and pathways.

In the case of the German *Energiewende*, we will analyse the creation of a consensual long-term vision (a largely renewable energy-based power system) and the establishment of short-, mid- and long-term targets for the development of renewable energy sources in the electricity sector.

II. **Experimentation, technological innovation and the creation of niche markets.** Transformational Change is more likely if there is a protected space in which innovations can develop.

In the case of the German *Energiewende*, we will analyse the creation of a niche market for renewable electricity producers through the establishment of feed-in tariffs and their specific design at different phases of the *Energiewende*. The development of the two most important technologies, namely wind energy and solar PV, will be analysed, including their respective cost reductions over time and the newly emerging international perception of renewable energy technologies.

Coalition building. Transformational change needs actors of change: innovators, disseminators, advocates, policy-makers. Protected spaces for transformation evolve into a dominant design through the support of powerful actors.

In the case of the German *Energiewende*, we will analyse important actors and the formation of advocacy coalitions for renewable energy deployment.

In order to test these hypotheses and understand the transformative change of the German *Energiewende* – and its implications for the evaluation of NAMAs in developing countries –

this paper will first summarize the history of the German *Energiewende*, from its initial policies in the 1970s to the consensual long-term targets established in 2010 and 2011. This will help us understand the process of establishing a consensual long-term vision. Secondly, we analyse the development of Germany's feed-in tariff legislation in the light of rapidly changing technologies and markets and with an eye on the pivotal role of policy entrepreneurs. Thirdly, the technological development of wind and solar PV will be assessed, including their implied costs and their implications for the ongoing energy transitions in developing countries. Finally, we will draw lessons based on empirical evidence in Germany for potentially transformational policies and measures in developing countries.

2. CONTROVERSIES IN GERMAN ENERGY POLICY: THE LONG ROAD TOWARDS A CONSENSUAL LONG-TERM ENERGY VISION

Energy policy-making in Germany was very controversial for many decades. Historically, power generation in Germany was primarily based on coal and lignite. In 1960, about 80 percent of total power generation was generated by coal-fired power plants. Germany and other Western countries modified their energy policies after the first and second oil crisis in the 1970s. In order to diversify the electricity mix, a series of nuclear power plants was developed. However, the development of nuclear energy had already become very controversial in Germany by the 1970s, and the construction of new nuclear reactors faced severe public opposition (Mez and Piening, 2006).

Alongside these developments, a strong ecological movement continued to push for alternative development paths in energy policy-making. It was in this context that the term *Energiewende* was first introduced back in 1980. The research institute Öko-Institut published a book called *Energiewende: Wachstum und Wohlstand ohne Erdöl und Uran* (Krause et al., 1980), assessing how far Germany could achieve economic growth without relying on fossil fuels (Jacobs, 2012a). In the same year, an *Enquete Commission* of the German Parliament recommended an energy policy primarily focusing on energy efficiency and renewable energies. However, nuclear energy was not discarded as an additional option (Meyer-Abich and Schefold, 1986).

While the German anti-nuclear movement gained further strength in the 1980s, it was transformed into a pro-renewable energy movement, being concerned to point out viable alternative energy policy options. This movement was backed politically by the creation of the German Green Party. Even though the actors' support this policy shift from fossil fuels to renewables was still limited at the beginning, an increasing number of policy initiatives to phase out nuclear energy and increase the share of renewable energy technologies were initiated at the end of the 1980s. These included rebates and R&D programs for renewable energy technologies and energy efficiency measures (Lauber and Mez, 2007).

The apparent need to re-design Germany's national energy policy was further spurred by the nuclear accident in Chernobyl in 1986 (Jacobsson and Lauber, 2006a). Within two years, opposition to nuclear power increased to over seventy percent (Jahn, 1992). This also affected the political spectrum. The Social Democrats committed themselves to phasing out nuclear power, and the emerging Green Party even demanded the immediate shutdown of all nuclear power plants. However, the ruling coalition government of the CDU/CSU and FDP did not change its attitude towards nuclear power. As an immediate reaction to Chernobyl, a Ministry of Environment was established. And, as of 1989, no new nuclear reactor was connected to the German grid, increasing the necessity for alternative energy sources. Support for renewable energy sources continued to increase. Nonetheless, as of the end of the 1980s, the Ministry of Economic Affairs was still reluctant to establish a market introduction program for renewable energy technologies (Lauber and Pesendorfer, 2004). However, several MPs brought forward policy proposals for the promotion of renewable electricity (Jacobsson and Lauber, 2006a, Kords, 1993, Hirschl, 2007). In addition, market incentive programs in the form of rebates were proposed. However, most proposals targeted policies for the implementation of feed-in tariffs (FIT) (Jacobs, 2012b).

At the end of the 1980s, climate change reached the political agenda, and the former Chancellor Helmut Kohl identified climate change as the most important environmental problem (Huber, 1997). The first climate *Enquete Commission* of the German parliament recommended reducing methane and CO_2 emissions by 80% in 2050 (Bundestag (ed.), 1991). Since building new nuclear power plants was politically not a feasible option, renewable energy and energy efficiency policies were increasingly being considered.

The first feed-in tariff law was introduced in 1990, an initiative of several conservative MPs. At a later stage, a Green Party MP supported the initiative, and finally an all-party coalition supported the implementation of the first German FIT (Kords, 1993). This cross-party support was crucial for passing the law since important actors from the incumbent industry were opposed to the policy initiative (Hirschl, 2008).

In 1998, the German electricity market was liberalized in line with a 1996 European Directive. Liberalization opened up the market for new actors, including non-utility renewable energy producers. In the same year the Social Democrats (SPD) and the Green Party won the general elections and agreed to phase out nuclear energy plants as quickly as possible. In the so-called nuclear consensus, the newly elected government agreed with the national energy supply companies to phase out nuclear energy by 2021. At the same time, policies for energy saving, energy efficiency and renewable energy support were further strengthened. This included the Renewable Energy Source Act (EEG) from 2000.

> *“The apparent need to re-design Germany’s national energy policy was further spurred by the nuclear accident in Chernobyl in 1986.*

However, during the 2000s the conservative and neo-liberal opposition parties and many conventional electricity producers voiced their opposition to aggressive renewable energy policies. In 2009, the conservative–liberal coalition of CDU/CSU and FDP won the general election. Even though both parties were previously opposed to the feed-in tariff, they did not repeal this legislation but merely modified it. Between 1990 and 2009, a thriving renewable energy industry had been established in Germany, and the ruling parties did not want to scare off voters who supported this development. In 2009 and 2010, large demonstrations in Berlin underlined the general public opinion of a pro-renewables and anti-nuclear energy policy. In those years, an all-party consensus emerged that feed-in tariffs were a good policy tool with which to support electricity generation from renewable energy sources.

The following year, a long-term energy policy, the so-called *Energiekonzept,* was tabled with the aim of setting out a strategy for a sustainable energy system until the year 2050. The paper gave short-, mid- and long-term climate targets, as well as putting forward a number of policies which would need to be adopted in order to reach these targets. The policy mix included measures for further increasing the share of renewables in a cost-effective way (fixing long-term target of 80% for the year 2050), measures for increased energy efficiency, increasing flexibility in the existing power plant feed, extending the grid, storage technologies, energy efficiency in the building sector, sustainable mobility, and extending the lifetime of existing nuclear power plants (by eight to fourteen years, depending on the type of reactor). Accordingly, the last nuclear power plant would have been shut down in 2036 or even later.

After the severe accident to the nuclear reactors at Fukushima Daiichi in March 2014, the German Chancellor, Angela Merkel, announced that all nuclear power plants in Germany would have to undergo security checks. Simultaneously, the seven oldest nuclear reactors in Germany were disconnected from the grid for a minimum period of three months (so-called 'nuclear moratorium'). At the end of this period in June 2011, the German government decided to phase out nuclear power by 2022 (Jacobs 2013). Now, there is a cross-party consensus in Germany on phasing out nuclear power (85% of MPs voted for an irreversible nuclear phase-out by 2022, and the remaining 15% voted for an even quicker phase-out). This increased investment security for all other power generation options, including renewable energy technologies.

The decision to phase out nuclear energy by 2022 was accompanied by a full legislative package, the so-called Energy Package (*Energiepaket*). This embraced seven additional laws, including an amendment to the German feed-in tariff (including an increase in the 2020 renewable electricity target from 30% to 35%), an amendment to the primary German energy law, a law for the acceleration of electricity grid expansion, a law for establishing a national climate and energy fund, and a law to strengthen climate protection in cities and communities.

Today, *Energiewende* policies in Germany include short- and long-term targets for the increase of renewables, CO_2 reductions, increased energy efficiency and the phasing out of nuclear power. These targets are supported by all parties in the parliament as well as about 90 percent of German citizens (BDEW, 2014, AEE, 2014a). The key German *Energiewende* targets are summarized in table 1:

Table 1: Key German *Energiewende* targets

	2020	2025	2035	2050
CO2 reductions versus 1990	40%	X	X	80-95%
Increasing share of renewable electricity	35%	40-45%	55-60%	80%
Improved energy efficiency over 2008 figures	10%	X	X	25%
Phase-out of nuclear plants	8 plants shut down in 2011, the shutdown of the remaining 9 to follow in 2015, 2017, 2019, 2021, 2022			

Source: (BMWi, 2014a)

In order to analyse progress in achieving these mid- and long-term targets, the government has begun issuing an annual monitoring report. The first report was issued in December 2012, measuring developments in the German energy sector against the objectives of the so-called energy policy triangle: security of supply, economic efficiency and environmental protection (Jacobs, 2012a). In addition, a set of 49 indicators was adopted in order to track developments in the fields of energy supply, energy efficiency, renewable energy, power plants, grids, buildings, transport, greenhouse gas emissions, energy costs and macroeconomic effects. In addition, independent experts critically evaluate the progress made in reaching the established *Energiewende* targets (Löschel et al., 2014).

> *“A variety of factors underlines the robustness of the transition path in Germany, including the strong social support, the support of all political parties and the overall perception that the transition towards renewable energies and energy efficiencies will be the least-cost energy system in the long-run, despite cost increases in recent years for final consumers.*

To sum up, energy policy-making in Germany was very controversial for many years. It took several decades to establish a social consensus on the long-term electricity mix. Prior to this consensual long-term vision, short-term targets for the roll-out of renewables had existed since 2000, which were equally important in gradually building up renewable energy capacity. Already in the 1990s, an increasingly strong renewable energy industry had been established which was able to exercise pressure on the ruling political parties. Together with environmentally conscious researchers, they were able to set out alternative development paths in energy policy. Building strong and broad coalitions in support of renewables was crucial during those years of controversies. With increasing economic impacts and related macro-economic effects, more and more political decision-makers, institutions and individuals supported the shift towards increasing shares of renewables. At the same time, the risk perceptions of alternative power-generating technologies changed. This holds true for nuclear security, but more recently also for coal in the light of climate change.

Today, the existence of short- and long-term targets for renewables creates investment security for the industry. A variety of factors underlines the robustness of the transition path in Germany, including the strong social support, the support of all political parties and the overall perception that the transition towards renewable energies and energy efficiencies will be the least-cost energy system in the long-run, despite cost increases in recent years for final consumers. In addition, alternative low-carbon energy options (nuclear, fracking, CCS) have no social or political backing in Germany.

Energy-intensive industries, which were previously opposed to renewable energy support due to fears of cost increases, have been exempted from paying additional surcharges and fees and are now benefiting from the very low wholesale electricity market prices triggered by the Merit-Order-Effect of wind and solar PV (Cludius et al., 2014). A remaining issue are the expected *stranded costs* in the coal sector, given that the mid-term carbon reduction targets cannot be reached without significantly reducing the share of coal and lignite in the German power sector (Agora, 2014).

Many of the old debates about energy policy-making are no longer applicable for renewable energy policies in developing countries today. In the 1990s and 2000s, renewable energy technologies were still many times more expensive than today and not yet cost-competitive with fossil fuels. This has since changed.

However, the role of opening markets to new entrants – which was possible under the FIT regime in German in the 1990s and after market liberalisation for the entire electricity sector – was pivotal in the development of renewables in Germany. Creating level playing fields for independent power producers (IPPs) and (formerly monopolistic) utilities is crucial if the energy systems of emerging economies are to be transformed.

3. NICHE MARKETS, MARKET EXPANSION AND STABILISATION: THE EVOLUTION OF THE FEED-IN TARIFF LAWS AND THE PIVOTAL ROLE OF POLICY ENTREPRENEURS

Germany was one of the first European countries to implement a feed-in tariff scheme, and it is still using this support instrument today. However, the support framework has been modified considerably several times in line with the development of technologies and the previously described phase model of transformation processes. In implementing and amending the different support frameworks, the role of policy entrepreneurs has proved crucial (Jacobs, 2014).

A feed-in tariff consists of at least the following three design features: i) an obligation to purchase, ii) a stable tariff payment, and iii) a guarantee of payments over a long period of time. First, the obligation to purchase obliges the nearest grid operator to buy all renewable electricity, independently of the demand for electricity. Secondly, the renewable power producer is guaranteed a certain amount of money per unit of electricity produced. Thirdly, this payment is guaranteed over a long period of time (usually fifteen to twenty years). All three design features together create a high degree of investment security since power producers can relatively easily calculate revenues over the project's lifetime (Jacobs, 2010).

Regarding the phase model of transformation processes (Rotmans et al., 2001), the pre-development stage of renewables already started in the 1970s. In the mid-1970s, the first research programs for renewable energy sources were implemented (Jacobsson and Lauber, 2006a). Even though the budget for renewable energy research was limited at the start (about €10 million in 1974), it increased until 1982 (about €150 million). In those years, activities in the renewable energy sector were mostly driven by pioneers.

In the 1990s, Germany managed to create a niche market for renewable energy sources through the introduction of feed-in tariffs. Tariff levels were related to the price of electricity for final consumers. Depending on the technology, tariff levels varied between 65 percent and 90 percent of the retail electricity price (BGBl, 1990). The feed-in tariff program managed to create a niche market because state-owned utilities were obliged to buy all the power produced by independent renewable electricity producers (obligation to purchase) at a preferential tariff (tariff payment). In addition, renewable energy producers benefited from a priority right to grid connection as of 2000 (Bechberger, 2000).

The first feed-in tariff legislation was passed successfully due to cross-party support in the German parliament. In addition, a number of non-governmental organisations promoted the concept of feed-in tariffs in the late 1980s, including the Förderverein Solarenergie (SFV), Eurosolar and the small hydro-power association, whose members were generally conservative (Jacobsson and Lauber, 2006b). The large German electricity companies opposed the implementation of a feed-in tariff, above all because they were excluded from tariff payments. But opposition was relatively weak since the expected share of renewable energy support under this law was marginal, and the electricity industry was mostly focused on the inclusion of the former East German market after reunification (Jacobs, 2014, Hirschl, 2008).

The exclusion of state-owned power companies from the support was controversial at the point of implementation. However, this policy helped to create a niche market for new entrants, such as independent power producers, community wind power, energy cooperatives and farmers. When the former (regional) monopolists were allowed to participate under the feed-in tariff scheme in 2000, many of the best locations for wind power had already been taken by independent power producers (Jacobs, 2012b). The first FIT law was crucial to the development of wind energy and hydro-power in Germany. Other technologies were supported by additional capital grants. The impact was much greater than expected, especially with regard to the deployment of wind power. At the end of 1999, installed wind capacity had reached 4.4 GW, almost twice as much as in the US, which ranked second globally at that time (AWEA, 2001).

Market growth started to accelerate in the 2000s. An important regulatory change to the FIT legislation took place in 2000. The major amendment to the feed-in tariff law – the Renewable Energy Source Act – extend the scope of the national renewable energy support scheme and also targeted investment in less mature technologies, such as solar PV and biomass. The new law also established fixed tariff rates that were no longer linked to the electricity price for final consumers. The tariff calculation approach was based on the generating costs of each technology, thus improving investment decisions (BGBl, 2000). Prior to the important amendment of the feed-in tariff in 2000, most actors in the conventional energy sector – counting on a large share of fossil and nuclear fuels, and using renewable energy sources mostly in the form of large hydro-power plants, which are not covered by the EEG remuneration scheme – were opposed to the feed-in tariff system and favoured a quota-based approach.

However, the supporters of the successful renewable energy policies – left-wing political parties, environmental NGOs, renewable energy industry associations – also managed to convince other powerful industry associations to support the new policy. Especially important was the support of the Association of Machinery and Equipment Producers (VDMA), counting on more than 3,000 members and about a million employees. In addition, the labour union IG Metall supported the more ambitious renewable energy policy because of the expected positive macro-economic benefits such as job creation and the development of innovative technologies (Lauber, 2007). Even Preussen Elektra, one of the major utilities, supported the policy.

> *“In the 1990s, Germany managed to create a niche market for renewable energy sources through the introduction of feed-in tariffs.*

In addition, the institutional setting within the German ministries favoured the development of renewables in the 2000s. The political influence of the Ministry for the Environment (BMU) significantly increased after the general elections in 2002. In the same year, the Green Party gained more votes than in 1998. Instead of demanding a fourth ministerial post from the Social Democrats, the Greens demanded that the responsibility for renewable energies be shifted from the Ministry for Economic Affairs (BMWA) to the Ministry for the Environment (BMU) (Reiche, 2004). Consequently, the BMU’s competence in energy policy increased, now covering renewable energy sources, climate protection and nuclear power.

The share of renewables continued to increase considerably, from about 6 percent in 2000 to 15 percent in 2008 and almost 26 percent in 2014. Even though a large portfolio of technologies was supported under the feed-in tariff mechanism, solar PV and wind onshore were the technologies which had experienced the most significant technological development. Both technologies are now cost-competitive with new fossil fuel-based power plants in Germany.

With the EEG amendment of 2014, Germany now focuses on these least-cost technologies. New investments in renewable energy technologies now have only very marginal effects on the price of retail electricity. According to the estimates of the German grid operators, the EEG surcharge is expected to remain relatively stable in the coming years.

However, final electricity consumers in Germany will continue to pay a surcharge of about €0.6/kWh, since the country started to develop and deploy these technologies at a time when they were still significantly more expensive. The development of offshore wind power is nevertheless likely to induce another cost increase related to the necessary and anticipated development of this emerging technology, which should keep total retail prices for households constant at roughly €0.30 per kWh for the coming years.

In the future, Germany's long-standing support framework will shift from feed-in tariffs to auctions. In accordance with the EU's new 2014 guidelines for state aid to environmental protection and energy (EU Commission, 2014), the EEG amendment of 2017 is likely to introduce competitive auctions for larger-scale renewable energy projects. To test the process, the reform just enacted includes a pilot auction scheme for 400 MW of ground-mounted photovoltaics annually. Small-scale projects might still be able to benefit from administratively set feed-in tariffs (Jacobs, 2015 (forthcoming)).

Germany can be considered to be a pioneering country in the development and deployment of forms of renewable energy (Bechberger and Reiche, 2007). Germany implemented feed-in tariffs as early as 1990 and is still using them in 2014. No other country in the world has made continuous use of this support mechanism for such a long period of time (Jacobs, 2012b). This kind of policy continuity has been crucial for the deployment of renewable energy in Germany, and the same holds true for developing countries. However, adjusting the policy to the development of technologies and to the increasing market shares of renewables was equally important.

4. TECHNOLOGICAL LEARNING AND COSTS: THE EVOLUTION OF WIND AND SOLAR PV IN THE CONTEXT OF THE GERMAN *ENERGIEWENDE*

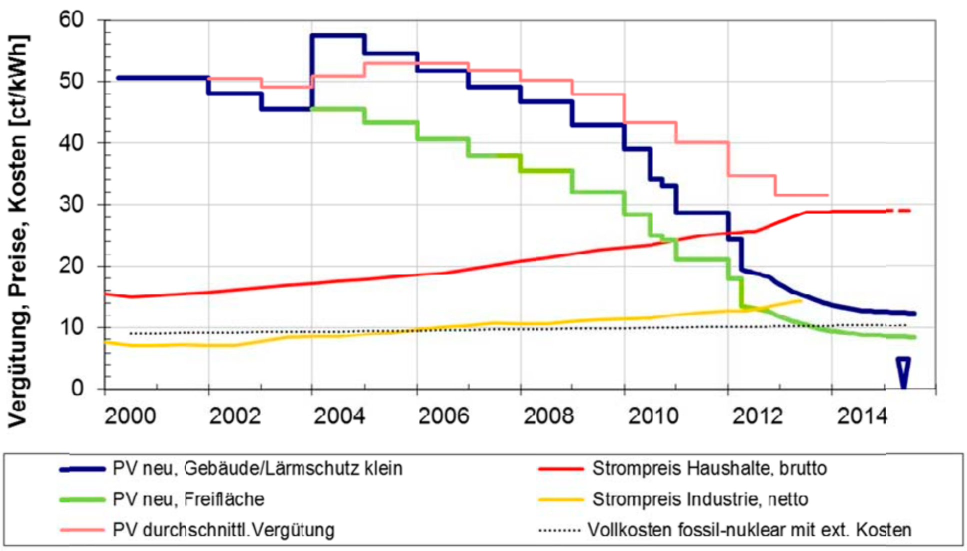
Although solar photovoltaic systems supply less than one percent of total global electricity demand, the solar market has experienced impressive growth rates since 2000. From 1999 to 2009, global installed capacity increased from 1.1 GW to 139 GW (Despotou et al., 2010, REN21, 2014). Germany was an important driver of the global PV market, especially from 2004 to 2011, during which time the German market represented about fifty percent of the world market (Jacobs, 2012b). In 2010 and 2011 the number of new installations soared, and capacity increased by about 7.5 GW. Through the amendment of the Renewable Energy Source Act in 2014, the government is intending to control the growth rates, now targeting an increase of 2.5 GW of solar PV per year. This should also help to control additional costs for final consumers. The total installed capacity of solar PV reached nearly 36 GW in 2013, 5.7% of total electricity demand (Wirth, 2014).

Investment in solar PV in Germany has been driven by a large diversity of actors. About one third of all solar PV modules have been installed on residential rooftops, mostly financed by

German citizens (Rickerson et al., 2014). In addition, PV systems have been installed on the roofs of farms and commercial and industrial buildings. With increasing shares of solar PV, prices per kilowatt-hour dropped significantly. Between 2009 and 2014 alone, average feed-in tariff payments for new solar PV decreased by about 80 percent in order to keep track of falling solar PV system costs.

However, the massive deployment of these technologies increased the average payment for each kilowatt-hour of renewable electricity. In the first decade, the EEG surcharge rose modestly, from less than 0.19 ct/kWh in 2000 to 1.3 ct/kWh in 2009. In this period, project developers primarily focused on onshore wind. In the years 2009 to 2013, the EEG surcharge increase very rapidly, to 5.28 ct/kWh in 2013. This sharp increase was due to a shift towards more expensive technologies, namely solar PV and biogas. 25 GW of new solar PV capacity were installed in those years, representing about fifty percent of the world market. At the same time, tariff payments for solar PV were still very high. These high costs are still reflected in retail electricity prices today, since tariffs under the German support framework are guaranteed for a twenty-year period (Jacobs, 2015 (forthcoming)). Policy-makers in developing countries that have started to invest in renewables today do not have to face these high costs.

Figure 2. Decreasing FIT payment for new solar PV in Germany (ct/kWh)



Source: Wirth 2014.

A similarly impressive development took place in the wind energy sector. In Germany, installed wind capacity increased from 56 MW in 1990 to more than 33,700 MW at the end of 2013 (BMWi, 2014b). In the case of wind energy, thirty to forty percent of new installed annual capacity world-wide from 1998 to 2003 was installed in Germany (BMWi, 2014b, GWEC, 2014). In the first half of the 1990s, installed capacity in Germany almost doubled every year. Even though annual growth rates slightly decreased during the second half of the decade, installed wind capacity in 1999 was more than 4,400 MW. While newly installed capacity in Germany was more in the range of 2,000–2,500 MW in the period 2000 to 2005, the number of new wind turbines decreased in the second half of the decade, mostly because many of the best spots for wind power development had already been taken. In recent decades, average turbine size in Germany increased from 170 kW in 1990 to 2600 kW in 2013. At the end of 2013, Germany was the third-largest wind market in the world, after the US and China (REN21, 2014).

A fresh challenge is the new offshore-wind energy plants in the north of the country. Since offshore wind energy is a less mature technology than onshore wind energy, the lead times for deployment are longer, and the costs are higher. Nonetheless, the German government plans to install 6.5 GW of offshore wind energy by 2020. As for the German transmission network, the major challenge lies in accelerating the implementation of grid expansion measures connecting the north and south of the country. Most electricity demand (especially from industry) is in southern Germany, whereas developments in wind energy are mostly taking place in the north. The four German transmission system operators publish an annual national network development plan (the so-called NEP) which lists the expansion and reinforcement measures required for the next ten years to ensure the stable and reliable operation of the grid.

Germany supported renewable energy sources at a very early stage. In the case of both wind energy and solar PV, the German *Energiewende* helped to drive down technology costs significantly so that developing countries today have the opportunity to invest in these technologies as well. In the case of solar PV, the German market absorbed about fifty percent of all modules installed world-wide between 2004 and 2010. In the case of wind energy, thirty to forty percent of new installed annual capacity world-wide from 1998 to 2003 was installed in Germany. Today the generating costs of these technologies are increasingly competitive with fossil fuel-based power generation.

If Germany were to install its total photovoltaic fleet today (more than 30 GW), German consumers would pay only about €60 to 80 billion (overnight costs), as opposed to the €180 billion that have effectively had to be paid. Any country that starts to invest in these renewable energy technologies today can benefit from the technological advances of the past. Furthermore, additional cost decreases can be expected. As of 2050, the LCOE of solar PV is expected to range from 2ct/kWh to 4.5 ct/kWh (Agora, 2015).

5. CONCLUSION: LESSONS LEARNED FOR ENERGY TRANSITIONS IN DEVELOPING COUNTRIES

The German *Energiewende* in the electricity sector includes many aspects that are crucial for the transformational change of NAMAs in developing countries, including the establishment of a long-term vision, the creation of a protected niche market via feed-in tariffs and constant adaptation of the support framework to keep track of technological development, and the creation of macro-economic benefits such as jobs and reduced health impacts. The role of policy entrepreneurs and advocacy coalitions in supporting renewable energy technologies was equally important.

The creation of a consensual long-term vision for the German electricity mix took several decades. This vision of a renewable energy-based power and energy system only entered the political mainstream at the start of the 2010s, being translated into long-term renewable energy targets for the year 2050. This long-term vision is certainly attracting investors since they know that a long project pipeline of renewable energy projects is needed in order to reach these goals in the coming decades. Long-term targets for renewables will also help to trigger investment in renewables in developing countries. However, policymakers tend to focus on shorter term objectives. Equally important for the development of renewable energy sources are short-term targets. For instance, the feed-in tariff law of 2000 included the target of doubling the share of renewables by 2010. The corresponding target for the feed-in tariff law of 2014 is a share of 40 to 45 percent by 2025. As of 2013, 144 countries had established targets from renewable energy sources, and 138 countries had implemented support policies, including 95 developing countries (REN21, 2014). In addition, the periodic assessment of target achievement – as built into Germany's energy transition process – can be considered an important lesson learned for developing countries.

> *"Understanding the rapidly falling costs of renewable energies is crucial for avoiding a grid-lock in fossil fuel-based power generation. The starting point for developing countries that are beginning to invest in renewable energy technologies today is much different. In fact, the transition of energy systems towards more renewable energies is now happening on a world-wide scale.*

Important actors in German society were working at an early stage for an energy system that would no longer be based on fossil fuels. The environmental movement, which was anti-nuclear in the 1960, 1970s and 1980s, turned into a pro-renewable energy movement. In the late 1980s, the support of MPs from all political parties was crucial in passing the first feed-in tariff law. In this sense, building coalitions for a transition to sustainable energy systems is very important.

An important feature of the German *Energiewende* is the active and broad participation of non-utility actors. In contrast to most other countries around the world, investment in renewable energy projects has not been utility-driven. About fifty percent of total installed renewable energy capacity (80GW) was financed by new entrants and smaller scale actors (energy cooperatives, community wind power plants, farmers, etc.) and private households. The largest four utilities in the German electricity market have a market share of only twelve percent of installed renewable energy capacity, with institutional investors and project developers being responsible for the remaining market share (trend:research and Leuphana, 2013, BEEn, 2014). For the most part (with the exception of offshore wind energy), these producers are connected to the distribution network. In the conventional electricity sector, competition was triggered by market liberalization at the end of the 1990s. State-owned companies were privatized, and competition was increased.

This increasing diversity of ownership cannot be observed in all countries that are moving towards a renewable energy-based power system. In other jurisdictions, for instance, Spain and the UK, renewable energy projects are primarily being developed by the existing (national) utilities (Stenzel and Frenzel, 2008). In the first place, the establishment of a protected niche market has led to the diversification of actors able to participate in the energy market and in energy policy-making in various ways. This unique ownership structure in turn contributes significantly to the broad support for the *Energiewende* among citizens. In particular, financial participation in local energy generating plants has led citizens to identify with these projects. Interestingly, acceptance of wind energy projects has proved to be higher in the case of local ownership. In addition, local ownership also triggers positive economic effects in those areas, mainly rural, where renewable energy power plants are located. In additions, these projects create added value in those communities and regions where power plants are located (Hirschl et al., 2010). Fostering the participation of citizens in developing countries is more difficult due to the fact that equity for project finance and debt-finance from national banks are usually more complicated to arrange.

However, some aspects that were important for a paradigm shift in politics, society and business in Germany are not, or no longer, applicable regarding energy transitions in developing countries. This is especially true for the debate over the cost of renewables. In the 1990s and 2000s, advocates of renewable energy in Germany had to convince policy-makers of the usefulness of renewables despite their significantly higher costs compared with fossil fuel-based power plants. However, energy transitions in several European countries (including Germany, Spain and Denmark) have triggered technological learning over the past two decades, leading to important cost reductions in several renewable energy technologies, namely wind energy and photovoltaics. The massive deployment of these technologies has increased the average payment for each kilowatt-hour of renewable electricity. It is important to realize that large parts of the cost increases related to the German *Energiewende* are due to these 'historic costs'. By supporting technologies like solar PV at an early stage, Germany (and other front-runner countries) have managed to drive down renewable energies through the learning curve.

By investing on these technologies at an early stage, Germany has also managed to benefit from many of the positive macro-economic effects. Today the renewable electricity industry has almost 300,000 employees with a turnover of more than €33 billion, mostly in exports (Jacobs, 2010). Germany is also exporting a lot of goods and services in the renewable energy sector, which support about 100,000 jobs. The export share of the German wind energy industry accounts for 67 percent of total turnover (AEE, 2014b). First-mover countries, that is, countries that have started to promote renewable electricity generation at an early stage, were generally able to achieve these objectives. Developing countries are frequently trying to achieve similar effects by establishing local content requirements. Despite these important cost reductions, many policy-makers in developing countries still think that renewable energy technologies are expensive due to past cost data.

Understanding the rapidly falling costs of renewable energies is crucial for avoiding a grid-lock in fossil fuel-based power generation. The starting point for developing countries that are beginning to invest in renewable energy technologies today is much different. In fact, the transition of energy systems towards more renewable energies is now happening on a world-wide scale. World-wide investments in renewables have increased five-fold within only one decade (Frankfurt School-UNEP Centre/BNEF. 2014). For the third year running, investment in new renewable capacity exceeded investment in fossil-fuel power (IRENA 2014). The BRICS countries (Brazil, Russia, India, China, and South Africa) accounted for approximately 38 percent of newly installed renewable capacity world-wide (REN 21, 2014).

In addition, the choice of support framework is not as important as the actual design. In the 1990s and 2000s, most policy-makers around the world opted for feed-in tariffs in order to support renewable energy sources. In recent years, an increasing number of countries – including many developing countries – are also opting for auction mechanisms (Lucas et al., 2013) or a mix of several policy instruments (Couture et al., 2015 - forthcoming). Similarly, solar PV market growth in Germany will be driven by an auction for large-scale, free-standing PV systems. The government is targeting a newly installed capacity of 400 MW in this market segment, whereas smaller-scale, roof-mounted systems continue to be supported under the feed-in tariff program.

In order to establish transformational policies and programmes in developing countries, it will be crucial to inform a wide range of actors about the shared benefits of climate change policies as identified by the Fifth Assessment Report of the IPCC, namely technological innovations, job creation, health impacts, etc. Only in this way can a strong advocacy coalition for sustainable development be established.

Dr. David Jacobs is founder and managing director of the consulting firm *IET – International Energy Transition*. He is also a Research Associate and Lecturer at the Environmental Policy Research Center at the Freie Universität, Berlin. Previously, he has been Project Director of the Transdisciplinary Panel on Energy Change at the Institute of Advanced Sustainability Studies in Potsdam and Director of renewable energy projects at the consulting firm IFOK. His research focuses on financing, policies and framework conditions for renewable energy sources. He has worked as a researcher and policy consultant for several governments and international organizations such as IRENA, World Bank, UNEP, UNDP, OSCE, and IDB, and has authored more than 50 articles, reports, books and book chapters on sustainable energy policy design in the developing and developed world.

REFERENCES

Energy Policy Act of 2005.

AEE 2014a. 92 Prozent der Deutschen wollen den Ausbau Erneuerbarer Energien, Press release, 15 October 2014. Berlin: Renewable Energy Agency (AEE).

AEE 2014b. Erneuerbare Energien stark im Export - Umweltfreundliche Energietechnik baut wegen eines teilweise schwierigen Inlandsmarktes zunehmend auf Auslandsgeschäft, press release (15 August). Berlin: Agency for Renewable Energies (AEE).

AGORA 2014. The German Energiewende and its Climate Paradox: An Analysis of Power Sector Trends for Renewables, Coal, Gas, Nuclear Power and CO2 Emissions, 2010–2030. Berlin: Agora Energiewende

AGORA 2015. Current and Future Cost of Photovoltaics. Berlin: Agora Energiewende.

AWEA 2001. Global Wind Energy Market Report. Washington DC, : American Wind Energy Association.

BDEW 2014. Energiemonitor 2014: Das Meinungsbild der Bevölkerung. Kommentierte Zusammenfassung. Berlin: Bundesverband der Energie- und Wasserwirtschaft (BDEW).

BECHBERGER, M. 2000. Das Erneuerbare-Energien-Gesetz (EEG): Eine Analyse des Politikformulierungsprozesses. *FFU Report 06/2000.* Berlin: Forschungsstelle für Umweltpolitik, Freie Universität Berlin.

BECHBERGER, M. & REICHE, D. 2007. The spread of renewable energy feed-in tariffs (REFITs) in the EU-25 in Mez (ed.), pp. 31-50. *In:* MEZ, L. (ed.) *Green Power Markets – Support schemes, case studies, and perspectives.* Brentwood (UK): Multi-Science Publishing.

BEEN 2014. Energiewende braucht Bürgerenergie. Berlin: Bündnis Bürgerenergie e.V. .

BGBL 1990. Gesetz über die Einspeisung vom Strom aus erneuerbaren Energien in das öffentliche Netz (Stromeinspeisegesetz), 7 December 1990, . Bonn: Bundesgesetzblatt 1, p. 2633. .

BGBL 2000. BGBl 2000. Gesetz für den Vorrang Erneuerbarer Energien, Bundesgesetzblatt I, 31 March 2000, p. 305. . Bundesgesetzblatt.

BMWI 2014a. Die Energie der Zukunft, Erster Fortschrittsbericht zur Energiewende - Langfassung. Berlin: Bundesministerium für Wirtschaft und Energie (BMWi).

BMWI 2014b. Erneuerbare Energien in Zahlen - Nationale und internationale Entwicklung im Jahr 2013. Berlin Bundesministerium für Wirtschaft und Energie.

BUNDESTAG (ED.) 1991. Protecting the Earth: A Status Report with Recommendations for a New Energy Policy. Third Report of the Enquete Commission of the 11th German Bundestag, Preventive Measures to Protect the Earth's Atmosphere, vol. II. Bonn: Deutscher Bundestag.

CLUDIUS, J., HERMANN, H., MATTHES, F. C. & GRAICHEN, V. 2014. The merit order effect of wind and photovoltaic electricity generation in Germany 2008–2016: Estimation and distributional implications. *Energy Economics,* 44**,** 302-313.

COUTURE, T. D., JACOBS, D., RICKERSON, W. & HEALEY, V. 2015 - forthcoming. The next generation of renewable electricity policy: How rapid change is breaking down conventional policy categories. Golden, CA: National Renewable Energy Laboratory (NREL)

DESPOTOU, E., EL GAMMAL, A., FONTAINE, B., MONTORO, D. F., LATOUR, M., LENOIR, S., MASSON, G., PHILBIN, P. & VAN BUGGENHOUT, P. 2010. Global market outlook for photovoltaics until 2014. Brussels, Belgium: European Photovoltaic Industry Association.

EU COMMISSION 2014. Communication from the Commission — Guidelines on State aid for environmental protection and energy 2014-2020, OJ C 200, 28.6.2014, p. 1–55. Brussels: European Commission

GWEC 2014. Global wind statistics. Brussels: Global Wind Energy Council (GWEC).

HIRSCHL, B. 2007. *Erneuerbare-Energien-Politik im Mehrebenensystem - Eine Multi-level Policy Analyse der deutschen Politik für Erneuerbare Energien in Strommarkt.* PhD, Freie Universität Berlin.

HIRSCHL, B. 2008. *Erneuerbare Energie-Politik, Eine Multi-Level Policy-Analyse mit Fokus auf den deutschen Strommarkt,* Wiesbaden, Germany, VS Research (Verlag für Sozialwissenschaften).

HIRSCHL, B., ARETZ, A., PRAHL, A., BÖTHER, T., HEINBACH, K., PICK, D. & FUNCKE, S. 2010. Kommunale Wertschöpfung durch Erneuerbare Energien. Berlin: Institut für Ökologische Wirtschaftsforschung.

HUBER, M. 1997. Leadership and unification: climate change policies in Germany. *In:* COLLIER, U. & LÖFSTEDT, R. (eds.) *Cases in Climate Change Policy: Political Reality in the European Unity.* London: Earthscan.

JACOBS, D. 2010. Fabulous feed-in tariffs. *Renewable Energy Focus,* July/August 2010**,** 28-30.

JACOBS, D. 2012a. The German Energiewende – History, Targets, Policies and Challenges. *Renewable Energy Law and Policy Review,* 1**,** 223-233.

JACOBS, D. 2012b. *Renewable Energy Policy Convergence in the EU – The evolution of feed-in tariffs in Germany, Spain and France,* Farnham, Ashgate Publishing

JACOBS, D. 2014. Policy invention as evolutionary tinkering and codification: the emergence of feed-in tariffs for renewable electricity. *Environmental Politics*.

JACOBS, D. 2015 (forthcoming). Understanding the Energiewende - The ongoing transition of the German electricity system within Europe Berlin: Agora Energiewende.

JACOBSSON, S. & LAUBER, V. 2006a. The politics and policy of energy system transformation: Explaining German diffusion of renewable energy technology. *Energy Policy,* 34**,** 256-276.

JACOBSSON, S. & LAUBER, V. 2006b. The politics and policy of energy system transformation: Explaining German diffusion of renewable energy technology *Energy Policy,* 34**,** 256-276.

JAHN, D. 1992. Nuclear Power, Energy Policy and New Politics in Sweden and Germany. *Environmental politics,* 1**,** 383-417.

KORDS, U. 1993. *Die Entwicklungsgeschichte des Stromeinspeisegesetzes vom 5.10. 1990. Ein Beispiel für die Mitwirkungsmöglichkeiten einzelner Abgeordneter an der Gesetzgebungsarbeit des Deutschen Bundestages.* Diplomarbeit (final year project), Freie Universität Berlin.

KRAUSE, F., BOSSEL, H. & MÜLLER-REISSMANN, K.-F. 1980. *Energiewende – Wachstum und Wohlstand ohne Erdöl und Uran,* Frankfurt, fischer verlag.

LAUBER, V. 2007. The politics of European Union policy on support schemes for electricity from renewable energy sources. *In:* MEZ, L. (ed.) *Green Power Markets – Support schemes, case studies, and perspectives.* Brentwood (UK): Multi-Science Publishing.

LAUBER, V. & MEZ, L. 2007. Renewable electricity policy in Germany 1974-2005. *In:* MEZ, L. (ed.) *Green Power Markets – Support schemes, case studies, and perspectives.* Brentwood (UK): Multi-Science Publishing.

LAUBER, V. & PESENDORFER, D. 2004. Success through continuity: Renewable electricity policies in Germany. *In:* DE LOVINFOSSE, I. & VARONE, F. (eds.) *Renewable electricity policies in Europe: Tradable Green Certificates in Competitive Markets* Louvain.

LÖSCHEL, A., ERDMANN, G., STAIß, F. & ZIESING, H.-J. 2014. Stellungnahme zum ersten Fortschrittsbericht der Bundesregierung für das Berichtsjahr 2013. Berlin, Münster, Stuttgart: Energie der Zukunft - Kommission zum Monitoring-Prozess.

LUCAS, H., FERROUKHI, R. & HAWILA, D. 2013. Renewable Energy Auctions in Developing Countries. Abu Dhabi: International Renewable Energy Agency (IRENA)

MERSMANN, F., OLSEN, K. H., WEHNERT, T. & BOODOO, Z. 2014a. From theory to practice: Understanding transformational change in NAMAs. UNEP DTU Partnership.

MERSMANN, F., WEHNERT, T., GÖPEL, M., ARENS, S. & UJJ, O. 2014b. Shifting Paradigms: Unpacking Transformation for Climate Action. A Guidebook for Climate Finance & Development Practitioners. Berlin: Wuppertal Institute for Climate, Environment and Energy.

MEYER-ABICH, K. M. & SCHEFOLD, B. 1986. *Die Grenzen der Atomwirtschaft,* Munich, Beck.

MEZ, L. & PIENING, A. 2006. Phasing-Out Nuclear Power Generation in Germany: Policies, Actors, Issues and Non-Issues. *In:* JÄNICKE, M. & JACOB, K. (eds.) *Environmental Governance in Global Perspective. New Approaches to Ecological Modernisation.* Berlin: Freie Universität Berlin.

REICHE, D. 2004. *Rahmenbedingungen für erneuerbare Energien in Deutschland - Möglichkeiten und Grenzen einer Vorreiterpolitik,* Frankfurt am Main, Peter Lang

REN21 2014. Renewables 2014 - Global Status Report Paris: Renewable Energy Policy Network for the 21st Century

RICKERSON, W., COUTURE, T., BARBOSE, G., JACOBS, D., PARKINSON, G., CHESSIN, E. & BELDEN, A. 2014. Residential prosumers – Drivers and policy options (RE-Prosumers) , June 2014. Paris: IEA-RETD.

ROTMANS, J., KEMP, R., VAN ASSELT, M., GEELS, F., VERBONG, G., MOLENDIJK, K. & NOTTEN, P. 2001. Transitions & Transition Management: The Case for a Low Emission Energy Supply. ICIS Working Paper. Maastricht: International Centre for Integrative Studies (ICIS).

STENZEL, T. & FRENZEL, A. 2008. Regulating technological change—The strategic reactions of utility companies towards subsidy policies in the German, Spanish and UK electricity markets. *Energy Policy,* 36**,** 2645-2657.

TREND:RESEARCH & LEUPHANA 2013. Definition und Marktanalyse von Bürgerenergie in Deutschland. Berlin: trend:research und der Leuphana Universität Lüneburg.

WIRTH, H. 2014. Aktuelle Fakten zur Photovoltaik in Deutschland. Freiburg: Fraunhofer ISE.

Photo credit: www.CGPGrey.com

Bjarne Gantzel Pedersen
Omstilling Danmark

Wind of change: Transformational change through wind power in Danish electricity production: moving towards 100% renewable energy by 2050

ABSTRACT

In 2014, Danish wind turbines supplied 39% of the total electricity demand in Denmark. Wind power in Denmark is actively pushing the market away from fossil-based energy production by aiming for a zero-carbon energy market by 2050. For decades, passionate pioneers drove wind power development in Denmark. Despite cheap oil prices, they continued to improve wind turbines, and their collaboration led to an accelerated development, demonstrating that cooperation is extremely important when aiming to achieve sustainable development goals. This case shows genuine transformational change from fossil-based energy production to renewable energy. A broad majority in parliament has agreed that Denmark should become fossil-free by 2050, thus ensuring that this sustainable development will continue.

INTRODUCTION

This article describes the development and breakthrough of wind power, and shows how Denmark is planning to abandon fossil-based power production by 2050. The aim is to improve the understanding of transformational change, pointing out important indicators, drivers and success factors in order to help NAMA facilitators and decision-makers determine where to give support.

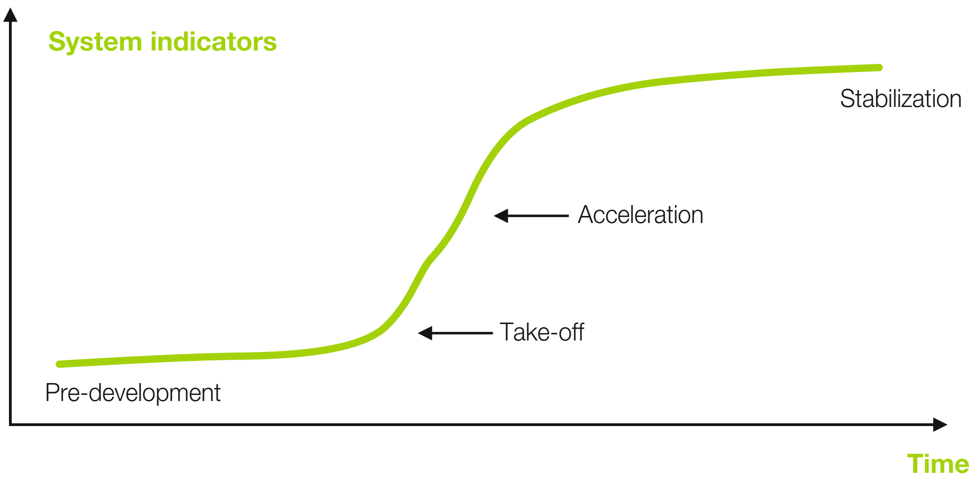
The paper is structured into the following six sections: 1) introductory section; 2) a theoretical section describing the phase model and multi-level perspective; 3) the analysis section, which is divided into pre-development, take-off, acceleration and stabilisation; 4) discussion; 5) conclusion; and 6) perspectives.

THEORIES OF TRANSFORMATIONAL SYSTEM CHANGE

The article uses two theories: the phase model and the multi-level perspective.

Phase model

Figure 1. Phase model (Timmermans 2006, after Rotmans et al. 2000)



The phase model is a theory that describes four distinct phases in a change of system: pre-development, take-off, acceleration and stabilisation. This is known as the 'S-curve' of transition, as shown in Figure 1.

In the pre-development phase, the dominant system is stable, and no large-scale changes are visible. The development takes place in laboratories, research departments or among pioneers.

In the take-off phase, the development becomes more coordinated among the pioneers or niche actors. Bergman et al. (2008) say that a more dominant concept of their innovation is emerging. This means that the technological development of the wind turbine has become more uniform. Some ideas have been tested and proven less efficient or safe, thereby being consigned to design improvements.

Explaining the third phase, Bergman et al. (2008) state that when the regime is under multiple pressures of different origins, the acceleration phase occurs.

Finally, once the fourth phase, stabilisation, has been reached, the old standardised system has been changed. The transition has reached a new dynamic equilibrium, and the speed of change is decreasing. Importantly, the development has now reached a point of no return, and reverting to the old system is unlikely.

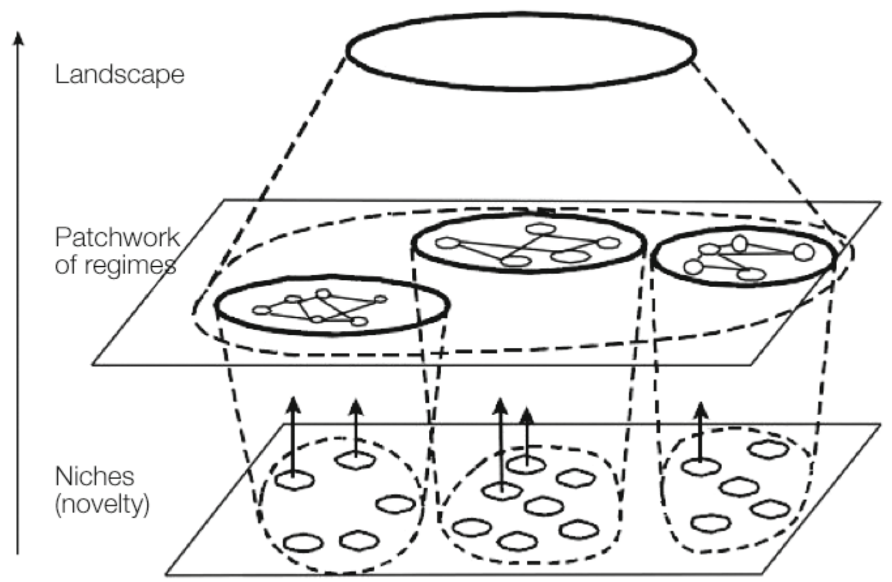
Multi-level Perspective (MLP)

This article will also use the MLP theory to analyse the development of wind turbines in Denmark.

Earlier studies using the MLP theory have focused on opportunities and barriers that are present when a technological innovation tries to enter an existing regime for which it would be advantageous.

The theory views the socio-technical interactions on three levels: niche, regime and landscape. The MLP theory can be seen as a natural supplement to the phase model because it pushes these three levels forward and explains the interactions between them. These interactions influence the phases and may be the reason why they are created in the phase model. Due to changes within one phase, development of the next phase occurs. The MLP theory describes the reasons for these changes.

Figure 2. Geels' model of the three levels in the MLP theory (Geels 2005)



As seen in the figure at the macro-level, the socio-technical landscape is superior to the regime and niche levels. Relevant to this research, the landscape could be climate change, fossil fuel prices or public awareness of these matters.

At the meso-level, the regime can be seen as the existing and standardised energy system that dominates in the generation of energy, the infrastructure (i.e. the electrical grid), and in determining how people use the energy.

The regime is influenced by changes and trends in society. If disharmony between regime and landscape occurs, the landscape may put pressure on the regime, and a 'window of opportunity' relating to the niche level is opened for a new innovative technology, created at this level, to challenge the dominant technology at the regime level. The Danish case shows how the wind turbines challenge the existing dominant fossil-based power production.

Timing is crucial. The 'window of opportunity' may only be open for a short time before the regime adjusts, protecting the existing and dominant technologies. This rests on the strength of the regime and the actors involved.

When looking at the energy sector, which includes power, heat and transport, from a global perspective, this regime has proven to be extremely powerful, and has resulted in alarmingly adverse effects on climate change. It is clear that transformational change is necessary.

Comparing the MLP to the phase model, and in particular the pre-development phase, changes can be seen happening at the niche level, while the two other levels, regime and landscape, are stable. This demonstrates how the two theories, the phase model and the MLP theory, are well suited to each other.

ANALYSIS

This article will use the phase model as the framing structure for an analysis of the development of wind turbines in Denmark.

Pre-development phase

The story of this transition begins with Danish meteorologist and folk schoolteacher Poul la Cour (1846-1908), who, in 1891, constructed the first electricity-producing windmill. Prior to this, windmills in Denmark had mostly been used to grind grain into flour or pump water.[1]

La Cour was very interested in the emerging electrification of the cities and understood that it could help with the hard work on the farms (Jensen, 2003). It would take a long time for the electrical infrastructure to reach farms in rural areas, so local electricity-producing wind turbines would be beneficial. La Cour worked and experimented a great deal on the aerodynamics of the wings, and built the first wind tunnel. Thus, the impetus for working on this transition was to provide rural areas with electricity.

In 1903 La Cour founded the Danish Wind Electricity Association, which gave advice on how to construct wind turbines, and later went on to publish a magazine on wind electricity (Jensen, 2003). This magazine enabled him to spread knowledge and awareness of the wind turbines and their possibilities to a broader number of interested people.

La Cour also began teaching a course on aerodynamics and the construction of wind turbines. In doing so, he attracted interested students who wanted to have expert knowledge

1 Windmills producing electricity will from now on, be called by their more appropriate name of 'wind turbines'.

of this technology, thereby creating the next generation of pioneers who would drive this development forward.

One of his students, Knud Lykkegaard, had success in building small 30-40 kW wind turbines. Today they are a hundred times bigger. When Lykkegaard would go to maintain the wind turbines, he drove his electric car, which he charged with power from his wind turbines. This made him a real visionary.

Due to the lack of coal and oil during World War II, Danish industry began showing an interest in wind turbines. The cement producer F. L. Smidth constructed 50 wind turbines of 60-70 kW during the war. Wind power became attractive, but when the war ended and large quantities of coal and oil were readily available to the power plants, the interest in electricity-producing wind turbines disappeared. Dynamics, both within the phases of transition and in the perspective of the multiplicity of levels, must be expected. World War II created a window of opportunity for niche development, but it was not open long enough to allow its continuation.

After the war, only one electricity company, SEAS, continued to construct wind turbines, including the first turbine to produce alternating current (AC). This was an important step because the electrical grids use alternating current, which resulted in the connection to the electrical grid and the infrastructure moving closer.

As a result of cheap coal and oil prices, once again the development of the wind turbines had to be driven by those with a passion -- where economic gain was of little or no interest. Again, it was one of Poul la Cour's students, Johannes Juul, who constructed the so-called Gedser wind turbine in 1957. It produced 200 kW AC, which was fed directly into the electricity grid, and was the biggest wind turbine in the world, at the time. It operated until 1967, when its gearbox failed.

As previously noted, most actors returned to using fossil-based fuel for electricity production due to low oil prices. Consequently, the Association of Danish Electric Utilities decided that it was not profitable to continue producing electricity from wind turbines.

Figure 3. The Gedser wind turbine (© Elmuseet, Bjerringbro)

In an article, Johannes Juul disagreed with the policy of quitting wind power. His arguments for wind power were:

1) Wind power will provide savings with respect to buying fuel from abroad
2) Wind power is an important reserve for steam power plants
3) The construction of wind power plants can be adjusted to the labour market
4) Big economic advantages could be produced if Danish wind power cooperated with Norwegian and Swedish hydropower
5) Danish industry could achieve greater exports by producing wind turbines and spare parts for foreign countries.
   (Jensen 2003).

Juul was clearly fighting for the retention of wind turbines, but his visionary arguments went unheard. The existing regime was fighting back. The low costs of the existing, well-known source for electricity production became the hard competitor, and many actors within the fossil fuel-based industry also preferred oil and coal to remain the top priority in this market.

> *"Responding to the political interest in nuclear power, an organisation and opposition movement started and quickly grew, informing Danes about the dangers of nuclear power and arranging large demonstrations. Some began looking for alternative environmentally friendly solutions, and a sister organisation focusing on increasing social awareness of renewable energy formed.*

The pioneers who wished to continue with the development and improvement of this technique had to do so without any prospect of a profitable income. This very strong, loyal and resilient niche development lasted several decades. However, it is typical for the pre-development phase to last longer because only a few people are driving the development. It is also important to note that, in this case, the niche development did not take place in the research and development departments but among craftsmen from various backgrounds.

These stories of pioneering activities serve to demonstrate to the general population and the politicians that alternatives are available. Both the dominant regime and the surrounding landscape are being informed of new possibilities.

Take-off phase

The steps throughout the take-off phase were reached by collaboration and shared experiences.

For some time, both oil prices and interest in wind turbines had remained low. However, in the 1970s, during the oil crisis, the situation was reversed. Wind turbines became interesting once again, and the Gedser wind turbine was refurbished with economic support from the Energy Research Development Agency, a public institution in the USA (Jensen, 2003). Their interest in this particular wind turbine was its innovative design, its size (200 kW) and the fact that it had been running for 10 years without maintenance. This time, however, it was primarily producing test results for further experiments as a real R&D project.

The fact that the Americans were showing this kind of interest in a Danish invention stimulated Danish politicians and other inventors to investigate this further. It is very important for politicians to show interest in these kinds of niche technology, as they can help to open the window of opportunity. The oil crisis created dynamics at the landscape level, which opened the window of opportunity, and presented the existing regime with another challenge. The oil crisis created dynamics at the landscape level, which again created a window of opportunity, providing the existing regime with another challenge.

The dependence on oil-producing countries and the fluctuations in prices were disturbing, and created a need for greater security of energy provision. Moreover, there was an increasing environmental awareness. Politicians, as well as others, were looking for alternatives to oil. One alternative was nuclear power, which was widely debated.

Growing environmental awareness within society can create additional pressure on the existing regime, at the landscape level, and further support the development taking off.

The oil crisis started many discussions on alternative ways to produce electricity. Among the most debated sources was nuclear power. Responding to the political interest in nuclear power, an organisation and opposition movement started and quickly grew, informing Danes about the dangers of nuclear power and arranging large demonstrations. Some began looking for alternative environmentally friendly solutions, and a sister organisation focusing on increasing social awareness of renewable energy formed.

Figure 4: the logo and badge of the nuclear opposition movement

Meanwhile, a carpenter in West Jutland named Christian Riisager, who had also been experimenting with wind turbines for many years, connected the turbine to the electrical grid one day and was able to watch the wheel on the household electricity meter run backwards. This was not the first time that a wind turbine had been connected to the grid, but electrical companies were very sceptical of allowing this 'alien' into their grid and resisted issuing a permit. Connecting to the existing infrastructure, the electricity grid, was an essential step in the development of wind turbines. In many other cases, niche production needs to create a new surrounding infrastructure to support it. However, with this development, a pre-existing infrastructure could be used.

Later, Christian Riisager also succeeded in starting the first mass-produced wind turbine (motiva.fi, 2015). Mass production is another important step when optimising production and keeping the costs down, as well as being necessary for continuing a niche development -- a clear sign of an active take-off phase.

In 1975, 400 teachers and students at Tvind, an international school centre, cut the first sod for a 2 MW wind turbine. They were motivated to create an alternative to fossil-based power production and nuclear power. Volunteers constructed the foundations and the tower, while scientists and researchers from the Risø National Laboratory designed the sails. The involvement of scientists and researchers was also very important to this development, as politicians and decision-makers rely on their knowledge and listen to their recommendations. A gearbox from a Swedish copper mine was reused in order to keep the costs down. For 22 years, from 1978 to 2000, this was the most productive wind turbine in Denmark, and it is still running today. Like a grassroots organisation, with many pioneers working on one project, Tvind managed to construct actual proof that there was a sustainable alternative.

The Tvind project was a breakthrough for wind turbines in Denmark, proving that wind turbines of a large size could also benefit the population. There was a great deal of media attention surrounding this, and many Danes went to see this new creation. In addition, the Risø National Laboratory (today the DTU Risø Campus) began working with aerodynamics and other kinds of wind energy research, and later started testing wind turbines.

After the energy crisis in the mid-1970s, different groups started focusing on the construction of wind turbines (Karnøe, 1987). These groups consisted of academics such as engineers and economists, as well as craftsmen like blacksmiths, carpenters and mechanics. The purpose and inspiration of these groups was to improve flexibility in energy supply, reduce pollution and develop Danish technology. In the long term they wanted to develop wind turbines capable of producing electricity at competitive prices. The groups made hundreds of tests in order to improve the construction, and ultimately the development, of the wind turbines.

> *“The Danish cooperative movement also played a significant role in the take-off phase of wind power development. This movement inspired the start-up of many guilds of wind turbines, or cooperative wind turbines. People from various backgrounds came together to find the capital needed to put up a wind turbine.*

These groups made hundreds of tests in order to improve the construction of the wind turbines and thus the development.

Another important institution in this phase was the ‘wind gatherings’, which took place two to five times a year (Karnøe, 1987). Here, the developers openly shared ideas and experiences, and, consequently, contributed to substantial moves forward in the development.

Collaboration is the keyword for this phase. It is reasonable to assume that, since the pre-development was populated by craftsmen pioneers working and experimenting by themselves, collaboration had a better breeding ground here than if it had arisen between research and development departments in different companies. The passion of these pioneers to create an even better, more efficient and safer wind turbine drove them together to share information and knowledge, giving good advice for free.

More and more people became aware of this new way of producing electricity, and slowly the landscape changed. Changing landscapes typically happens over decades, however, in this case, it was the awareness of the Danish population that changed. People started seeing, hearing and reading about wind turbines, and the subject entered daily conversations much more.

Technological improvements were seen in different areas of the turbines. The sails were now constructed of fibreglass, the braking system was improved, as were the electronics that monitored the operation of the turbine and the production of electricity to the grid. These varying specialities involved different producers now additionally focusing on the need for better wind turbines.

In the public sector, two initiatives proved very important. The first was the establishment of a test centre for small wind turbines at the Risø National Laboratory (1977) to improve the safety of the turbines and draw up the standards and rules they needed to follow. A type approved as a wind turbine pushed up their quality and made them internationally famous (Karnøe, 1987).

Secondly, subsidies of 30% of the wind turbine sales price were introduced for buyers of the tested types. Since the late 1970s, subsidies have been given for power production from wind turbines. The subsidies helped companies with stable wind turbines to compete with the prices of electricity produced by central power plants (using oil or coal).

Furthermore, good collaboration existed among the owners of wind turbines, who organised themselves in the Danish Wind Turbine Owners' Association. Wind turbines are expensive, but with proper and constant care, operation and maintenance they will run longer and more efficiently. These experiences provided some shared values among Danish owners (Jensen, 2003). This thriving environment of non-competition also supported the industry.

In the take-off phase, collaboration was the development's main driver, but other important drivers and indicators were realised. Connecting wind turbines to the existing electrical grid drew the attention of society to what was happening and what was needed to win infrastructural support for further development of the niche technology.

It can be seen how the fluctuations in oil prices influenced the interest in wind turbines and how a window of opportunity for this niche development opened, closed and opened again. The existing regime of power production came under pressure from the surrounding landscape in the form of such things as oil prices and increasing social support.

Society's growing environmental awareness was an important source of support, and the Tvind project was able to organise many people to work together on one big wind turbine, proving a greater interest in the niche.

Finally, the first serially produced wind turbines were an indicator of a development undergoing persistent progress.

Acceleration phase

In entering the acceleration phase, the present situation in Denmark has been reached.

Social acceptance and support of a new technology are essential to any new development, and this is a potential driver in all four phases of a transition from one regime to another. In

Denmark, it was environmental awareness in society, the desire to develop a competitive alternative to nuclear power and the need to increase energy security that put pressure on the fossil-based regime.

The Danish cooperative movement also played a significant role in the take-off phase of wind power development. The cooperative movement is part of Denmark's cultural heritage. It began in 1866 with consumer cooperatives, and later expanded into cooperative dairies and housing. This movement also inspired the start-up of many guilds of wind turbines, or cooperative wind turbines. People from various backgrounds came together to find the capital needed to put up a wind turbine.

The cooperatives that owned the wind turbines had two important roles: they supported the industry and the continuation of its development, and they minimized the economic risks for the individuals. With this agreement, many more people could have a share in a wind turbine, as most single persons or families could not afford one.

With regard to ownership of wind turbines, Denmark is a role model. When the guilds of wind turbine ownerships were at their maximum, 100,000 Danes, or one in fifty of the population, had a share of a wind turbine. Due to its popularity, wind power won strong social support (Danmarks Vindmølleforening (a) 2013).

> *"Recent opinion polls have measured whether or not Danes want to expand current wind power in Denmark, with 86% answering in the positive. Of those who live alongside wind turbines, 81% said that they experience no disturbance or inconvenience from the turbines (Danmarks Vindmølleforening (a) 2013).*

As quantitative proof of the occurrence of the acceleration phase, another example from the pioneers can be drawn. Two pioneers, Karl Erik Jørgensen, a blacksmith, and Henrik Stiesdal held a patent on a wind turbine, which was bigger than usual (ing.dk 2015). They sold the royalties to a nearby company, Vestas, that was producing agricultural machinery. In 1980, Vestas had an independent department of wind power with twelve employees, which by 1985 had grown to 650 employees (JV Film & TV 2003). This story shows how wind turbines were introduced to this company, which was to become the world's largest producer of wind turbines and which grew exponentially within five years. Clearly, the development had entered the acceleration phase. In 2011, Vestas Wind Systems had close to 23,000 employees (Vestas 2012).

The exponential growth of both employment and exports within this industry can be regarded as an indicator of an active acceleration phase.

Seen from the multi-level perspective, the niche had come through the window of opportunity and started to change the regime of electricity production.

Other Danish companies also started production of wind turbines, including Nordtank, Micon and Bonus. Danish industry was now taking wind power seriously. Employment in this industry followed the market, and, product-wise, the turbines started becoming larger (Karnøe, 1987).

In 1982, Denmark began exporting wind turbines to the USA (Karnøe, 1987). These exports and the increase in manufacturing jobs appeared to have had a positive effect on decision-makers and politicians, since this new industry had the potential to positively influence Denmark's trades with foreign countries.

For Danish companies, it was rare for the biggest competitors in the world to be found in the home market, as was the case with producers of wind turbines during these years (Karnøe, 1987).

Johannes Juul was right when he said that Danish industry could achieve greater levels of exports by producing wind turbines. He was simply 20 years too soon in saying so.

Looking over time, the following two figures have been included in the analysis of the acceleration phase:

Figure 5: Wind power production [TJ] from 1978 to 2014 (energistyrelsen.dk 2014)

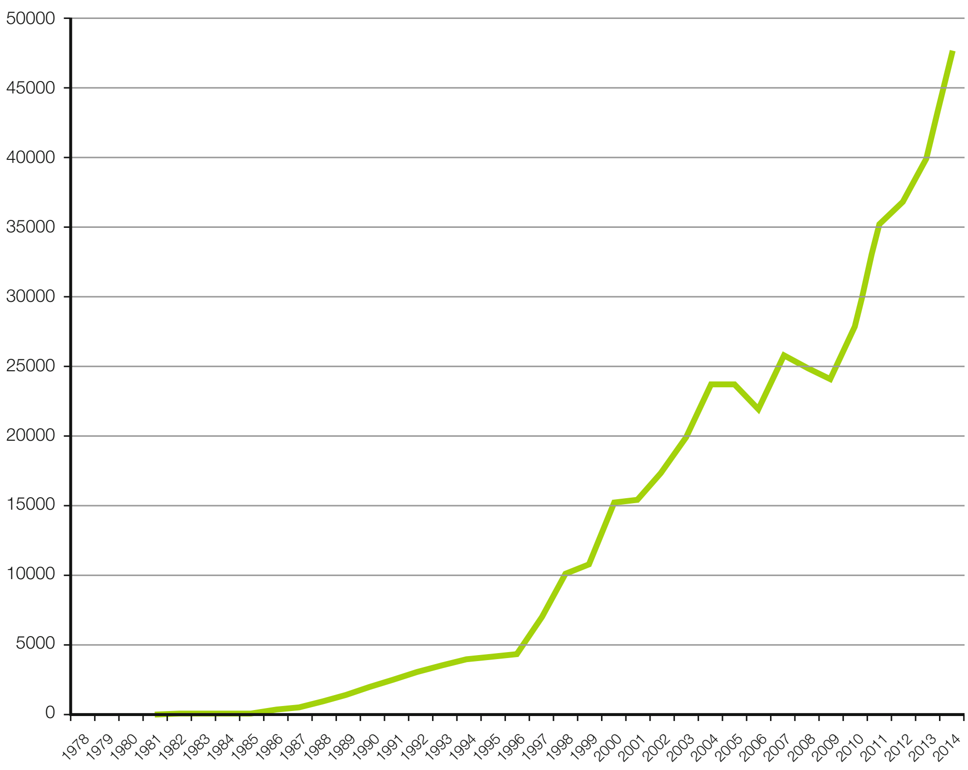
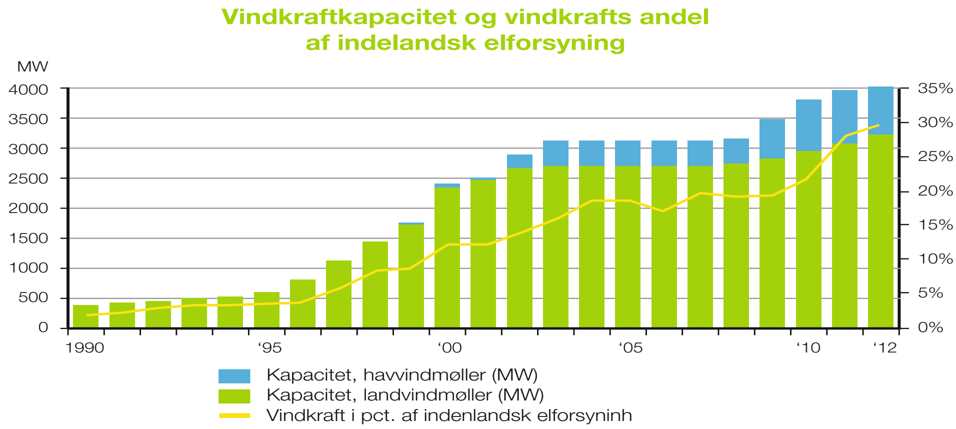


Figure 6. Wind power share of total electricity production = red line, 1990 to 2012 (Ens.dk 2015)



Source: Energi styrelsen

The first three phases of the phase model can be seen in Figure 5, although they do not form an ideal S-shape.

Together, Figures 5 and 6 show how electricity production from wind turbines developed from 1978 to 2014, and how the share of electricity from wind power developed from 1990 to 2012.

These trends, combined with the latest information that wind power had a 39% share of total electricity demand in 2014, clearly demonstrate that wind power is in the acceleration phase.

As previously mentioned, social support in this phase was expressed through increased environmental awareness and the need for security in energy supply. These were the two most important drivers among civil-society actors that were seriously looking into alternative sources of energy like wind power. Reaching both left and right political agendas, wind power offered a solution to these problems and formed a synergy between the two drivers of change.

These interactions in society affected the landscape, and the changes became more stable. The landscape is now pushing the old dominant actors and fossil-based technologies to maintain the new technology within the changing regime.

> *“In order to ensure the new technology’s position in the regime, it is important that energy plans and targets are agreed upon by a broad political majority and not threatened by an upcoming national election.*

Recent opinion polls have measured whether or not Danes want to expand current wind power in Denmark, with 86% answering in the positive. Of those who live alongside wind turbines, 81% said that they experience no disturbance or inconvenience from the turbines (Danmarks Vindmølleforening (a) 2013). It is very important for a niche development to have strong social support if a regime is to be changed. The producers also seek to reduce impacts on the surrounding environment, for example, by reducing noise. In this way, the producers maintain continued social support.

At the production level, technological development is continuing, as it will throughout this period.

The Danish wind industry has a world-class reputation. Due to decades of extensive research and development, Danish engineers find themselves at the top of the industry, which has been specialised into different areas. This has allowed for the creation of many different disciplines and sectors. Technological development primarily focuses on increasing wind turbine size to produce more electricity. Efficiency also plays an important role, such as reducing weight while improving strength.

A Supervisory Control and Data Acquisition (SCADA) system is used to monitor and maintain the wind turbine at optimal performance, turning it into a safe position if wind speeds become too high.

Fine-tuning the turbine is very important when optimising its production, which is also done by the SCADA system. With these improvements, the new technological innovation becomes a stronger competitor of the existing fossil-based alternative.

At the regime level, we find infrastructure such as the electrical grid. In this case, the niche actors were fortunate to be able to use the existing infrastructure. In other cases, a niche may also have to build an entire new infrastructure from scratch to support its innovation.

The Danish electrical grid is one of the most stable in the world, and is of very high quality. The wind turbines need to meet the high quality demands, primarily amplitude and phase, when they are connected to the grid.

The role of politics is an important component of this phase. The Danish parliament took charge of regulating the national wind industry, and the first energy plan was decided in 1976. At the time, energy plans were updated every five to nine years. Today, these plans are updated almost yearly.

The text box on the right provides a short summary of the evolution of energy plans in Danish policy, with a focus on wind power.

The energy plans are described in order to show how Danish politicians have framed the development of wind power and welcomed it into the regime of electricity production.

It should be noted that, presently, Danish politicians are more eager to have the most current information on available energy sources and how to mix them in reliable ways. They want security of energy supply and a higher share of renewable energy.

Another example of the current acceleration phase can be seen in the 1996 Danish parliamentary decision that 10% of the electricity demand should be met by wind power by 2005 -- a goal that was achieved ahead of time, in 1999. Therefore, the speed at which wind turbines were being developed proved faster than expected.

Figure 7. Popular presentation of energy agreement of 2012 in English (kebmin.dk 2015)

In order to ensure the new technology's position in the regime, it is important that energy plans and targets are agreed upon by a broad political majority and not threatened by an upcoming national election. This can be seen in the latest political agreement from 2012, where it was decided that wind power should cover 50% of electricity production by 2020. Furthermore, it was decided that in 2020 Denmark would have only 3,000 onshore wind turbines compared to the current 4,500.

Therefore, the forecast is for fewer but larger turbines. New modern wind turbines are not only larger but also more efficient. This improves their ability to compete with low fossil fuels prices.

Smaller wind turbines are being phased out, which is a challenge for the cooperative wind turbines and wind guilds. Instead, new parks of wind turbines are being seen as big investments mainly aimed at other interested parties, rather than those of the 1980s and 1990s. This is in keeping with the current changes in society and landscape. The deeds and values of the old cooperative movement are seldom found in Denmark in 2015. Therefore, from an energy perspective, in order to have as much wind power as possible, smaller turbines must be replaced with larger and more efficient ones.

WIND TURBINES IN ENERGY PLANS

1976: "… energy from wind, solar and geothermal will not contribute a measurable amount within the century"

1981: overall goal: to ensure energy to society at lowest price. Three possibilities were outlined, including nuclear power and increases in renewable energy.

1985: parliamentary decision on energy planning without nuclear power. This was not mentioned in an energy plan, but it was a very important decision on future energy planning and a big relief to the environmental movement.

1990: emissions of CO_2 should be reduced by 20% before 2005 compared to the 1988 baseline.

1996: specific measurable goals on the implementation of both onshore and offshore wind turbines.

2004: old small wind turbines being replaced by larger ones.

2008: minimum share of 20% renewable energy in total energy supply by 2020

2011: Denmark will not be dependent on fossil fuels by 2050, and renewable energy will be increased to 33% by 2020.

2012: 50% of Danish electricity demand to be provided by wind power by 2020. (Reference to all of above: Danmarks Vindmølleforening 2014).

At the annual wind gathering in Denmark in 2013, Thomas Becker, CEO at EWEA, the European Wind Energy Association, said that when it comes to Europe's present energy supply, we are currently transferring our wealth to the Persian Gulf and to Russia. The EU sends 1.2 billion Euros out of Europe every day in order to sustain the energy supply. According to Becker, this is the best argument for expanding renewable energy (Møller, 2013).

Therefore, political, industrial and social support are aligned and ready to take wind power development into the final phase.

Stabilisation phase

In this phase, the degree of change decelerates. A new regime, which in this context is renewable energy, is replacing the old fossil-based regime of power production. As this is entering the future of this research, the analysis is based more on assumptions.

It is also important to set aside any analysis focusing only on wind power, as the 2050 energy plan embraces a range of renewable energy sources. These include solar, geothermal, wave and any others that may become interesting in the next 35 years.

It is expected that the political motivation for increasing the share of renewable energy will last, although alternatives to renewable energy sources, like nuclear power, have also entered the scene. However, the 2011 accident at Fukushima, combined with the on-going problems of waste handling, makes this a less than viable option.

Universities and other research organisations like the Danish Energy Agency frequently calculate new scenarios on how to reach the goal. The current ones describe the continued growth of the relative share of wind turbines in the energy sector and the extended use of photovoltaic, solar panels, and later synthetic gas and liquid (Energistyrelsen, 2014).

Researchers also expect energy consumption itself to decrease. This would be of great benefit in helping reach the goal. A decrease in energy consumption can be realised through changes in social behaviour or developments in energy efficiency. Today the industry is already focusing on the latter. Big programs, including within the UN, are being set up to facilitate this path of sustainable development. Due to fluctuations in electricity production from wind power, storage facilities and smart grids are being developed.

The Danish Energy Agency is running models to predict future demand in different scenarios. In the wind scenario, it is predicted that gross energy demand will be reduced from 594 PJ in 2035, to 575 PJ in 2050. The degree of self-sufficiency will increase from 74% in 2035, to 104% in 2050 (Energistyrelsen, 2014).

Technological developments will also continue. Wind turbines are expected to continue producing more electricity and become increasingly efficient. Another technology, photovoltaics, is also expected to have a big future. This technology is newer than wind power, and many producers worldwide are now investing in research and development into its use. The 35 years from 2015 to 2050 is a long time, and other renewable technologies and ways of using existing technology should be expected. The demand for these is very high, and as such they are being prioritised.

Social support for renewable energy is expected to remain high. Most Danes are aware of the threats of climate change, and the younger generations, in particular, appear to be taking it even more seriously than their elders.

DISCUSSION

The phase model proved to be a useful tool with which to frame the analysis in different periods, by allowing a search for drivers and indicators on the continuation of a development. However, the phase model is still a theoretical and ideal S-curve that will never be experienced in reality. Deviations will always occur, as can be seen in Figure 5. Deciding which event facilitates the transition from one phase to another will be a matter of debate. Moreover, emphasizing that the different phases of this development have lasted altogether from 1890 to 2050 produces a degree of uncertainty. However, the take-off phase started approximately in 1970, the oil crisis having been one of the events triggering the opening of a window of opportunity. The acceleration phase started approximately in 1985, with a rapidly growing export market and major social support and interest.

The multi-level perspective theory is also a good tool, since it provides the analyst with a certain set of perspectives from which to study the development. Sudden changes at the landscape level are not well described, as with the oil crisis in 1973, when oil prices rose to three times their normal cost within a few months. But the description of the different dynamics within the same level and across two levels – showing how an existing regime is resistant and sometimes aggressive towards niche development, and how a window of opportunity may open for niche developers when the landscape puts pressure on the existing regime – has proven very helpful in the present analysis of wind power development in Denmark.

> *"Subsidies, grants and cooperatives were necessary drivers to keep the developers continuing their work. On the consumer side, this instrument was also used to make the sustainable technology attractive and cost-competitive in relation to other high-carbon technologies.*

This paper has focused on wind power, but in order to reach a 100% renewable energy system other sources must contribute. Some of these were mentioned in the stabilisation section, to which waste incineration and biomass can be added, and are already contributing an important part of the energy system. Although waste incineration and biomass emit carbon dioxide, their emissions are much lower than those of fossil-based fuels, and thus they provide a more sustainable way of covering the demand for heat.

CONCLUSION

Today Denmark is a role model in supplying the electricity system with energy from wind turbines.

On 2 November 2014, at the release of the Synthesis Report on the 5th Assessment Report from the IPCC (Intergovernmental Panel on Climate Change) in Copenhagen, the Chair of the IPCC, R. K. Pachauri, said: 'We have little time before the window of opportunity to stay within 2°C of warming closes' (IPCC, 2014).

This 'window of opportunity' was taken advantage of in the case of wind power development in Denmark. Before the 'window' was opened, the surrounding landscape had been able to put pressure on the existing fossil fuel-based power regime due to the oil crisis, the increased public awareness of environmental issues and the importance of reducing emissions, and the opposition to nuclear power.

At the niche level, passionate pioneers managed to create and develop a technology that entered the existing regime with the help of the surrounding landscape pressing for change. These innovators took on the task of fighting the existing regime and won.

An example showing how important the pioneers were in relation to this development can be seen in the film *Vindkraft: en dansk historie* (J V Film 2003). In the middle of a storm, two pioneers drove to their wind turbine because one of the sails had been torn off. Wanting to investigate exactly what had happened, risking their lives, they crawled up in the wind turbine in the stormy weather searching for the cause.

The main drivers and indicators found in this case

This article has shown how different drivers have helped the process move forward, and how different indicators in the process provided proof that a transformational development has taken place.

In the pre-development phase, the passionate pioneers were the main drivers leading this phase of the transition. With no economic expectations, and putting everything else aside, they undertook the hard work to investigate this technology, facing all its preliminary barriers, as well as its opportunities.

In the take-off phase, collaboration between the pioneers was a strong driver. In their eagerness to improve the technology, the pioneers organised gatherings several times annually, where they shared information and knowledge about their experiences with wind turbines. A magazine contributed to the collaboration and knowledge sharing.

In the current phase, acceleration, and the final phase, stabilisation, the Danish population has shown that they welcome the new technology. This social support shows that the landscape level is accepting the niche creation and that actors other than the pioneers are developing the technology.

Subsidies, grants and cooperatives were necessary drivers to keep the developers continuing their work. On the consumer side, this instrument was also used to make the sustainable technology attractive and cost-competitive in relation to other high-carbon technologies.

A broad majority of MPs supported the technology and the prospective energy plans. This gave the industry the motivation and security it needed to continue the research and development of the technology and to proceed with production.

Energy researchers are constantly analysing ways of reaching 100% of renewable energy by 2050, providing recommendations to politicians and other decision-makers by means of annual energy plans.

Success factors

Aside from the drivers and indicators that are pushing the development forward, some success factors or important milestones can be noted along this S-curve of transition.

Poul la Cour started the development very strongly, providing courses on wind power and aerodynamics, and publishing the first magazines on this subject. These are success factors in the pre-development phase because they nurture those in society who recognise the potential in a new idea.

Clearly, it was extremely important for the local power producers at the niche level to connect the turbines to the existing electricity grid – the infrastructure of the existing regime. Otherwise, they would have needed to build a parallel grid, which would not have been economically feasible. This acceptance of grid connection was a window of opportunity made possible by actors, politicians and decision-makers within the existing regime, who recognized the merits of the new technology.

In developing the wind turbines, the oil crisis can be considered a success factor. The industry and energy suppliers had shown an interest in the technology at an earlier stage, but due to low oil prices they had abandoned wind power development. When the oil crisis occurred, interest was shown once again, both in Denmark and abroad, and subsidies for new research were provided.

Environmental awareness and opposition to nuclear power also strongly motivated the work on this sustainable alternative. Moreover, the wind industry creates jobs, which is an extremely popular driver for further social and political support. Jobs are being created in production, maintenance, consultancy, planning, etc.

International recognition, honouring Denmark as a front-runner in reaching ambitious and sustainable goals, makes both citizens and politicians proud.

PERSPECTIVES

The term 'transformational change' should be used with caution in order to not water down its meaning.

Replacing a fossil fuel-based energy system with a 100% renewable energy system is a genuinely transformational change. It is recommended that the concept be used based on an understanding of this example.

This author will not recommend emphasizing the need for transformational change in future NAMAs. Every NAMA aims for sustainable development, and other parameters than TC should be prioritised. For example, improving a coal-fired power plant to produce more electricity using the same amount of coal should be characterized as a developmental change, while switching from a high GHG emitting energy source to a lower one (but still fossil-based) should be characterized as a transitional change. While none of these are transformational changes, they are, nevertheless, important steps in reaching the overall goal.

This article will not define developmental or transitional change; other literature is available on these subjects. These changes are simply mentioned here in order to provide an understanding of the special category of transformational change. Knowing this distinction, the reader is asked to appreciate that other sustainable projects are less subject to change than transformational ones.

Deciding which NAMA to prioritise involves many parameters, such as how well it fits into existing national development programs and legislation, how big the impact is, co-benefits like social equity, and many more. Therefore, this author does not recommend adding any further demands to transformational change in this decision-making process, as it would be unfortunate if it were to lead to fewer NAMA projects.

The development of wind power has revealed a very important driver: development through collaboration. Instead of competing with one another, knowledge and experiences were shared. This is one of the two most important lessons of this analysis. Development through collaboration is born from an attitude of striving for something better, with the respect and understanding of collaborators and society, alike.

The other important driver is the persistent work of the pioneers. Despite the lack of enthusiasm and support of other actors, they continued to improve the wind turbines. For more than half a century, they demonstrated unwavering commitment and were responsible for this sustainable development.

In order to reach the shared goal of abandoning fossil-based power production in Denmark by 2050, there needs to be a persistent and continuous effort to improve the understanding of transformational change, while building on the important indicators, drivers and success factors. With the support of all actors involved, and in particular NAMA facilitators and decision-makers, this is a goal that can be achieved.

Bjarne Gantzel Pedersen is head of the Danish transition movement (Omstilling Danmark) and holds a master of science in Sustainable Cities (June 2015).

REFERENCES

Literature

Bergman, Noam, Haxeltine, Alex, Whitmarsh, Lorraine, Köhler, Jonathan, Schilperoord, Michel and Rotmans, Jan, 2008, 'Modelling Socio-Technical Transition Patterns and Pathways'. Journal of Artificial Societies and Social Simulation 11(3)7.

Danmarks Vindmølleforening (a), 2013. 12 myter. Danmarks Vindmølleforening.

Danmarks Vindmølleforening, 2014. Vindmøller i energiplanerne. Danmarks Vindmølleforening.

Energistyrelsen, 2014. Energiscenarier frem mod 2020, 2035 og 2050. Energistyrelsen.

Geels, Frank W., 2005. Co-evolution of technology and society: the transition in water supply and personal hygiene in the Netherlands (1850–1930)—a case study in multi-level perspective. Technology in Society 27 pp. 363–397

IPCC, 2014. Concluding instalment of the Fifth Assessment Report: climate change threatens irreversible and dangerous impacts, but options exist to limit its effects. IPCC Press release.

Jensen, Ib Konrad, 2003. Mænd i modvind, Børsen.

Karnøe, Peter, 1987. Udviklingen i Dansk VindmølleIndustri 1976–1986, Nordvestjysk Folkecenter for Vedvarende Energi.

Møller, Torgny, 2013. EU's uholdbare energiforsyning vindkraftens bedste argument. Naturlig Energi 36. årg., nr. 4. Danmarks Vindmølleforening.

Rotmans, J., Kemp, R., van Asselt, M.B.A., Geels, F., Verbong, G. and Molendijk, K. (2000), *Transitions and Transition Management: the case of a low-emission energy supply*, ICIS Report.

Timmermans, J. 2006. *Complex Dynamics in a Transactional Model of Societal Transitions.* Interjournal 1769: 1–18

Vestas, 2012. Annual report 2011. Vestas.

Websites

Energinet.dk, http://energinet.dk/DA/El/Nyheder/Sider/Vindmoeller-slog-rekord-i-2014.aspx, accessed January 6th 2015.

Energistyrelsen.dk, graph is based on data from two excelsheets found on www.ens.dk: grunddata12.xls and el-maanedsstatistik.xls, accessed September 22nd 2014.

Ens.dk, http://www.ens.dk/undergrund-forsyning/vedvarende-energi/vindkraft-vindmoller/fakta-vind/nogletal-statistik, accessed January 7th 2015.

Ing.dk, http://ing.dk/artikel/mr-vindkraft-holder-jubilaeum-128570, accessed January 6th 2015.

Kebmin.dk, http://tinyurl.com/lhcvql6, accessed January 7th 2015.

Motiva.fi, http://www.motiva.fi/myllarin_tuulivoima/windpower%20web/da/pictures/eighties.htm, accessed January 6th 2015.

Movie

JV Film & TV, 2003. *Vindkraft: en dansk historie*. Director: Vestergaard, Jørgen.

Photo credit: Kate Evans for Center for International Forestry Research (CIFOR)

Doug Boucher
Union of Concerned Scientists
dboucher@ucsusa.org

Brazil's 2005-2014 Reduction in Amazon Deforestation as a Transformational Change

ABSTRACT

The striking reduction of deforestation in the Brazilian Amazon between 2005 and 2014 has produced the most rapid reduction in greenhouse gas emissions achieved by any country. Many actors and actions have been responsible for this climate success, including government enforcement of existing laws, pressure from civil society, supply-chain moratoria on purchasing commodities from deforested areas, suits by public prosecutors, recognition of indigenous land rights, effective monitoring from space and support from Norway's REDD+ program. The change clearly qualifies as transformational, but its pattern does not appear to correspond to any of the prevailing theories of change in socio-technical regimes.

1. INTRODUCTION

Over a single decade, from 2005 to 2014, deforestation in the Brazilian Amazon dropped by 75%. This dramatic change, after decades of varying but essentially unimpeded destruction of the Earth's largest tropical forest, has taken place with unexpected rapidity and unprecedented scope. From a climate point of view, this change represents the largest decrease in emissions by any country, reducing what had been the largest single component of Brazil's greenhouse gas pollution by more than ¾ of a gigaton of carbon dioxide annually – the biggest reduction achieved by any country in the world (Boucher, 2014).

This chapter considers the causes and consequences of this development in the context of the theories of transformational change (Mersmann et al., 2014). It finds that, although some elements certainly do fit aspects of these theories, the overall pattern of change calls into question what appear to be some of their important underlying assumptions.

This case study, as with most of the literature, uses the 'Legal Amazon' defined by state boundaries as its limits, since this is the unit for which data are most readily available. Within that region, it focuses not only on 'forestry' or 'the forest sector', but rather on the whole of the land use system, including the agricultural sector that has been the major driver of deforestation. In IPCC terminology, this is referred to as 'AFOLU' – Agriculture, Forestry and Other Land Use. Politically and economically, however, the major actors in the case study include not only those within the Amazon, but important players in government, civil society and business on the national and indeed global scales. Thus the case study must necessarily include the federal level and beyond.

In building my argument, I first describe the roles played and the steps taken by the major actors involved, both prior to the period of dramatic change and in response to each other's actions as the transformation developed. These actors include a variety of entities and personalities: government leaders at different levels (federal, state and in some cases even municipal) and in different branches (executive, legislative, judicial and Brazil's unique 'fourth branch' of independent federal public prosecutors); Indigenous Peoples; non-governmental organizations, both Brazilian and international; the trade associations of the major industries that are driving Amazon deforestation (soybeans and beef cattle); and both governmental and non-governmental scientific institutions whose data and analyses were important in stimulating the transition and monitoring its progress.

This is followed by a discussion of the definition of 'transformational change' and a summary of the elements showing that change in this case has been truly transformational, not only in terms of the figures that indicate the rapid drop in deforestation, but also several other pieces of evidence. These include the 'delinking' of deforestation from the prices and the growth of the leading drivers, as well as from currency exchange rates; the important social progress, as indicated by rates of poverty and hunger, that took place in parallel with environmental progress; the changes in the economic behavior of corporate actors throughout the supply chains; the adoption of public commitments by both governments at different levels and by private sector groups representing the industries driving deforestation; a new political dynamic around deforestation and the environment, as shown in the presidential elections of 2010 and 2014; the extension of deforestation reduction to other biomes in Brazil and to other drivers; and the international influence of the Brazilian example, as shown by steps taken in other regions concerning other drivers of deforestation (e.g. oil palm in southeast Asia) and by zero-deforestation commitments undertaken by major multinational corporations. This is followed by a brief discussion of possible future reversals. I conclude that, while deforestation rates are likely to continue to fluctuate in future years, and eliminating the 'last 25%' of deforestation is likely to be considerably more difficult than the first 75%, the changes that have occurred are fundamental and structural, indicating a basic shift in the socio-technical regime.

How does the Brazilian deforestation case appear in light of the theoretical approaches described by Mersmann et al. (2015)? There are certainly important elements of the case that fit into the theoretical perspectives put forward by Mersmann et al., but there are also many that do not. Several of the underlying assumptions of their theories – that socio-technical regimes are fundamentally stable; that change comes from innovation within initially small niches in the system, spreading by outcompeting the existing 'ways in which things are done'; and that one can delimit a 'manager' (often the national government) whose actions are key to the development of the process of transformational change – do not apply to this case.

There are other lessons that come from this case study and that are important to both the continuation of Brazil's progress and its transfer to other countries. In particular, negative incentives have far outweighed positive ones in contributing to the success so far. However, these have not all been simple 'command-and-control' actions; some have arisen from civil society pressure on business supply chains, voluntary commitments adopted in response and government actions turning them into legal requirements. Thus, they were mostly 'sticks' rather than 'carrots', but some grew from the actions of private entities (both NGOs and corporations) rather than legislative or regulatory action.

Furthermore, the idea that deforestation is reduced because increases in productivity make it possible to produce greater yields on the same amount of land – the land-sparing hypothesis – does not provide an adequate explanation of Brazil's reduction in Amazon deforestation. For both soy and cattle, the causal relationships seem to go in the opposite direction from what land-sparing would predict.

I am not an expert on transformational change or the theories aimed at describing and guiding it, and those who are may well feel that I have misinterpreted these theories and/or ignored ways to read them as including the elements that I find wanting. I look forward to further discussion of this case in comparison to others, which will help determine whether the contradictions between evidence and theory that I perceive are due simply to my limited vision, or to more fundamental issues with regard to how socio-economic change is perceived and framed for analysis.

> *“In particular, negative incentives have far outweighed positive ones in contributing to the success so far. However, these have not all been simple 'command-and-control' actions; some have arisen from civil society pressure on business supply chains, voluntary commitments adopted in response and government actions turning them into legal requirements.*

Overall, this chapter argues that the success in reducing deforestation in the Brazilian Amazon came not from a managed process led by a single entity, but from the interacting efforts of important players to advance contrasting and often conflicting programs at a time of rapid social change. The success does not fit into theories of transformational change that see progress either as a process managed by a leading entity or as a consequence of changing technology and productivity. Rather, it requires re-thinking some of the frameworks and dichotomies that have been used to analyze socio-technical change, such as 'market-based' versus 'command-and-control,' so as to develop an understanding of how conflicting pressures can sometimes produce rapid shifts in direction.

The structure of the paper is as follows:

- Section 2 narrates the story of the transformation, explaining how the interactions between civil society, different levels of government and the private businesses involved in deforestation led to structural changes that rapidly reduced deforestation rates.
- Section 3 asks whether the change fits the definition of 'transformational,' concluding that several lines of evidence indicate that indeed it does.
- Section 4 asks how well the case corresponds to the theories of change explained by Mersmann et al., namely the Multi-Level Perspective and the Phase Model, with the associated ideas of Strategic Niche Management and Transitions Management.
- The conclusion (Section 5) extracts some additional lessons concerning two other important concepts regarding change – the 'carrots versus sticks' dichotomy, and the idea that changing land use is driven by productivity increases (so-called 'land-sparing').

2. THE HISTORY OF THE TRANSFORMATION

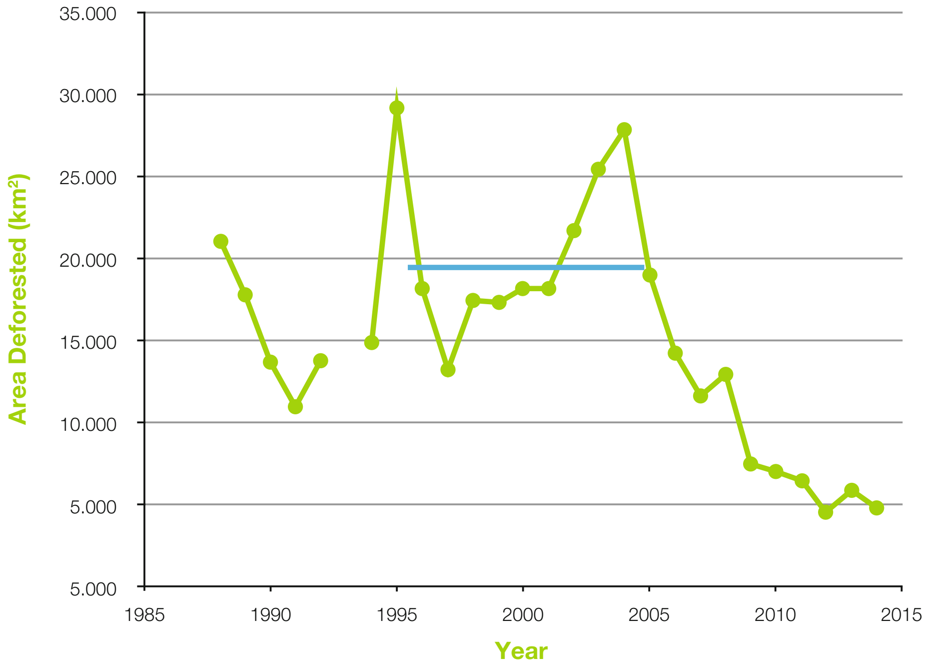
This section amplifies the points made above with a more detailed history of how the transformation occurred. It relies to a considerable extent on (and recycles some text from) my previous analyses (Boucher et al., 2011; Boucher, 2013; Boucher, Fitzhugh and Roquemore, 2013; Boucher, 2014; Boucher et al., 2014), to which I refer the interested reader for further discussion and evidence.

2.1 Before the Change

One can summarize the situation prior to the mid-2000s by saying that, despite decades of effort to reduce deforestation in the Amazon, nothing seemed to have worked. International campaigning to 'save the rain forest', innovative financing approaches such as debt-for-nature swaps, broad global education about the value of biodiversity and scientific analyses warning of the dangers of new economic developments such as the expansion of the soybean industry – all had been tried, but without much success. Deforestation fluctuated from year to year, driven by both the weather and the prices of the commodities driving it (Nepstad, Stickler and Almeida, 2006; Richards et al., 2012), but the phenomenon itself seemed impervious to change. Analyses during this period often emphasized the deep-seated problems of governance, insecure tenure and the dominance of rural society by large landowners as reasons that change would be difficult and slow.

Then, after the midpoint of the 2000s, things suddenly shifted dramatically (Figure 1). Initially it could be interpreted that deforestation had decreased because of the Great Recession of 2007-2008, which drove down soy and beef prices, as well as because of the increasing value of the Brazilian *real* relative to the dollar. But as deforestation continued to drop while global prices recovered – in the case of soy, to record levels – and the *real*'s exchange rate dropped, it became clear that something more than business cycles was involved (Richards et al., 2012; Arima et al., 2014).

Figure 1. Deforestation in the Brazilian Amazon, 1988-2014 (square kilometers per year). The horizontal red line indicates the 1996-2005 average. that is Brazil's official baseline level.



Source: Data from the PRODES program, INPE (National Institute for Space Research).
Online at: http://www.obt.inpe.br/prodes/index.php

2.2 The Actions that Succeeded

2.2.1 The Soy and Beef Moratoria

For several decades, deforestation in the Amazon had occurred mostly to create cattle pasture, but by the time that deforestation rates peaked in the early 2000s, soybean expansion had become responsible for nearly one-fourth of forest clearing in key regions (Morton et al., 2006). The new soybean farms were large, some reaching tens of thousands of hectares in size. Soybean expansion was heavily concentrated in the state of Mato Grosso, where clearings for soybean planting were more than twice as large as those for pasture. Soybean producers were heavily capitalized, using bulldozers to clear land and tractors and combines to cultivate it.

In the Amazon soybeans were overwhelmingly grown by large, capital-intensive producers. Over several years, Brazilian deforestation mirrored the swings in world soy prices, with rapid deforestation in years such as 2003 and 2004, when prices were high (Nepstad, Stickler and Almeida, 2006). Events in Europe also had an impact on soy production. For example, the ban there on feeding animal parts to livestock because of mad cow disease increased the demand for Brazilian soy. Also, the EU's demand for non-genetically modified soybeans initially favored soy from Brazil, although this is no longer the case now that GM soy has been approved for use in Brazil and has taken over a large proportion of the market.

Transportation was also important, with new highways connecting soybean farms to domestic markets in southern Brazil and to the new deep-water ports of Itacoatiara and Santarém on the lower Amazon River. Deforestation in the Amazon became 'teleconnected,' through globalized markets, with expanding chicken, pork and beef production in Europe and China. By 2005, Brazil had become the largest soybean exporter in the world (Morton et al., 2006).

As soybean production expanded, academics and environmentalists began to point out the growing threat to the rainforest. Initially there was little response, and forest clearing continued unabated, reaching record clearance rates (27,329 square kilometers annually) in the 2003/2004 crop year (Figure 1). But a critical turning point came in early 2006, with the release of Greenpeace's report, *Eating Up the Amazon* (Greenpeace International 2006), which linked the soybean industry to deforestation, global warming, water pollution and the use of slave labor. It focused particularly on two multi-national companies: the giant grain trader and exporter Cargill, and the world's largest fast-food chain, McDonald's.

Action came within weeks. The two associations that bring together nearly all soybean processors and exporters in Brazil, the Brazilian Association of Vegetable Oil Industries (ABIOVE) and the National Association of Cereal Exporters (ANEC), announced a moratorium on deforestation. Their members agreed not to buy any soybeans produced on Amazon farmland deforested after June 24, 2006. Initially the moratorium was temporary, but it has been renewed each year since – most recently until May 2016.

Now that it has been in place for several years, there is clear evidence that the moratorium has been remarkably successful. Satellite data make it clear that the clearing of forest for soybeans has been reduced practically to zero. By comparing the satellite images showing deforestation with views of the same areas in subsequent years, Rudorff et al. (2011) found that by the 2009/2010 crop year, only 0.25 percent of land with soybean crops had been planted in deforested areas since the moratorium began. These fields represented only 0.04 percent of the total soybean-growing area in Brazil.

Macedo et al.'s (2012) detailed examination of soybean production and deforestation in Mato Grosso, where the industry's expansion has been concentrated, reinforces these conclusions and provides evidence that the link between soy and deforestation has now been broken. Despite the rise of soy prices to record high levels since 2007, tropical forest clearing for soybeans has declined to very low levels in Mato Grosso, and the behavior of soybean farmers has been altered fundamentally (Gibbs et al. 2015a). Furthermore, there does not seem to have been substantial 'leakage' in the *cerrado*, where deforestation has also been substantially reduced (Macedo et al., 2012; Lapola et al., 2014; Persson et al., 2014).

> *“But a critical turning point came in early 2006, with the release of Greenpeace's report, Eating Up the Amazon (Greenpeace International 2006), which linked the soybean industry to deforestation, global warming, water pollution and the use of slave labor.*

Beef cattle have a much longer history in Brazil than soybeans, but their story shows some parallels, in that the most dramatic changes have occurred in just the past few decades.

Under the military dictatorship in the 1960s and 1970s, the Brazilian government promoted and subsidized the development of the Amazon, and the cattle industry began to penetrate into the region. During the 1990s a significant boom in cattle-ranching occurred, driven by growth in cattle product exports. This was favored by changes in currency exchange rates (Richards et al., 2012) and then, in the 2000s, by the elimination of foot-and-mouth disease in the Amazon, which had formerly prevented beef from Amazon states from being shipped overseas. While domestic beef consumption grew slightly, the big jump was in exports, which increased sevenfold in a decade. The country became the biggest beef exporter in the world, and a fourth of Brazil's beef production now comes from the Amazon.

With clearing of forest increasing the value of the land five- to tenfold, cattle-ranching in the Amazon could be profitable despite its low productivity (McAlpine et al., 2009). In fact, land speculation – the ability to capture increases in land values – has provided a substantial part of the economic incentive for forest clearing by cattle ranches (Bowman et al., 2012).

The result was widespread deforestation as the industry moved into the rain forest. At both the state and municipal levels, deforestation rates correlated with the growth of cattle herds. Although soy became an important deforestation driver for a number of years, pasture was by far the predominant new land use in the deforested region, and it has continued to be the cause of about 80% of Amazon deforestation (Persson, Henders and Cederberg, 2014).

“All in all, the expansion of the cattle industry was based on using small amounts of capital and labor combined with the large amounts of cheap land that could be obtained by clearing the forest.

While the Brazilian cattle industry showed the same pattern of rapid export-driven expansion northward into the Amazon as the soybean industry, the industry was quite different in some important ways. Unlike soy, cattle production was extensive rather than intensive, with low levels of investment per hectare, the frequent abandonment of cleared land and low productivity. Stocking rates (animals per hectare) were also low, and slow animal growth rates limited meat production per year as well as per hectare. With high rates of abandonment prevailing in the 1990s, barely half of the cleared land would remain in production over the long term. Employment in ranching was limited, and ownership was highly concentrated. All in all, the expansion of the cattle industry was based on using small amounts of capital and labor combined with the large amounts of cheap land that could be obtained by clearing the forest. This business model, in addition to the rapid growth of export demand, was enough to make the expansion of the cattle industry profitable.

Because of the growth of environmental and social movements in Brazil in the 2000s and the commitment of the new government of Luis Inácio Lula da Silva (known to Brazilians simply as ‘Lula’) to reducing deforestation rates, a more skeptical view of the industry that was the principal deforestation agent was inevitable. However, for the first several years of Lula’s administration (beginning in 2003), actions aimed at reducing deforestation emphasized not the cattle sector, but the creation of protected areas and declaration of indigenous lands, as well as enforcement actions against illegal logging. These steps did in fact begin to bring down deforestation rates, but the rising Brazilian environmental movement pushed not only for strong government action, but also for direct steps by the cattle industry supply chain.

With the publication of two widely publicized reports by Brazilian NGOs in April and June 2009, the pressure became irresistible. These reports, Amigos da Terra Amazônia Brasileira’s *Time to Pay the Bill* (Amigos da Terra – Amazônia Brasileira, 2009) and Greenpeace’s *Slaughtering the Amazon* (Greenpeace International, 2009), showed the overwhelming role of cattle pasture in destroying the Amazon forest and placed the responsibility not only on the ranchers, but on the banks that financed forest clearing for pastures, the slaughterhouses that bought the meat, the exporters that shipped it abroad, and the government policies that directly and indirectly subsidized the entire process. As with the soybean industry three years before, NGOs and civil society demanded a moratorium on deforestation.

While ranchers objected loudly, the other parts of the export supply chain, recognizing their vulnerability to bad publicity, soon realized that they needed to deal with the controversy. The concentration of the slaughtering, packing, distribution and exporting in the hands of a small number of large businesses meant that just a few companies had the power to stop deforestation for the creation of cattle pasture through their supply chain management. So in July 2009, the major slaughterhouses and distributors announced that they would refuse to buy cattle from any ranch that expanded its pasture at the expense of the forest.

> *“As with the soybean industry three years before, NGOs and civil society demanded a moratorium on deforestation.*

Enforcement was to be based on overlaying the boundaries of each ranch (its ‘polygon’) with the satellite photos showing deforestation published on the web by INPE. Either a ranch would have to provide the polygon information to the slaughterhouse, or else (since boundaries of some ranches are poorly delimited, and ranchers are often reluctant to share this information for fear of government action against them under the Forest Code), they would need to demonstrate that their ranch location was at least ten kilometers away from any area of recent forest clearing.

Peer-reviewed studies of the beef moratorium based on satellite images are now beginning to be published, allowing a quantitative assessment of the moratorium’s impact. As with the soy moratorium, the beef moratorium has had important effects on the deforestation behavior of ranchers (Walker, Patel and Kalif, 2013; Gibbs et al., 2015b). And, as in the case of soy-driven deforestation before it, deforestation for the expansion of cattle pasture has dropped dramatically, producing a decline in deforestation overall, as well as in Brazil’s greenhouse gas emissions (Persson, Henders and Cederberg, 2014).

2.2.2 Government Actions

Brazil’s reduction in deforestation is now part of the Brazilian federal government’s National Climate Change Plan, which includes the goal of reducing its emissions from deforestation by 80% by 2020. This objective grew out of the historic Plan for the Prevention and Combating of Deforestation in the Amazon (PPCDAm), instituted by the Lula government in 2004. This was not originally motivated by climate change, but rather by other environmental and socioeconomic concerns. But the PPCDAm has grown and been transformed, and its efforts are now a key element of the National Climate Change Plan. Under this plan, reductions are to be achieved in several steps, with the average yearly emissions over the ten-year period from 1996 through 2005 as the ‘reference level’ – the starting point from which reductions will be measured.

Both the national framework established by the National Climate Change Plan and the Amazon-level accounting of emissions reductions that it incorporated were important contributions to meaningful reductions in rates of forest clearing. Even though many of the actions implemented in the plan were performed by actors at lower levels – state governments, indigenous groups, trade associations and corporations, and NGOs – the national plan created a framework to verify that all these actions, taken together, really did reduce Brazil’s emissions. They also enabled the compensation mechanism negotiated with Norway (see below) so that Brazil could benefit financially from its emission reduction efforts.

Brazil showed the seriousness of its commitment to combating deforestation by putting the Climate Change Plan into legislation at the end of December 2009. The resulting Climate

Change Law inscribes the commitment to reduce overall emissions by between 36.1% and 38.9%, relative to business as usual, by 2020. This is equivalent to a 20% reduction from Brazil's 2005 level.

These high-level actions have been complemented by on-the-ground steps to strengthen the enforcement of existing laws, for example, those against illegal logging. The data made available by INPE showing areas of new deforestation identified through the DETER and DEGRAD satellite monitoring programs on a monthly basis have made it possible to crack down quickly. Steps taken include the closing of illegal sawmills and jailing of the perpetrators, including government officials who had been taking bribes to look the other way. Deforesting landowners are finding themselves cut off from access to credit, and municipalities with high deforestation rates risk the loss of federal funding. All these enforcement actions have contributed to reducing the incentive to clear the forests.

Much of the success in reducing deforestation has come from establishing – and effectively protecting – an extensive network of indigenous lands and protected areas across the Amazon since 2002. Just over half of the forest in the Brazilian Amazon is now protected in some form, with nearly half of this area reserved for indigenous peoples, about a fifth under strict protection, and about a fourth designated for sustainable development.

The protection of indigenous peoples' territories now plays a critical role in conservation of the Amazon rainforest (Ricketts et al., 2010). Legally, the indigenous lands are not off-limits to cutting trees. The collective tenure of these lands by Indigenous Peoples, legally confirmed and enforced by the Brazilian government, gives them the right to use them for sustainable forest management and the exploitation of timber and non-timber forest resources. In practice, they have generally chosen to keep almost all of their lands in forest, and studies of Brazil's reserves have found that they have reduced the rate of emissions from deforestation about tenfold compared to neighboring areas (Ricketts et al., 2010).

“Deforesting landowners are finding themselves cut off from access to credit, and municipalities with high deforestation rates risk the loss of federal funding. All these enforcement actions have contributed to reducing the incentive to clear the forests.

The Brazilian states have also been responsible for a substantial part of the country's success in reducing deforestation. Brazil has a federal system in which the states share responsibility for land-use policies with the national government in Brasilia. Deforestation is heavily concentrated in just a few states, especially Mato Grosso and Pará, and their state governors have both acted themselves and pushed the federal government in the direction of stronger anti-deforestation policies. These actions have produced substantial decreases in emissions from deforestation in these states, which account for the majority of Brazil's deforestation, over the past several years.

The actions of federal public prosecutors, particularly in the key state of Pará, have also been very important. The Federal Public Prosecutors (MPF) were established in the Constitution of 1988 as part of Brazil's return to democracy after decades of military dictatorship and are independent of both the judiciary and the executive. They have responsibility for defending 'collective and diffuse' rights and can prosecute not only individuals and companies, but even agencies of the executive branch. Their actions have helped turned the voluntary commitments of the soy and bean moratoria into effective legal obligations (Arima et al., 2014.)

> *“Deforestation is heavily concentrated in just a few states, especially Mato Grosso and Pará, and their state governors have both acted themselves and pushed the federal government in the direction of stronger anti-deforestation policies.*

The statements from the slaughterhouses and supermarkets that they would buy only non-deforestation beef have been enforced by strong threats from the public prosecutors in those two states. First in Pará and then in Mato Grosso, the slaughterhouses signed agreements under which ranchers were required to provide the GPS coordinates of their property boundaries in order to sell to them. This in turn makes it possible to use remote sensing data not only to detect deforestation, but to know on which ranch it is taking place and to take action against it. The prosecutors' warnings to supermarkets that they too would be held responsible for the sale of beef produced in violation of environmental laws, combined with the new ability to enforce them using GPS data, has effectively made the supply chain a part of the system through which ranchers are pressured, both economically and legally, to end deforestation (Gibbs et al. 2015b).

2.2.3 Civil Society's Role

Governments and businesses did not take action simply because they wanted to do the right thing. Instead, the political pressure generated by organized civil society, serving as a counter-force to pressure from the drivers of deforestation, played a key part in convincing government institutions to act.

Although there was some international pressure, Brazil's citizens have played a critical role, pushing their governments to act and exerting pressure on the businesses that constituted the main agents of deforestation. As described previously, Brazilian NGOs were the key actors in the widely publicized 2006 and 2009 exposés of the roles that the soybean and beef industries had played in deforesting the Amazon, as well as in negotiating deforestation moratoria with those industries. The Zero Deforestation campaign, launched in 2008 by a broad coalition of non-governmental organizations, including environmental, indigenous, rubber-tapper, human rights and other groups, exerted strong pressure on the federal government. It proposed what became the Amazon Fund and its management by the Brazilian national development bank BNDES (Banco Nacional do Desenvolvimento), and members of the campaign participate in the Fund's steering committee as important stakeholders. Non-governmental research institutes such as IPAM and IMAZON have been important in monitoring progress and in showing how ranchers, farmers and loggers can increase their productivity in ways that make deforestation unnecessary.

As seen in the soy and beef moratorium efforts, the movement was both political and economic, pressuring not only governments but also the industries that were the major drivers of deforestation. Although the threat of an international consumer boycott was always present as an overtone of the debate, the political strategy emphasized pressure on businesses all along the deforestation-related supply chain, not just the market pressure of individual consumers' shopping decisions. All the businesses involved – not just the farmers and ranchers producing soy and cattle, but also the banks financing them, the slaughterhouses buying their cattle, the exporters shipping their products overseas, and the intermediaries and supermarket chains distributing them domestically, were targets of the campaigning. Indeed, the concentration of market power at particular points in the supply chains, such as the vegetable oil trade association (ABIOVE) and major slaughterhouses, was one of the reasons that the industries could respond rapidly to pressure and agree to moratoria. The point of the campaigning was not to persuade individual consumers to change their behavior, but to force action by businesses that were critical links in the supply chain.

The political leadership that contributed to the progress in reducing deforestation had a long history of engagement with civil society, before and after as well as during the leaders' time in government. A key figure, of course, is Lula himself, not only during his two terms as President (2003–2010) but also during his previous decades of organizing and building the social movement and the Workers' Party (PT) through which he was eventually elected President at the fourth attempt. Equally as important was Marina Silva, Lula's first Minister of the Environment. Her activism, aimed at curtailing the rate of forest clearing, went back to her early experience in Acre, where she worked with Chico Mendes to organize the rubber tappers union and the PT. As Minister she was responsible for implementing the government's actions to reduce deforestation, often in conflict with other ministries' plans for development and economic growth. Equally significantly, after several years she resigned from Lula's cabinet in protest against the inadequate pace of action on deforestation and became the Green Party's candidate for President in the race to succeed Lula in late 2010.

Quite unexpectedly, Silva won nearly 20% of the vote in the first round in 2010, and even more in the 2014 election (although she finished third each time). Her electoral success both showed the strength of the popular commitment to ending deforestation, and exerted pressure on the PT and its candidate Dilma Rousseff (Lula's former Energy Minister and then Chief of Staff) to commit to continued environmental progress. Rousseff's partial veto in 2012 of the amendments to the Forest Code that would have issued an amnesty for past illegal deforestation reflects the new political dynamic that has emerged, at least in part through Silva's campaigning.

3. HAS THE CHANGE BEEN TRANSFORMATIONAL?

As this history shows, the change in Brazil has been broad and far-reaching. It is not merely a question of decreasing deforestation numbers, but of widespread participation in a movement that made deforestation an important political issue and created the pressure to reduce it. But, does it truly deserve the label 'transformational'?

3.1 The Definition of Transformational Change

Mersmann et al. (2014) define *transformational* change (in the context of climate change NAMAs) on the basis of three elements:

a) The Goal dimension – the change disrupts high-carbon pathways, contributes to sustainable development and sustains the change's impacts.

b) The Process dimension – the change is triggered by the interventions of actors who innovate low-carbon development models, connect these innovations to day-to-day economic and social practice and convince other actors to apply the innovations, as well as influencing the overall system to adopt the innovation process.

c) The Lock-in dimension – the change overcomes persistent barriers to low-carbon development models and/or creates new barriers that hinder the system from falling back into its pre-change state.

As discussed below, I disagree with using the second of these (the Process dimension) as part of the definition of transformational change. This dimension is based on a model in which individual innovators develop new approaches that are copied by others and that outcompete the old ways of doing things, eventually replacing them throughout the system. This is not the way change happened in the case of Brazilian deforestation, and thus it should not be used as a criterion for whether that change has been transformational. However, the first and the third dimensions – Goal and Lock-in – do apply to this case, and thus one can validly use these criteria to assess whether the change has been transformational. Several elements indicate that the answer should be yes.

3.2 Evidence for Transformation

First of all, deforestation has been 'delinked' from the economic forces that were its main drivers. The low rates of deforestation over the past few years – 4,000 to 6,000 km^2/year, versus an average of nearly 20,000 km^2/year between 1996 and 2005 – have been maintained despite a global boom in commodity prices and a decline in the *real*'s exchange rate. The beef and soy industries have continued to grow steadily even as deforestation has fallen by three-fourths.

This has also been true for the economy as a whole, and for indicators of social welfare. The country's GDP increased at a rapid rate during the later 2000s. It stagnated in 2009 because of the worldwide recession, but then resumed, with growth rates now having ranged from 3% to over 7% annually for nearly a decade. This continued progress, well after the economy has rebounded from the Great Recession, makes clear that the reduction in deforestation cannot be attributed to poor economic growth; it has now continued well after the recovery.

Even more important than macroeconomic growth itself was the fact that, because of the policies of Lula's Workers Party government, this progress was widely shared. Through social programs such as Fome Zero (Zero Hunger) and Bolsa Familia (Family Allowances), Brazil reduced its poverty rate from over 34% to less than 23%, and 29 million citizens transitioned into the middle class (Chapell and LaValle, 2010). Hunger and malnutrition rates dropped substantially, and important advances were made in reducing economic inequality. Brazil has shown that it is possible to make economic progress while still maintaining forests.

Furthermore, the reduction has not been the result of a single policy or actor, but rather reflects changes in the behavior of many parts of society. In particular, actors at all steps in the supply chains of beef and soybeans – farmers, ranchers, slaughterhouses, soybean crushers, exporters and supermarkets – have all adjusted their actions to the new reality (Gibbs et al., 2015a, 2015b). 'Business as usual' has changed, so that transparency and abiding by the law are now fundamental requirements of participation in the marketplace.

This is reflected in the adoption of legal commitments by both these private-sector actors and different levels of government, from 'zero-deforestation' municipalities and states on up to the federal level. The agreement with Norway and the 2009 Climate Change Law showed the willingness of the national government to inscribe its plans in legal form – not because of international pressure, but as a voluntary commitment driven by domestic political forces.

A further sign of the changed political situation is the unexpected success of Marina Silva's two campaigns for president. Admittedly, she did not win, or even get to the second-round run-off stage. Yet there are few if any other countries, developed or developing, in which an environmental candidate identified most strongly with the deforestation issue could win over a fifth of the vote in two successive national elections. For this to have happened in a country such as Brazil is even more surprising, an indication of the new political dynamic that has been created.

> *"The 75% reduction in deforestation by 2014 means that the end of deforestation in the Amazon is in sight, but the final 25% is likely to be the hardest.*

The Amazon deforestation issue is now extending beyond that biome to impact other ecosystems within Brazil, as well as tropical forests in other parts of the world. Reduced deforestation in Brazil's *cerrado* (Macedo et al., 2012) and other biomes such as the *caatinga* and *pantanal*, as well as the broad campaign to reforest its Atlantic Forest (over 95% of which has been cleared over the past five centuries), show the influence of the changes in the Amazon on all ecosystems in Brazil, not just the rainforest (Lapola et al., 2014). Furthermore, corporate zero-deforestation commitments on oil palm (May-Tobin and Goodman, 2014), over 90% of whose global production is in southeast Asia, show that the example of the soy and beef moratoria is spreading from the Amazon to the other global center of deforestation.

Even with all this progress, there remain many unfinished tasks. The 75% reduction in deforestation by 2014 means that the end of deforestation in the Amazon is in sight, but the final 25% is likely to be the hardest. It involves a larger number of smaller producers, making the administration and enforcement of both the laws and the corporate commitments to source only deforestation-free commodities more difficult (Rosa, Souza and Ewers, 2012; Godar et al., 2014). The Forest Code amendments of 2012, although partially vetoed by President Rousseff, nonetheless weakened legal protections for some areas of forest (Soares-Filho et al., 2014). And the *ruralista* bloc that expresses the viewpoints of large landowners and pushed for the Forest Code amendments remains strong, as shown most recently by the appointment of its political leader, Katia Abreu, as Minister of Agriculture in December 2014.

With these dangers, none of the positive changes outlined above can by themselves be taken to indicate that change, however transformational, will necessarily be permanent. They do not 'lock in' continued progress, for there are no guarantees in human history. But taken together, they show clearly that, not only has deforestation declined impressively, but that 'the way things are done' has changed. Beyond the numbers, the economics and politics underlying deforestation have been transformed.

THEORY AND EVIDENCE

How, then, does this case confirm or contradict the theories of transformational change described by Mersmann et al.? This section does not describe those theoretical approaches – the Multilevel Perspective and Phase Model theories, and the ideas of Strategic Niche Management and Transitions Management – but rather assumes that the reader is familiar with them from the other chapters in this volume.

4.1 The Multi-level Perspective

There is no doubt that the decrease in deforestation in the Brazilian Amazon involved many players at many levels. Some levels, however, seemed to be much more important than others.

In particular, the outside 'socio-technical landscape' changed relatively little as deforestation decreased. No important new inventions or technological processes were developed. The industries driving deforestation – predominantly, beef and soybeans (Boucher, Fitzhugh and Roquemore, 2013) – continued to operate in essentially the same ways, with little change in their production processes or supply chain structures. Yields increased, but no more rapidly than in previous years. The major change was simply that soybean fields and cattle pasture were created less and less by clearing primary forests, and more and more by taking over previously cleared land. The reduction in deforestation was essentially a change in the local geography of agricultural expansion, not any major technical innovation.

One change in the landscape did have an important influence, but it did not start until the process of transformation was well underway. This was the growth of international concern about climate change, with the recognition that deforestation was the source of a substantial fraction of the emissions causing climate change – 17% at the time, according to the IPCC (2007), and now about 10% (Smith et al., 2014). (The decrease in the percentage is due partly to reductions in emissions from deforestation – most notably, Brazil's – and partly due to increased global emissions from energy and fossil fuels.)

In the Amazon case, this expressed itself concretely in the Norway–Brazil REDD+ agreement announced at the 2007 Bali meeting of the UNFCCC, which provided a concrete commitment of funds to Brazil as an incentive for, and in proportion to the success of, its reductions in Amazon deforestation. Yet this commitment took place well after the program to reduce Amazon deforestation was underway, and its specific terms actually compensated Brazil by much less than the international carbon-market value of its emissions reductions (Boucher, 2014). Its importance was predominantly as a symbol of international support for the actions that were already well underway in Brazil, not as the catalyst for that action.

> *"The main change – to expand soybean and pasture into already cleared lands rather than into uncleared forests – did not require any kind of technological breakthrough.*

Technology did help to monitor and enforce the steps that reduced deforestation through the work of both public institutions (e.g. INPE, the National Agency for Space Research) and non-governmental organizations (e.g. IMAZON, the Amazon Institute of People and the Environment). Their analysis of satellite images contributed importantly to the transparency of the process, allowing other actors to act in response to specific deforestation events, as well as to changes in the overall figures. Yet this was not a particularly new development: INPE had been monitoring deforestation by satellite since 1988. Nor was it based on any particular technological innovation, but rather on gradual and steady progress in remote sensing and image analysis. The main change – to expand soybean and pasture into already cleared lands rather than into uncleared forests – did not require any kind of technological breakthrough.

A broader problem with the Multilevel Perspective (and others) as applied to Brazil's reductions in deforestation is the assumption of that theory that 'A socio-technical regime is essentially stable, and will not change fundamentally by itself' (Mersmann et al. 2015). This appeared to be the case in Brazil for many years, with deforestation fluctuating around the same high level for decades. However, this stability proved to be illusory, with internal changes leading to a dramatic decrease in deforestation. Furthermore, 'MLP posits that every change process starts in niches,' but the Brazil case is notable in that most of the important steps were taken at the national and international level, and transformed the entire system. It is not a case of changes within niches spreading because they had out-competed the existing technology; indeed, at least initially, no deforestation production was probably less profitable than the conventional alternative, since it could not capture the speculative value of forest land, which made up a considerable proportion of the economic value of deforestation (Bowman et al., 2012). Rather, this is a case of political decisions overcoming a lack of economic advantage.

4.2 The Phase Model

The Phase Model initially seems to apply better to the Brazil case than the Multilevel Perspective. It describes a transition from a nearly stable 'pre-development' stage through a 'take-off' into a period of rapid change ('acceleration'; Mersmann et al. 2015). There is no doubt that change in the Amazon occurred rapidly and with little advance warning, although in retrospect one can identify important early indications of progress. The rate of change did indeed accelerate, with the largest decreases occurring in a very few years (Figure 1).

However, in qualitative terms, little else changed during this period. The growth of the soy and beef industries continued at essentially the same rates as in the decade prior to 2005, during which they were driving deforestation at a rate averaging nearly 20,000 km^2/year (Figure 1). They remained profitable and grew in terms of output, but showed no major changes in yields, technologies or costs. Rather, they simply continued to grow as before, but more and more on non-forested land.

4.3 Strategic Niche Management and Transition Management

The management approaches (SNM and Transitions Management) highlighted in connection with these theories (Mersmann et al., 2014) may provide useful guidance for actors in some cases, but a striking aspect of the reduction in Amazon deforestation is that no single entity was managing it. Certainly important government programs were undertaken (e.g. the PPCDAm and the deal with Norway), but other branches and levels of government (the public prosecutors, the states and municipalities), the private sector (soy and beef trade associations) and NGOs (Greenpeace, Amigos da Terra Amazona) played equally important roles.

Even recognizing the leadership of the two successive PT administrations and the Zero Deforestation Campaign, it seems far-fetched to say that these institutions 'managed' the transformation. The story is not one of a single entity guiding the process of change, or even nudging it in the desired direction. Rather, it is one of conflicts of interest and the competing interests of many players each trying to mobilize political strength. Over time, these actions combined with a gradually shifting political, social and economic context – the internationalization of commodity markets, rising global concerns about climate change and the rights of Indigenous Peoples, technological progress in the capacity to monitor deforestation, and the new political and economic circumstances created by Lula's victory – to produce sudden and unexpected change. Many players can claim a share of the credit, but none can say that they were the manager.

5. FURTHER LESSONS

What other lessons can be derived from Brazil's reductions in deforestation rates for transformational change, particularly as concerns land use and climate?

First of all, they show that dramatic and rapid transformations are possible, even in situations in which the obstacles appear to be overwhelming. Looking back on the early 2000s, we can see that actions begun then – the expansion of indigenous reserves and protected areas, the campaigning of NGOs, the writings of scientists and the establishment of the PPCDAm – laid the groundwork for the progress of the later 2000s. Yet hardly anyone can claim to have foreseen at the time how rapid that progress would be. On the contrary, the social, political and economic impediments to reducing deforestation seemed overwhelming.

This means that, although the pace of progress in this case matches the prediction of the Phase Model, it also calls into question how useful that model can be in guiding transformational change. How do we know whether we are approaching the take-off phase or not? In the Brazilian context, how can we tell whether this is a turning-point year like 2004, or one of the many years in previous decades in which no real progress was made?

a. Carrots and Sticks

The reductions in deforestation in the Brazilian Amazon also challenge a fundamental assumption of these theories and others – one that has implicitly guided both the thinking and practice of many policymakers, as well as academics. This is that change comes about through *positive* incentives that reward innovation and make new practices competitive, rather than through *negative* incentives that discourage the continuation of business as usual. In everyday language, they assume that carrots have been used rather than sticks.

A few positive incentives did play a role in the Brazilian transformation – for example, the REDD+ deal with Norway, and to a minor extent projects funded by voluntary carbon market credits. But a striking feature of this case is the overwhelming importance of negative incentives. These included:

a) The large-scale expansion of protected areas and indigenous reserves, excluding the agents of deforestation from over half of the Brazilian Amazon (Ricketts et al., 2010).

b) Stepped-up enforcement of existing laws against deforestation, as well as the increasing effectiveness of the protection of forests against illegal incursions (Assunçao et al., 2013b).

c) Exclusion of agents of deforestation in municipalities with high rates of deforestation from obtaining agricultural credit (Assunçao et al., 2013a).

d) Use of INPE's remote sensing systems, overlain with property boundaries from the CAR and supplemented by the analyses of non-governmental organizations, to detect deforestation rapidly and determine who is responsible.

e) NGO campaigning against deforestation and the industries driving it, not only at the producer level (cattle-ranchers and soybean farmers) but at all levels of the supply chain, including processors, retailers and exporters (Gibbs et al., 2015a, 2015b).

f) Action by the public prosecutors that turned the voluntary soy and beef moratoria adopted in response to NGO campaigns into legal obligations, with heavy penalties for violations (Walker, Patel and Kalif, 2013).

g) Continuing pressure on both business and government to maintain and expand the progress achieved, as manifested in the Zero Deforestation Campaign, Marina Silva's resignation and subsequent electoral success, media stories and the joint statements of prominent Brazilian scientists (Soares-Filho et al., 2014; Ferreira et al., 2014).

In political discourse, a contrast is often made between support for market-based private-sector actions and governmental 'command-and-control' measures, often with the implication that the latter have failed. But the Brazilian case challenges not only this assumption, but also the dichotomy on which it is based. While some of the negative incentives came from government action alone (e.g., points a) to c) in the above list), others were a result of the mutual responses of government, business and civil society (e.g., points d) to g)). Rather than a simple government-or-business distinction, the deforestation case shows the transformational power of civil society pressure on supply chains, leading to voluntary actions by private businesses which are turned into legal obligations enforced by government agencies. This process is neither one of simple command-and-control actions nor of voluntary private steps, but rather a third alternative that reflects new political dynamics.

> *"Rather than a simple government-or-business distinction, the deforestation case shows the transformational power of civil society pressure on supply chains, leading to voluntary actions by private businesses which are turned into legal obligations enforced by government agencies.*

Some have seen the success so far as having been based on punitive actions and fear, and have questioned whether it can be maintained and extended without stronger positive incentives (Nepstad et al., 2014). Indeed, the conventional wisdom internationally about reducing deforestation is that it requires large-scale financing from the private sector, for example, through carbon market offsets that would reward landowners and jurisdictions for reducing emissions. There are examples in other countries where such approaches have been successful, but they have only played a minor role in Brazil's achievements so far (Boucher et al., 2014).

b. Land Sparing, or the Reverse?

Another common prediction about reductions in deforestation – that they will come about as a result of increasing yields, which will make it possible for farmers and ranchers to produce higher output while sparing land for nature – also appears inadequate to explain the Brazilian Amazon case. The per hectare productivity of soy and cattle showed no departure from previous trends in the mid-2000s, when deforestation began to fall. Total production of these commodities continued to rise at similar rates during the periods when deforestation was both increasing and decreasing. The difference was in the places to which they expanded (Nolte et al., 2013; Lapola et al., 2014; Barber et al., 2014). Rather than continuing to move into forests, these drivers increasingly took over already cleared lands, so that deforestation and agricultural output became 'delinked' (Macedo et al., 2012; Gollnow and Lakes, 2014; Lapola et al, 2014).

In fact, for soybeans, the story seems to be the reverse of land-sparing. The initial wave of deforestation from soy expansion was actually stimulated by the development of high-yielding production systems, through which 'a remarkable increase in productivity made soybean farming much more profitable, transforming it into a leading cause of deforestation' (Strassburg et al. 2014, p. 92; see also Morton et al., 2006).

For cattle the story is different, but here also it turns the land-sparing explanation on its head. There was no major change in productivity associated with the expansion of cattle-ranching into the Amazon forest. Productivity remained low, and indeed it still is (Strassburg et al., 2014). Rather, much of the growth was driven by speculation on increasing land values rather than operational profitability (Bowman et al., 2012). However, now that deforestation has been reduced and much of the Amazon forest has become effectively off-limits to beef expansion, there is an increased incentive to raise yields, to which both ranchers and government agencies are responding (Walker, Patel and Kalif, 2013; Gibbs et al., 2015b). Thus, rather than land-sparing reducing deforestation, the reduction in deforestation is now stimulating land-sparing, with potentially far-reaching consequences for future land use and greenhouse gas emissions (Strassburg et al., 2014).

Perhaps the most important lesson of the Brazilian Amazon case is its challenge to the assumption of the Multilevel Perspective that 'A socio-technical regime is essentially stable, and will not change fundamentally by itself' (Mersmann et al., 2014). It shows that, even in those regimes that appear solidly entrenched and that have persisted for decades, the system may be fundamentally unstable. While raising doubts about whether any single entity can manage transformational change, it shows that such change can happen even when and where it appears most difficult, particularly in the context of the rise of new social forces. In the words of Nelson Mandela, it shows that 'it always seems impossible until it is done.'

Doug Boucher is Director of the Tropical Forests and Climate Initiative at the Union of Concerned Scientists (UCS) since July 2007. He was previously Professor of Biology at Hood College for over a decade and has served as the Washington Office Director of Representative Bernie Sanders (I-VT) and as Director of the Western Hemisphere Cooperation Program at the American Association for the Advancement of Science. He has published nearly 100 articles in scientific journals and books on ecology, climate and natural resource issues. Doug has a Ph.D. in Ecology and Evolutionary Biology from the University of Michigan (1979) and a B.A. in Ecology and History from Yale University (1971).

REFERENCES

Amigos da Terra – Amazônia Brasileira. 2009. *A Hora da Conta - Time to Pay the Bill*. Friends of the Earth-Brazilian Amazon, São Paulo, April 2009. Available at: http://www.amazonia.org.br/guia/detalhes.cfm?id=313449&tipo=6&cat_id=85&subcat_id=413

Arima, E.Y., P. Barreto, E. Araujo and B. Soares-Filho. 2014. Public policies can reduce tropical deforestation: lessons and challenges from Brazil. *Land Use Policy* 41: 465-473.

Assunçao, J. C. Gandour, Romero Rocha and Rudi Rocha. 2013a. *Does credit affect deforestation? Evidence from a rural credit policy in the Brazilian Amazon*. CPI Technical Report, Climate Policy Initiative, Rio de Janeiro, Brazil. Available at www.climatepolicyinitiative.org.

Assunçao, J., C. Gandour and R. Rocha. 2013b. *DETERring deforestation in the Brazilian Amazon: environmental monitoring and law enforcement*. CPI Report, Climate Policy Initiative, Rio de Janeiro, Brazil. Available at www.climatepolicyinitiative.org.

Barber, C.P., et al. 2014. Roads, deforestation, and the mitigating effect of protected areas in the Amazon. *Biological Conservation* 177: 203-209.

Boucher, D. et al. 2011. *Brazil's Success in Reducing Deforestation.* Tropical Forest and Climate Briefing # 8, Union of Concerned Scientists, Cambridge, MA, USA. Available at: http://www.ucsusa.org/sites/default/files/legacy/assets/documents/global_warming/Brazil-s-Success-in-Reducing-Deforestation.pdf.

Boucher, D. 2013. Three datasets agree: Amazon deforestation has been reduced. *The Equation* blog (Union of Concerned Scientists). Available at: http://blog.ucsusa.org/three-datasets-agree-amazon-deforestation-has-been-reduced .

Boucher, D., S. Roquemore and E. Fitzhugh. 2013. Brazil's success in reducing deforestation. *Tropical Conservation Science* 6: 426-443. Available at: http://tropicalconservationscience.mongabay.com/content/v6/TCS-2013_Vol_6%283%29_426-445-Boucher_et_al.pdf .

Boucher, Doug. 2014. How Brazil has dramatically reduced tropical deforestation. *Solutions Journal* 5 (2): 66-75. Available at: http://thesolutionsjournal.org/node/237165.

Boucher, D. et al. 2014. *Deforestation success stories: tropical nations where forest protection and reforestation policies have worked*. Union of Concerned Scientists, Cambridge, MA, USA. 51 pp. Available at: www.ucsusa.org/forestsuccess.

Bowman, M. S. et al. 2012. Persistence of cattle ranching in the Brazilian Amazon: a spatial analysis of the rationale for beef production. *Land Use Policy* 29: 558-568.

Chappell, M. J. and LaValle, L.A. 2010. Food security and biodiversity: can we have both? An agroecological analysis. *Agriculture and Human Values* 28: 3-26.

Ferreira, J. et al. 2014. Brazil's environmental leadership at risk. *Science* 346: 706-707.

Gibbs, H.K. et al. 2015a. Brazil's Soy Moratorium: Supply chain governance is needed to avoid deforestation. *Science* 347: 377-378

Gibbs, H.K. et al. 2015b. Did Ranchers and Slaughterhouses Respond to Zero-Deforestation Agreements in the Brazilian Amazon? *Conservation Letters*, in press.

Godar, J. et al. 2014. Actor-specific contributions to the deforestation slowdown in the Brazilian Amazon. *Proceedings of the National Academy of Sciences* 111: 15591-15596.

Gollnow, F. and T. Lakes. 2014. Policy change, land use, and agriculture: the case of soy production and cattle ranching in Brazil, 2001-2012. *Applied Geography* 55: 203-211.

Greenpeace International. 2006. *Eating Up the Amazon.* Greenpeace International, Amsterdam, Netherlands, April 2006. Available at: http://www.greenpeace.org/international/Global/international/planet-2/report/2006/5/cargill-amazon.pdf/.

Greenpeace International. 2009. *Slaughtering the Amazon.* Greenpeace International, Amsterdam, June 2009. Available at: http://www.greenpeace.org/international/en/publications/reports/slaughtering-the-amazon/

IPCC. 2007. *Climate Change 2007: Synthesis Report*. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland, 104 pp.

Lapola, D.M. et al. 2014. Pervasive transition of the Brazilian land-use system. *Nature Climate Change* 4: 27-35.

Macedo, M.N. et al. 2012. Decoupling of deforestation and soy production in the southern Amazon during the late 2000s. *Proceedings of the National Academy of Sciences* 109: 1341-1346.

May-Tobin, C. and L. Goodman. 2014*. Donuts, deodorant, deforestation: scoring America's top brands on their palm oil commitments*. Union of Concerned Scientists, Cambridge, MA, USA. Available at: http://www.ucsusa.org/global_warming/solutions/stop-deforestation/palm-oil-scorecard.html.

McAlpine, C. A. et al. 2009. Increasing world consumption of beef as a driver of regional and global change: a call for policy action based on evidence from Queensland (Australia), Colombia and Brazil. *Global Environmental Change* 19: 21-33.

Mersmann, F. et al. 2015*. From theory to practice: understanding transformational change in NAMAs*. Wuppertal Institute/UNEP DTU Partnership

Morton, D.C. et al. 2006. Cropland expansion changes deforestation dynamics in the southern Brazilian Amazon. *Proceedings of the National Academy of Sciences* 103: 14637-14641.

Nepstad, D. C., Stickler, C. M. and Almeida, O. T. 2006. Globalization of the Amazon soy and beef industries: opportunities for conservation. *Conservation Biology* 20:1595–1603.

Nepstad, D. et al. 2014. Slowing Amazon deforestation through public policy and interventions in beef and soy supply chains. *Science* 344: 1118-1124.

Nolte, C., et al. 2013. Governance regime and location influence avoided deforestation success of protected areas in the Brazilian Amazon. *Proceedings of the National Academy of Sciences* 110: 4956-4961.

Persson, M., S. Henders and C. Cederberg. 2014. A method for calculating a land-use change carbon footprint (LUC-CFP) for agricultural commodities: applications to Brazilian beef and soy, Indonesian palm oil. *Global Change Biology* 20: 3482-3491.

Richards, P. D. et al. 2012. Exchange rates, soybean supply response, and deforestation in South America. *Global Environmental Change* 22.2 (2012): 454-462.

Ricketts, T.H et al. 2010. Indigenous lands, protected areas, and slowing climate change. *PLoS Biology* 8: e1000331.

Rosa, I.M.D, C. Souza Jr. and R. Ewers. 2012. Changes in size of deforested patches in the Brazilian Amazon. *Conservation Biology* 26: 932-937.

Rudorff, B. F. T. et al. 2011. The soy moratorium in the Amazon biome monitored by remote sensing images. *Remote Sensing* 3: 185-202.

Smith, P. et al. 2014. Chapter 11: Agriculture, forestry, and other land use (AFOLU). *Contribution of working group III to the fifth assessment report of the Intergovernmental Panel on Climate Change*. Available at www.mitigation2014.org.

Soares-Filho, B. et al. 2014. Cracking Brazil's Forest Code. *Science* 344: 363-364.

Strassburg, B. B. 2014. When enough should be enough: improving the use of current agricultural lands could meet production demands and spare natural habitats in Brazil. *Global Environmental Change* 28: 84-97.

Walker, N.F., S.A. Patel and K.A.B. Kalif. 2013. From Amazon pasture to the high street: deforestation and the Brazilian cattle product supply chain. *Tropical Conservation Science* 6: 446-467. Available at: http://tropicalconservationscience.mongabay.com/content/v6/TCS-2013_Vol_6(3)_446-467-Walker_et_al.pdf.

Photo credit: Carlosfelipe Pardo

Carlosfelipe Pardo
Executive Director,
Despacio.org

Bogotá's transport system as a case of transformational change to low carbon and sustainable development

ABSTRACT

This document provides a review of transformations to Bogotá's transport system around the turn of the twenty-first century, including the urban development plan and specific improvements to public transport, non-motorized transport and travel demand management (its development and current status). The document then describes the relationship of these transformations and the concept of transformational change, as well as the impact of such changes to national policies, financial frameworks, impacts beyond the scope of the interventions and, more particularly, innovation, the replicability and scalability of the interventions, and the learning processes associated with the transformation.

1. INTRODUCTION AND BACKGROUND

This case study focuses on transformational change in low-carbon and sustainable development in relation to sustainable transport measures in Bogotá, Colombia, with interventions in bus rapid transit, walking and cycling infrastructure, and travel demand management. These interventions are complementary and have achieved change in the city only because of their sound technical approach, complementary implementation and the political drive behind them. The theoretical background of transformational change and its relation to NAMA development is based on Mersmann et al. 2014, which will be taken as the main reference document for the discussion. The reason for choosing the transformation of Bogotá's transport system is because the period from 1995 to 2015 can be described as one in which there has been a 'structural change that alters the interplay of institutional, cultural, technological, economic and ecological dimensions of a given system' (Mersmann et al. 2014, p. 3).

The document addresses the following objectives:

- To relate the theory or theories of transformational change to a discussion of the transformation of Bogotá's transport system
- To describe the evolution of Bogotá's transport system during the past fifteen years
- To evaluate the outlook for transformational change to Bogotá's transport systems and the risks of it relapsing, and to propose potential scenarios

The document has the following sections:

- **Factors that made the transformation possible** (economic and financial issues at the country and city levels, the goals of the city government, previous government goals)
- **The transformational change in urban transport in Bogotá** (describing the key characteristics and timeline of interventions developed in the areas of mass transit, non-motorized transport and travel demand management in the city, showing how these were aspects of a broader program of urban transformation)
- **The impacts and consequences of transformational change:** changes in the sector itself and to local and national transport policies and financial frameworks, impact beyond the project's scope (e.g. changes in land values, urban re-densification), institutional transformation, involvement of the private-sector (in mass transit and in parking operations), innovation (in mass transit concepts and demand management), replicability (at the national, regional and global levels), scaleability (in particular with respect to BRT implementations) and learning processes (at the governmental and citizen levels)
- **Relevance of the transformational change for NAMAs:** have high carbon pathways been disrupted? Has transformation change been triggered by the interventions of innovative actors? Did it overcome persistent barriers and/or create new barriers?
- **Outlook for the interventions:** After fifteen years of implementation, how have the interventions evolved and what is their future potential; more specifically, how do they relate to the phases proposed by the phase model of transformational change, and what are its implications?.

2. THE TRANSFORMATION OF BOGOTÁ'S TRANSPORT SYSTEM: A SUMMARY

Bogotá's transport system was transformed at the end of the 1990s and beginning of the 2000s, as has been described in detail in various documents (see i.e. Montezuma 2003; Martin et al. 2007; PNUD et al. 2002). Below is an indication of the most relevant issues involved in that transformation, in particular those related to the discussion of transformational change.

2.1 Bogotá's mayors and the major role of Enrique Peñalosa (1998-2000)

A principal character in the recent history of the transformation of Bogotá's transport system was Enrique Peñalosa, the city's mayor from 1998-2000. He was directly responsible for the physical transformation of the city overall during his three years in office and was fundamental in producing the main shift towards sustainable transport because of the implementation of the crucial elements described above. The specific outputs and outcomes of his mandate are described in great detail in his mayoral reports and in other documents published specifically in order to describe the transformation (Alcaldía Mayor de Bogotá 2000; Martin et al. 2007). It must be noted, however, that other individuals, such as Antanas Mockus (mayor from 1995-1997 and 2001-2003), were also important in introducing the cultural changes that allowed the citizens of the city to acquire a stronger sense of their citizenship of it (Montezuma 2003; Martin & Ceballos 2004). In some accounts, the previous mayoral mandate of Castro Caycedo is also identified as a fundamental stepping stone, as he substantially improved the city's financial management, thus making it possible for Peñalosa to implement truly large-scale projects.

The drivers of the transformation can be summarized in terms of one overarching policy and three main interventions: Improvements to public transport, Non-motorized transport and travel demand management (with an overarching urban development plan). These are described in the following subsections.

2.2 The POT (Territorial Ordainment Plan): an overarching policy

Before 1998, Bogotá did not have a comprehensive and overarching urban development plan encompassing all sectors and giving a clear indication of how the city should be planned, built and managed in the longer term. It did have two regulations (the Urban Reform Law and Statute from 1989 and 1990), meaning that greater competence had been given to cities in their planning by 1991. The city had mayoral plans that were restricted to the duration of a single mandate (three years). Thus, the creation of the Plan de Ordenamiento Territorial (Alcaldía Mayor de Bogotá 2004), published initially in 2000, was a first step towards the long-term planning of the city.[1]

The key elements of this plan relating to transportation are the following:

- A clear indication of the need to have policies of densification (and re-densification)
- A requirement to draw up a specific master plan for transport (Mobility Master Plan, published in 2006)

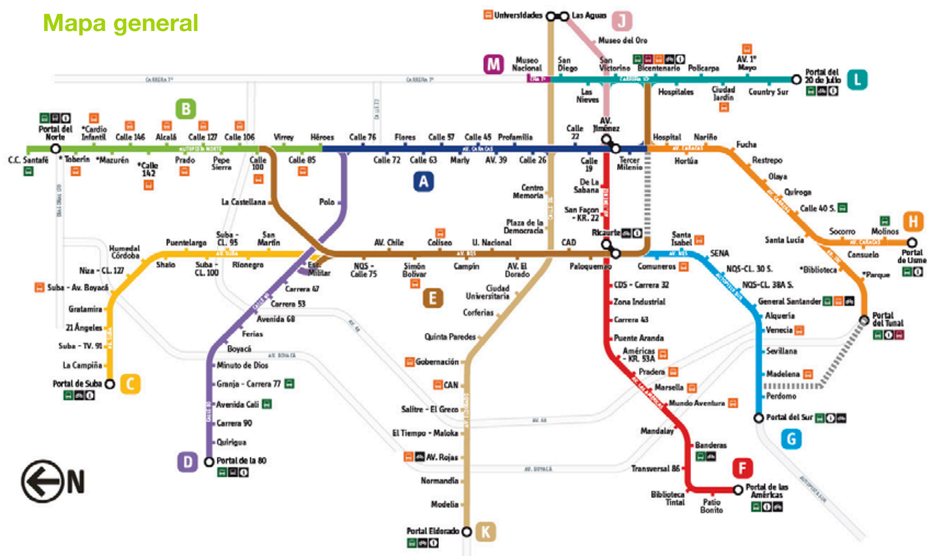
1 Le Corbusier's urban plan for Bogotá (O'Byrne Orozco 2010) might have had this aim, but it was drawn up in 1950, was not legally binding and had no finance attached to it.

Specific indicators regarding the development of sustainable transport systems (mass transit, bikeways, public space and sidewalks, parking policies).

2.3 Implementation of improvements to public transport and mass transit

While the POT was being developed in Bogotá, a crucial effort was also being made, primarily during the mandate of Enrique Peñalosa (1998-2000), to develop a high-capacity, bus-based mass transit system in the city based on other experiences in the region (a bus rapid transit system called 'TransMilenio'). The system was launched in December 2000 with a plan to develop 338 kilometres of trunk bus routes by 2015 (Bogotá 2005). Figure 1 presents a map of the TransMilenio corridors as of 2015.

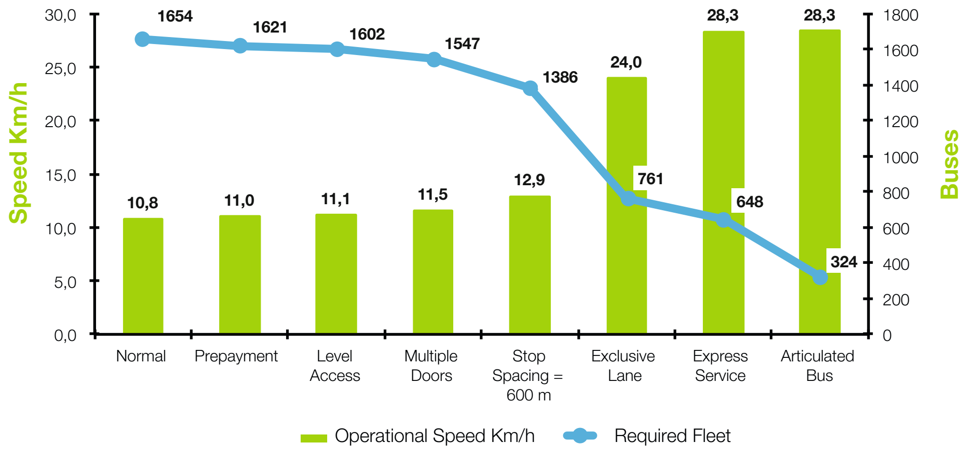
Figure 1. TransMilenio Map as of today



Source: TransMilenio SA

TransMilenio truly represents a breakthrough in developments in mass transit. Though it was based on the system developed in Curitiba (Brazil) in the 1970s, being copied in Quito (Ecuador) in the 1990s, TransMilenio introduced key improvements that enhanced it even more when compared to regular bus systems. For example, TransMilenio adopted the segregated bus lanes and off-board fare collection that was developed in Curitiba, greatly increasing the speed of the system. It also introduced a comprehensive transition in industry, learning lessons here from Quito's experience, with regular informal bus operators being transformed into fully professional, formal and legal bus operators. The system also used a median-aligned station configuration, which made it possible to have seamless interchanges between services. In addition, TransMilenio developed considerable improvements related to bus operation itself, introducing 'express services' which required the construction of a passing lane at stations and in some corridors and also increased the system's capacity and efficiency considerably. Figure 2 shows the impact of all of TransMilenio's improvements when compared to regular bus systems and their impact on operational speed and fleet requirements.

Figure 2. Specific improvements of BRT and their impact on operational speed and required fleet.



Source: (Hidalgo 2006)

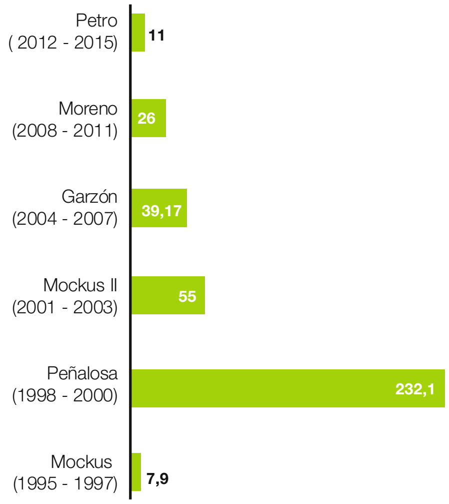
2.4 Non-motorized transport

Another crucial component of the transformation of transport in Bogotá was the development of a specific bikeway master plan ((Alcaldía Mayor de Bogotá and Instituto de Desarrollo Urbano 1998), 232 kilometres of bikeways being marked out during the 1998-2000 mandate. The city also undertook considerable efforts in building 836,000 square metres of new public space in the form of sidewalks or pavements (Pardo and Calderón 2014, p. 58). Figure 3 shows the amount of kilometres of bikeways built by each mayor, while Figure 4 shows the evolution of bicycle use in accordance with the main surveys conducted in the city. Though the share of trips in Bogotá is quite low (6%) when compared to cities like Amsterdam or Copenhagen (over 25%), the change from 1996 (less than 1%) to the current figure of more than six times higher demonstrates the potential for even greater increases in the coming ten or fifteen years.

The most important transformation when discussing non-motorized transport interventions in Bogotá is that Peñalosa's mandate changed the reigning paradigm of public space allocation in a city: before his mandate, space would be allowed first and foremost for roads and automobiles and his mandate made it clear that pedestrians would go first, followed by bicycles and then public transport. His interventions followed that logic as well, especially in low-income areas where car use was low and people walked or used bicycles as a daily mode of transport.

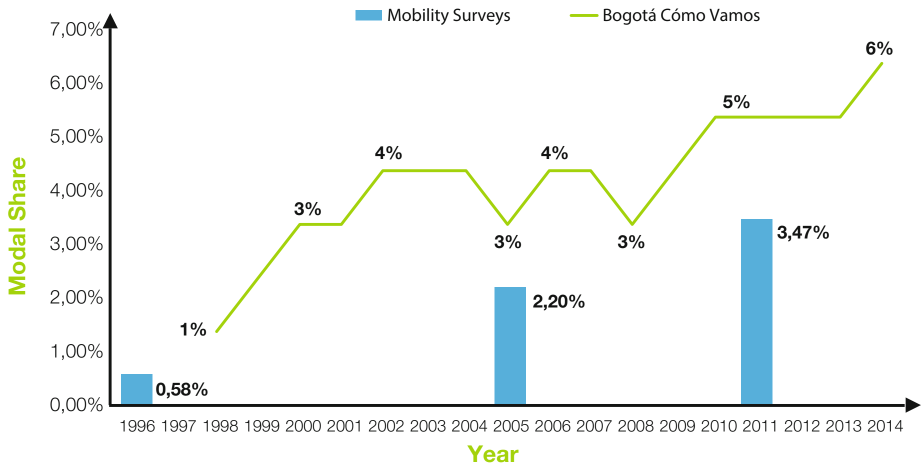
Though the idea of building space for pedestrians and cyclists is not something technologically innovative (i.e. European cities have been following that line of thought since the 1960s), Bogotá was the first city in the developing world to 'make a stand' prioritizing pedestrians and cyclists and converting road space to bikeways and sidewalks. It could be described as a change in the *socio-technical regime* as per Mersmann et al (2014).

Figure 3. Kilometers of bikeway built per mayoral term



Source: (Verma et al. 2015)

Figure 4. Bicycle use in the city (periodic OD surveys and annual phone surveys)



Source: (Verma et al. 2015)

2.5 Travel demand management

An issue that is seldom discussed, mentioned or documented in relation to the transformation of Bogotá's transport system is the adoption of a series of travel demand management (TDM) measures to complement the city's improvements to public transport and non-motorized transport. Specifically, the city implemented the following measures:

- **Road diets.** Some roads (such as Carrera 15) lost traffic lanes as a result of the widening of sidewalks. This follows the same rationale as for the allocation of road space described earlier, with pedestrians now being given priority over automobiles. The reduction in road space sent a clear message to citizens: pedestrians need better infrastructure than cars.

- **Elimination of on-street parking.** Many roads (such as Carrera 15, Avenida 19) lost their on-street parking, which the city replaced with underground parking lots (under concessions), as well as encouraging the private sector to replace the on-street parking facilities with off-street parking (see Pardo, 2010 for a detailed description). The rationale behind this was also that the municipality should not 'solve' automobile owners' need to park a car, as this was a private need that should be solved by the private sector and at a price (Peñalosa compared it to the city providing space to keep citizens' socks).

- **Parking pricing measures.** The city also created policies to charge parking by the minute (previously free or charged by the hour). This measure was only implemented in 2008.

- **Plate restriction measures.** The city implemented a plate restriction measure to reduce the use of cars on roads during peak hours. Though the scheme has undergone several changes down the years, it is still considered one of the city's TDM policies (Broaddus et al. 2009). This measure aimed to restrict car use in the city, and was different from measures developed previously in Santiago de Chile, Mexico, in that it was not an odd–even scheme and applied not to the whole day but only during peak hours (Banco Interamericano de Desarrollo 2013 provides a review of these types of measures and their effectiveness).

- **Congestion charging proposals.** As part of a national-level policy, the city has begun to think and plan for a congestion charging scheme.

2.6 Climate change/low-carbon development as a 'late driver'

The question of whether climate change and/or low-carbon development are drivers of this change is also relevant here. However, they really became issues of interest for the country (and the city) ten years after the actual implementation of the interventions described above, specifically through the development and approval of the Low Carbon Development Strategy for Colombia (ECDBC) by the Ministry of Environment in 2011 and the development of NAMAs related to urban transport (specifically, the Transit-Oriented Development NAMA, approved for funding from the NAMA Facility in November 2013). Though TransMilenio was a project with a CDM methodology for various years, this should not be seen as a driver of change but rather as a by-product of the transport system itself. However, one can say that climate change and low-carbon development have become 'late drivers' of change in recent years, both because of the ECDBC and because of the existence of various funds aimed at mitigating and adapting to climate change (NAMAs, Green Climate Fund, Partnership for Market Readiness, GEF, GIZ and USAID projects on climate change, among others).

2.7 Current status of transport transformation and interventions

As happens in all cities in the world, a transformation that is developed at one point in time will experience developments of its own in later years. After the significant interventions of 1998-2000, the following has occurred in respect of each of the four interventions:

POT. Though the POT had various changes over the years (one in 2004 that is still valid, and an 'exceptional modification' that has been under discussion since late 2013), it was a useful instrument that began to guide the city towards the implementation of an improved urban transport system.

BRT TransMilenio. Though the system has been developed in three phases to date and has implemented 113 kilometres (less than a third of the planned development), it serves 2.4 million journeys a day (39% of journeys within the city). More recently (since 2012), the third phase of the system has integrated various 'additional' elements in operational terms that have extended its scope, reach and potential emissions reductions:

- An integrated system of public transport as an overarching transport policy for the city, with TransMilenio being one system in a wider array
- The introduction of 'mixed' services along specific corridors (mainly, Carrera Séptima), with buses using segregated bus lanes (with left, high-platform doors) and non-segregated lanes (with right, low-platform doors);
- 22 low-emission buses (hybrid) in a specific corridor (Carrera Séptima).

Non-motorized transport. Cycle use has increased substantially since the first measurement in 1995 (less than 1% of journeys), and current estimates indicate that 6% of journeys are now made by bicycle (Bogotá Como Vamos 2014). When compared to world cities with below ten million inhabitants, Bogotá is the city with the largest number of cyclists in the world in absolute numbers (Ríos Flores, R. A., Taddia, A. P., Pardo, C., and Lleras 2015). Though plans envisaged 500 kilometres of bikeways by 2010, the city currently has 392 kilometres of constructed bikeways, and plans are underway to build a further 108 kilometres by the end of 2015 (Verma et al. 2015; Pardo and Calderón 2014).

Travel Demand Management. This set of interventions has suffered greatly since it was first implemented, though not entirely:

- road diets have not continued
- off-street parking has increased substantially, and the actual price per minute of parking has been frozen for several years (Banco Interamericano de Desarrollo 2013)
- a large study of congestion charging was developed and finalized in 2014; feasibility studies are planned.

3. BOGOTÁ'S TRANSPORT SYSTEM AND TRANSFORMATIONAL CHANGE

The measures, policies and projects described above can be seen as examples of transformational change if we follow the working definition posed by (Mersmann et al. 2014).[2] First of all, these measures disrupted established high-carbon pathways that now contribute to sustainable development: the implementation of mass transit, bikeways and TDM measures goes in the direction of low carbon transport and has been demonstrated to reduce emissions when implemented as a whole (see Dalkmann and Brannigan 2010 for a full description of how transport measures contribute to climate change mitigation).

Secondly, these policies and projects were triggered by the interventions of actors who innovated and connected the innovation to day-to-day practices. The relevant actors here

2 The full working definition of transformational change is 'a change: (1) that disrupts established high-carbon pathways, contributes to sustainable development and sustains the impacts of the change (goal dimension), (2) that is triggered by interventions of actors who innovate low carbon development models and actions, connect the innovation to day-to-day practice of economies and societies, and convince other actors to apply the innovation to actively influence the multi-level system to adopt the innovation process (process dimension), (3) that overcomes persistent barriers toward the innovated low carbon development model and/or create new barriers which hinder the transformed system to relapse into the former state (sustains "low-carbon lock-in")' (Mersmann et al. 2014, p.3)

are the mayors (mostly Peñalosa) and the technical staff who developed these systems, as well as the fact that they were actually built and continue to expand (see next section). The fact that transportation is one of the few sectors that is clearly visible to all stakeholders in society at least twice a day (in their daily commute) makes it directly and explicitly related to their day-to-day activities.

Thirdly, the transformation described here overcame persistent barriers in adopting a low-carbon development model. These barriers are mostly related to the lack of credibility of any transport-related measure in the city when Peñalosa started his mandate. However, it must also be noted that the current state of these changes in policy and these projects (see next section and subsequent discussion) is that they may be at risk of relapse.

3.1 Factors that made the transformation possible

There are various factors that made the transformation in transport policy possible during Enrique Peñalosa's mandate, other factors that are making its continuation possible, but also yet other factors that have caused it to move forward at a slower pace. First of all, the interventions were primarily possible due to four main factors: political will at the mayoral level, technical thoroughness in conducting the necessary studies, local financial stability and cash flow, and national laws that enabled the transformation.

3.1.1 Political will

As has been indicated in various documents and reports that review these policies (Post et al. 2010; Schumpeter et al. 2010), political will at the mayoral level is a crucial factor that made this transformation possible[3] . Mayor Enrique Peñalosa had a clear vision and a complete understanding of how the city should be transformed. As described earlier, Peñalosa became mayor after Antanas Mockus (mayor 1995-1997) had focused on increasing citizens' positive attitudes towards the city and enhancing their sense of citizenship. This enabled and facilitated the large-scale changes that Peñalosa would later propose.

3.1.2 Technical thoroughness

The mayor's (Peñalosa) inspiration and drive were complemented by the carrying out of technical studies that responded to his main interests in transforming the city. The bus rapid transit system was planned in intricate detail by local, regional and global experts on transport (Transmilenio SA 2005), and it 'broke the mould' in terms of mass transit operations and performance. The bikeway system took a quantum leap in terms of what was possible in all of Latin America (and essentially in the developing world), while the travel demand management measures were justified through the carrying out of adequate surveys in project areas.

3.1.3 Local financial solidity

By the time Peñalosa took office, Bogotá had recently undergone a total restructuring of

---

interventions of actors who innovate low carbon development models and actions, connect the innovation to day-to-day practice of economies and societies, and convince other actors to apply the innovation to actively influence the multi-level system to adopt the innovation process (process dimension), (3) that overcomes persistent barriers toward the innovated low carbon development model and/or create new barriers which hinder the transformed system to relapse into the former state (sustains "low-carbon lock-in")' (Mersmann et al. 2014, p.3)

3 In reading the analytical documents describing the essence of political will as a tool for transformation, it is also evident that this is not a clear-cut concept and that it still needs refining. For the purposes of this document, it will be retained as in the general understanding of political will, namely as the intention of a person or institution of political nature to generate substantial changes in government and policy that pose a challenge.

its finances (led by a previous mayor, Jaime Castro), and a very austere mayor (Antanas Mockus) had spent only little of the city's budget in the previous mandate. In addition, Peñalosa's mandate had considerable cash flow since he had recently sold 50% of the energy company (Empresa de Energía de Bogotá) (Montezuma 2003). Added to the efficient management of resources, all this made possible a large-scale transformation of the city.

3.1.4 National financial issues

In the case of the city's bus rapid transit system (the city's largest expenditure), a national-level law (Ley 86 de 1989) established that the national government should finance up to 70% of a mass transit system, while the city would pay for at least 30%. The city took the opportunity to develop a transit system that would not only be a high-capacity system with bus lanes and stations, but rather constitute a complete transformation of the street into a 'complete street' approach that would include all transformations ('façade to façade') in the city.

These policies have continued due to the following factors:

3.1.5 Overarching policies

The fact that the city enacted policies that would have a longer timescale than a single mayoral term has improved the continuity of policies and interventions. Specifically, the fact that the city has a POT and a Mobility Master Plan has been crucial in this respect.

3.1.6 Continuity in policies

Though not to such a great extent, there has been some continuity in the policies that were implemented or initiated during the 1998-2000 term. Some mayors respected and followed up on Peñalosa's projects (notably Antanas Mockus in his second mandate in 2001-2003, and to a lesser extent Luis Garzón in his 2004-2007 term), while others reversed many of his projects (most particularly Samuel Moreno in 2008-2011 and to a certain extent also Gustavo Petro in his current term since 2012).

3.1.7 National-level support

The great success of the different sustainable transport policies described above gave the national government in Colombia a reason not only to continue supporting Bogotá but also to create a national policy for public transport (as well as providing the financial resources for these projects) and, more recently, a national sustainable urban mobility policy.

3.2 Theories of transformational change theory and how they apply to Bogotá's transport system

The three theories of transformational change described by Mersmann et al. 2014 can be applied to the case of Bogotá. First of all, when analysing the transformation through the lens of the ***multilevel perspective*** (p. 9), it is clear that Bogotá has effected a change in the socio-technical regime, as this not only improved transport systems but totally transformed the typical approach to solving transport problems. This is clear when reviewing JICA's Transport Master Plan (JICA 1996) and its proposals to develop a high-capacity, rail-based mass-transit system, with a series of elevated highways and complementary bus lanes. At the time of Mockus's mandate (when the study was published), he did not make substantial decisions related to implementing any of the plans proposed by the Japanese agency. When Peñalosa came into office the political and economic context was not conducive, and it could be said that he was somehow forced to introduce an innovative (low cost, high impact) approach that was wonderfully complemented by his already developed vision of how a city should run (Mr Peñalosa has always been an explicit advocate of buses, bicycles and automobile restrictions, regardless of economic conditions).

These fundamental changes in the socio-technical regime clearly generated changes in the socio-technical landscape as well: transportation planning has changed substantially based on the implementation of bus rapid transit systems, as they have proved to be an efficient solution for high-demand corridors. As a complement to this, bicycles had never been taken as a serious alternative in a Latin American country (nor in most of the developing world), but Peñalosa proposed and implemented Bogotá's bikeways. Though they have not proved to have the same replication potential as BRT and bikeways, nor were TDM measures popular in any developing country when Peñalosa implemented them.

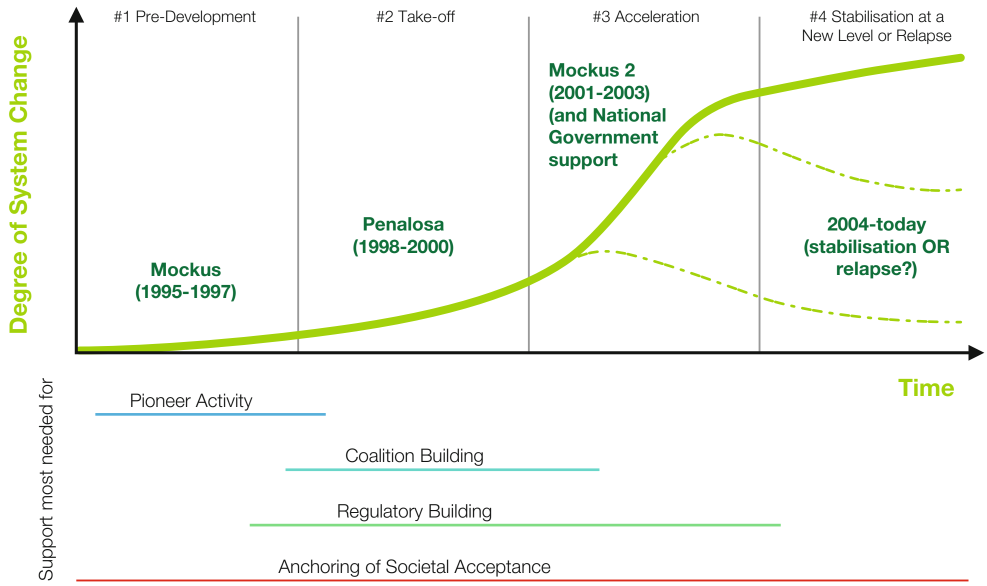
> *“It is widely accepted by Bogotá society that Peñalosa is the ‘owner’ of the vision of BRT, bikeways and TDM, while other mayors from opposing political parties have distanced themselves from those projects or reduced their impact.*

When analysing the transformation of Bogotá's transport system through the phase model (Mersmann et al. 2014, p.12), one can even indicate a clear historical ‘location’ for each phase of the transition curve proposed by Timmermans (2006, cited by Mersmann et al. 2014). However, the more ‘critical’ approach of the same curve as developed by Mersmann (2014) provides a more adequate approach, as it introduces two main issues. First of all, stabilisation may not always be possible, and relapse may even occur. This is a crucial discussion today in Bogotá following the major interventions and their current status, mostly in the case of TransMilenio (bikeways have recently received greater attention, and TDM has not really been an strong set of policies, so it may not have a pronounced S-curve in its development).

Secondly, Mersmann introduces the dimension of support received for the intervention in terms of the ‘pioneer activity’ (proposed by mayors in the preparatory phase, but in this case it is probably better situated in the take-off phase with Peñalosa), the coalition building, the regulatory building (mostly through the national government's support to Bogotá and other cities) and the anchoring of social acceptance.

The last of these aspects of support (the anchoring of societal acceptance) deserves special attention here. As noted above, transport has the characteristic that it is a daily activity for all people in society. As such, it is subject to daily scrutiny and is reflected upon much more explicitly by society as a whole (much more than, say, energy supply or waste, which only come to light generally in times of crisis or in specific sectoral discussions and with experts). This ‘quotidian’ aspect of transport has also tied it very closely to particular political alignments in the case of Bogotá, and this may well be the major reason for the implementation of ‘Peñalosa's’ transport systems in the city having been slowed. To date, there has not been any substantial and thorough analysis of the implications of this view, but it is widely accepted by Bogotá society that Peñalosa is the ‘owner’ of the vision of BRT, bikeways and TDM, while other mayors from opposing political parties have distanced themselves from those projects or reduced their impact. Figure 6 presents the Bogotá case in terms of this discussion.

Figure 5. The 'critical' transition s-curve applied to Bogotá's transformation (Mersmann 2014 version)



4. IMPACTS AND CONSEQUENCES OF TRANSFORMATIONAL CHANGE

4.1 Changes in national policies

As discussed earlier, the national government has adopted large-scale changes to its transportation policies based on Bogotá's success. These include the following:

- The development of a national public transport policy, including a strategy for large cities with BRT systems (eight cities in total), medium-sized cities with public transport improvements called Strategic Public Transport Systems (twelve cities in total) and small cities with basic public transport improvements.

- Restructuring of the Vice-Ministry of Transport with the aim of improving sustainable urban mobility as a whole, specifically through the development since 2011 of a 'Sustainable Urban Mobility Unit' to follow up on the development of interventions in mass transit, non-motorized transport and travel demand management.

- The creation of specific laws and regulations for travel demand management (National Decree 2883 of 2013), and the drawing up of a complete Urban Mobility Law (CONPES de Movilidad Urbana, under development) encompassing sustainable transport measures as a whole and providing financial arrangements for their implementation.

4.2 Changes to financial frameworks

The development of these sustainable transport measures has created or strengthened existing and new instruments to finance projects, including three in particular: the 'Metro Law', the fuel surcharge and a betterment levy.

The Metro Law was established to develop mass transit systems, with the city financing at least 30% of a mass transit system and the national government up to 70% of the remaining project costs. Interestingly, this law was extended in practice to all other public transport systems and is now applied to medium-sized cities and their SETP systems.

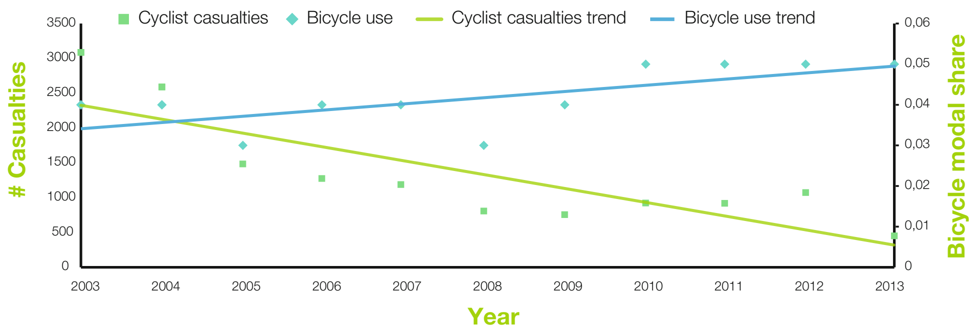
The fuel surcharge was enacted nationally to make the 30% share of local financing viable. Although it is a national law, the surcharge is collected and used locally. The city can impose 25% of a fuel surcharge that will then be used to finance both mass transit systems (half of the resources collected) and mixed traffic roads.

The third of these measures is the betterment levy, which is collected locally when a major infrastructure project is developed in an area and paid by landowners in areas where these major infrastructural improvements are being implemented. This instrument was previously used only for general road investments. However, the development of high-capacity mass-transit systems gave the levy a greater focus on these projects. Cities hope to complement this instrument with other value-capture instruments (land benefit levies and other related instruments).

4.3 Impacts beyond the scope of the interventions

Interestingly, the sustainable urban transport measures described here have had a greater, generally positive impact than originally expected. Studies related to Bogotá's BRT system have found that properties less than five minutes' walk from TransMilenio have . increased in land value, some even up to 22%, though generally between 6 and 13% (as per Estupiñan 2011). It has also been found that TransMilenio has a positive impact on land use and density (more mixed land uses, greater density along TransMilenio trunk lines) (Bocarejo et al. 2013). Also, though not so thoroughly studied, it has been shown that Bogotá's bikeway developments have had specific impacts in road safety and user satisfaction. Verma et al. found that there is a clear relationship between bicycle use and road safety (the 'safety in numbers' hypothesis of Jacobsen 2003), as is seen in Figure 6.

Figure 6. Safety in numbers in Bogotá: greater bicycle use seems to be related to road safety.



Source: (Verma et al. 2015)

Another, very important aspect to note is the considerable institutional transformation in Bogotá, specifically the development of new and renewed agencies related to transport: TransMilenio (a publicly owned, private-nature company that manages the BRT and concessions operations of the system) and the Mobility Secretary of Bogotá (previously the Transport Secretary, but transformed in accordance with the city's Mobility Master Plan).

> *"Studies related to Bogotá's BRT system have found that properties less than five minutes' walk from TransMilenio have . increased in land value, some even up to 22%, though generally between 6 and 13% (as per Estupiñan 2011).*

Finally, there has been considerable private-sector transformation and involvement in a positive sense, and in two ways: private bus operators have transformed themselves completely from an informal and traditional setting to being entirely formal and business-oriented companies. Also, urban developers have put their efforts in building projects along the TransMilenio trunk lines throughout the years, demonstrating a specific and explicit interest in building them there.

4.4 Innovation, replicability and scalability

The interventions discussed here can be described as innovative, replicable and scalable, thus proving the following three arguments:

They are **innovative** because they 'broke the mould' of previous projects of similar scope in terms of their operation. TransMilenio has the largest capacity of any bus-based system in the world, rivalling many metro systems (Wright and Hook 2008). Bikeways have been built taking local culture into account, and they deviate substantially from Dutch standards (CROW 2007) by enhancing their level of safety. Finally, some of the travel demand management measures were totally innovative in their specific operation (changes of specific hours and rotation of plates) (Banco Interamericano de Desarrollo 2013).

The interventions have also shown to be **replicable**: since TransMilenio was built, the country has implemented eight BRT systems, and the world as a whole has implemented more than a hundred of them (Embarq and Bus Rapid Transit Center n.d.) in cities in Asia and Africa as well as Latin America. Also, bikeway developments have been replicated in various Latin American cities (BID 2014).

Finally, these interventions have also proved to be **scalable**: they have all been developed in other cities of very different sizes (e.g. Pereira is city of 350 thousand with a BRT system that works well, while Guangzhou in China is a city of 8.5 million inhabitants that has also built a BRT). Bikeways and plate restrictions (and parking policies) have also been implemented in various cities of the country, region and the world (Broaddus et al. 2009; Banco Interamericano de Desarrollo 2013).

4.5 Learning processes

These interventions have posed considerable lessons that have been implemented in projects after Bogotá's. Among the specific lessons learned are the following:

In developing BRT systems, Bogotá learned the proper negotiating skills that were necessary to approach operators, and more recently it has realized the complexity involved in expanding a system to a city-wide network of public transport (and its financial implications). These lessons were applied to the implementation of subsequent BRT projects in the country. The BRT in Bogotá has also suffered from crowding due to various factors (among them, paradoxically, their great success and therefore greater demand than expected).

In its implementation of bikeways, the city has learned that bicycle-specific infrastructure must be complemented with other, non-bicycle-related measures such as education, traffic speed reductions and overall people-oriented transport measures.

In its development of travel demand management measures, the city has learned that plate restriction measures are a short-term practice that will not have the same impact in the medium or longer term. This justified the city's reflections on improved parking policies and congestion charging.

5. RELEVANCE OF BOGOTÁ'S TRANSFORMATIONAL CHANGE FOR NAMAS

These sustainable transport measures have great relevance for the discourse and essence of NAMAs and related instruments (CDM, INDCs and others). As is widely known, Bogotá's TransMilenio BRT system was the first approved transport CDM methodology (Methodology AM0031), followed by others in the same country (Pereira, Cali). This has demonstrated that Bogotá's transport projects are a genuinely low-carbon measure that can disrupt high-carbon pathways.

Further, discussions about NAMAs in Colombia have enhanced the potential for transport interventions in a broader sense: in addition to the country's attraction of foreign investment, loans and grants from various banks (IDB, CAF, World Bank, OPEC) that have financed mass transit projects, the country has developed a Transit-Oriented Development NAMA financed by the German-UK 'NAMA Facility. It is also developing an NMT NAMA with support from German International Cooperation (GIZ), and innovative actors have played a role in these developments. Non-traditional mayors (Peñalosa and Mockus) made the transformation and its continuity possible, and civil society has supported most of the transformations (notably those related to cycling and pedestrians) by developing highly innovative advocacy efforts (i.e. 100enundia, Flashmob Transmilenio, Cebras de Colores, etc).

> *“This has demonstrated that Bogotá's transport projects are a genuinely low-carbon measure that can disrupt high-carbon pathways.*

In terms of overcoming persistent and new barriers, many large barriers were overcome in the actual implementation of these large-scale transformations (1998-2000), such as corruption practices, transport operator mafias, and private-sector versus public space interventions. However, current barriers related to low levels of performance in maintaining and improving the city's transport systems have made it difficult to move forward at the same pace as before.

5.1 Embedded layers of transformational NAMAs in Bogotá's transformation

Mersmann et al. 2014, p. 22 proposed a set of layers as a framework with which to understand the relevance of different aspects of transformational NAMAs. When applied to Bogotá, one can see that Peñalosa clearly set out an **ambitious vision** from his first day in office (even his inaugural address as mayor clearly states his goal of transforming the city). There is also a clear level of **experimentation and innovation** involved in the policies and projects described in this case, as outlined earlier: Bogotá created a new type of bus-based system that had incredibly high capacity, and it was probably the only developing city able and willing to implement large-scale bicycle and pedestrian infrastructure and TDM measures at that time. Also, the **actors and coalitions** that reinforced the projects and policies strongly supported these transformations both when they were developed and in later years (recently this has been supported mostly by the national government and, in the case of cycling, locally as well). These policies can also be seen as having **removed barriers** to implementation, especially when they were being implemented. The push towards markets has been constituted mainly by private-sector bus operators (and parking companies), who have supported this change, as well as by the policies that were adopted as an overarching driving force based on the success of Bogotá's transformation. The issue of systemic change is interesting to analyse, as the change in public transport has clearly taken the form of a change of system and has been widely accepted by society in the first years of its implementation. The issue of cycling as a mode of transport also led to a change in practice: bicycles were previously seen as a recreational and sports mode and were mostly used as such, but the policies of this transformation have enabled their greater utilitarian use (Pardo 2013).

6. OUTLOOK OF THE INTERVENTIONS

After fifteen years of implementation, it is relevant to evaluate the outlook for these interventions. As indicated above, the status of the interventions could be described as continuing to exist, but not at the same level as when they started. At the risk of being too prophetic, but with an interest in producing an outlook, four future scenarios can be considered for Bogotá, as described below. These are inspired by Dennis and Urry 2009 and by the scenarios posed by Acevedo et al. 2010 in the specific case of Bogotá.

6.1 Scenario 1: total neglect of projects

This scenario is unlikely but still possible. It would involve the approach towards sustainable transport and low carbon development being neglected entirely and a different approach being pursued characterized by high investment in infrastructure, greater priority of automobile use and reduced interest in public transport. This would have very negative consequences for low carbon transport, NAMAs and sustainable development as a whole. This scenario is similar to 'scenario one' proposed by Acevedo et al. (Acevedo et al. 2010), a 'business as usual' scenario based on their study of projections until 2040, which has a projected outcome of a 'complete halt' to traffic in the city in ten years' time (it also describes that scenario as one of great urban expansion, great investments in roads and intensive use of the automobile). Theoretically, it is aligned with the scenario of Dennis and Urry's 'regional war lordism' (Dennis and Urry 2009).

6.2 Scenario 2: renewed interest in the same projects

This scenario is also not very likely, as it would imply a political alignment between Peñalosa (or someone very closely associated to him) and the implementation of his policies. It could, however, have considerable impact in terms of the improvement of the pace of project implementation and would have considerable impact in terms of the reduction of GHG emissions and overall sustainable development. There are no similar scenarios outlined in the literature studied for this document.

6.3 Scenario 3: interest in similar but slightly modified projects

This seems to be the most probable scenario, mostly for political reasons. It implies an emphasis on the same principles as today for sustainable urban transport, but with different instruments and specific projects. This would mean the implementation of a strong TOD-like urban development set of policies, the introduction of a metro of high-capital cost currently in its design phase, low-speed zones as a rule for all secondary roads rather than the expansion of bikeways, and parking pricing measures combined with a reduced supply of off-street parking. Though it is difficult to compare these two scenarios, this one could have a similar impact as scenario 2, and its higher probability would make it the preferred scenario.

This scenario is similar to 'scenario two' proposed by Acevedo et al. (Acevedo et al. 2010), which they describe as one in which 'real costs' are applied to automobile use, while public transport is greatly supported with policies and investment. Dennis and Urry have proposed a similar scenario called 'local sustainability'.

6.4 Scenario 4: new and innovative approach to interventions in transport

This scenario is simply theoretical, and its level of probability is difficult to judge, though plausibly it has only low probability. It would imply a new vision of transport interventions which would revolutionize (once again) the approach to reducing journey distances, the carbon-intensity of journeys and the overall sustainable development benefits of new types of technologies and projects. Such a scenario does not seem likely in the short term, but it should nonetheless be considered. The literature does not contemplate any scenario of this sort.

Carlosfelipe Pardo is a Colombian psychologist with an MSc in Contemporary Urbanism from the London School of Economics. His work has focused on transportation, urban development, climate change and linkages between the three topics. He has worked with bilateral, cooperation agencies and development banks, focusing on these issues from the advocacy and policy perspectives, with several projects in Latin America, Africa and Asia. He has been the manager, coordinator and supervisor of various international projects in developing cities. He is the Executive Director of Despacio.org.

REFERENCES

Acevedo, J. et al., 2010. *El transporte como soporte al desarrollo de Colombia: una visión al 2040* Primera ed. Uniandes, ed., Bogotá: Universidad de los Andes.

Alcaldía Mayor de Bogotá, 2000. *Bogotá: La Bogotá del tercer milenio, historia de una revolución urbana*, Bogotá: Alcaldía Mayor de Bogotá.

Alcaldía Mayor de Bogotá, 2004. Decreto 190 de 2004, Por el cual se adopta el Plan de Ordenamiento Territorial para Santa Fe de Bogotá, Distrito Capital Alcaldía Mayor de Bogotá, ed. , p.344.

Alcaldía Mayor de Bogotá & Instituto de Desarrollo Urbano, 1998. *Plan Maestro de Ciclorrutas. Manual de diseño*, Bogota: Consorcio Projeckta Ltda. Interdiseños Ltda.

Banco Interamericano de Desarrollo, 2013. *Guía Práctica: políticas de estacionamientos y reducción de congestión en América Latina.* First ed. Despacio & ITDP, eds., Washington: BID. Available at: http://publications.iadb.org/handle/11319/3577?locale-attribute=es.

Bocarejo, J.P., Portilla, I. & Pérez, M.A., 2013. Impact of Transmilenio on density, land use, and land value in Bogotá. *Research in Transportation Economics*, 40(1), pp. 78–86. Available at: http://www.sciencedirect.com/science/article/pii/S0739885912001023.

Bogotá, A.M. de, 2005. *CINCO años construyendo futuro: Transmilenio S.A.* Primera Ed., Bogotá: Panamericana Formas e Impresos S.A.

Bogotá Como Vamos, 2014. *Resultados de la Encuesta de Percepción Bogotá Cómo Vamos 2014*, Bogotá.

Broaddus, A., Todd, L. and Menon, G., 2009. *Transportation Demand Management: Training document* 1st Ed., Eschborn: GTZ. Available at: www.bjainbooks.com.

CROW, 2007. *Design manual for bicycle traffic*, The Netherlands: CROW.

Dalkmann, H. and Brannigan, C., 2010. *Transport and Climate Change. Module 5e. Sustainable Transport: A Sourcebook for Policy-makers in Developing Cities* re-editiio. S. Thieldman, ed., Eschborn: gtz. Available at: www.bmz.de.

Dennis, K. and Urry, J., 2009. *After the car*, Cambridge: Polity.

Embarq and Bus Rapid Transit Center, Global BRT Data. Available at: http://brtdata.org/ [Accessed January 25, 2015].

Estupiñan, N., 2011. Impactos en el uso del suelo por inversiones de transporte público masivo. *Revista de Ingeniería, Universidad de los Andes.*, 33, pp.34–43.

Hidalgo, D., 2006. Bus Rapid Transit training course.

Jacobsen, P., 2003. Safety in numbers: more walkers and bicyclists, safer walking and bicycling. *Injury Prevention*, 9, pp.205–209.

JICA, 1996. *Estudio del plan Maestro del transporte urbano de Santa Fé de Bogotá en la República de Colombia: informe final (informe principal)*, Bogotá: Chodai Co Ltd, Yaicho Engineering Co Ltd,.

Martin, G. et al., 2007. *Bogotá: el renacer de una ciudad: Catálogo oficial de la exposición de Colombia en la X Muestra Internacional de Arquitectura de la Bienal de Venecia 2006*, Bogotá: Planeta.

Martin, G. and Ceballos, M., 2004. *Bogotá: anatomía de una transformación*, Bogotá: Editorial Pontificia Universidad Javeriana.

Mersmann, F. et al., 2014. *From theory to practice: understanding transformational change in NAMAs*,

Montezuma, R., 2003. *La transformación de Bogotá 1995-2000: entre redefinición ciudadana y espacial*, Bogotá: Fundación Ciudad Humana.

O´Byrne Orozco, M.C., 2010. *Le Corbusier en Bogotá: 1947-1951: Tomo 2, Precisiones en torno al Plan Director* M. C. O`Bryne Orosco, ed., Bogotá D.C.: Ediciones Uniandes.

Pardo, C (2010), Parking (r)evolution in Bogotá: The Golden Era, 1998-2000. Reinventing Parking. Available at: http://www.reinventingparking.org/2010/10/parking-revolution-in-bogota-golden-era.html [Accessed January 25, 2015].

Pardo, C., 2013. Bogotá's non-motorised transport policy 1998-2012: the challenge of being an example. In W. Gronau, W. Fischer, and R. Pressl, eds. *Aspects of Active Travel How to encourage people to walk or cycle in urban areas*. Mannheim: Verlag MetaGISInfosysteme, pp. 49–65.

Pardo, C. and Calderón, P., 2014. *Integración de transporte no motorizado y DOTS* 1st ed., Bogotá: Despacio; CCB. Available at: http://despacio.org/2014/12/01/publicacion-integracion-de-transporte-no-motorizado-al-dots/.

PNUD, Universidad Externado de Colombia and Riveros Serrato, H., 2002. *Bogotá: una experiencia innovadora de gobernabilidad local*, Bogotá: PNUD.

Post, L.A., Raile, A.N.W. and Raile, E.D., 2010. Defining political will. *Politics and Policy*, 38(4), pp.653–676.

Ríos Flores, R. A., Taddia, A. P., Pardo, C., and Lleras, N., 2015. Ciclo-inclusión en America Latina y el Caribe: guía para impulsar el uso de la bicicleta. , p. 33 il. Available at: www.iabd.org.

Schumpeter, J., Convention, U.N. & Resource, A.-C., 2010. Unpacking the concept of political will to confront corruption. *U4*, (1).

Transmilenio SA, 2005. *Cinco años construyendo futuro: TransMilenio SA*, Bogotá: Alcaldía Mayor de Bogotá.

Verma, P., López, J.S. and Pardo, C., 2015. *Bogotá 2014 Bicycle Account*, Bogotá: Despacio. Available at: www.bicycleaccount.org.

Wright, L. and Hook, W., 2008. *Bus rapid transit planning guide*, New York: ITDP.

Photo credit: D. Gallop

Sallem Fakir
Manisha Gulati
World Wide Fund for Nature,
South Africa

The role of state-owned companies in national development towards a low-carbon future in South Africa

ABSTRACT

This paper uses the case of South Africa to illustrate the complexity of choosing an economic agent capable of catalysing a low-carbon transition (LCT) and shaping the social, economic and political response to the transition. It builds the case for state-owned companies (SOC) in South Africa to lead this transition, increasing understanding of how SOC can become levers of the LCT and of the tools they can deploy to enable the transition while not compromising their commercial viability.

1. INTRODUCTION

The South African government regards climate change as one of the greatest threats to sustainable development and believes that, if unmitigated, it has the potential to undo or undermine many of the positive advances made in meeting South Africa's own development goals and the Millennium Development Goals (DEA, RSA, 2011). At the same time, there is a growing realization that existing ways of conducting activities are not sufficiently resource-efficient and that economic activities should be conducted in ways that are more sustainable. The government has committed itself to reducing the country's carbon emissions by 34% in 2020 and 42% by 2025 compared to a business as usual scenario. This will be conditional on finance, technology and capacity-building support from the international community, as well as on the long-term transition to a climate-resilient, equitable and internationally competitive low-carbon economy. Concrete policy measures towards this end are beginning to become visible.

The extent and pace of this transition towards environmentally sustainable economic activities depends on how the technologies and sustainable practices resulting from policy measures overcome existing incumbent and non-sustainable socio-technological systems. This in turn is influenced by a number of factors, including but not limited to the institutional setting, which has multiple dimensions: norms, habits and values; institutional arrangements by way of the economic actors involved; rules for regulating and supporting economic actors, and access to and use of financial and natural capital; and institutional sectors defined as sectors that provide a certain type of product or service, as well as societal systems such as education, research or financial markets (Hollingsworth, 2000; Decker, 2012).

This chapter focuses on the role of institutions in the context of South Africa's low carbon transition (LCT). Specifically, it asks which economic actor can catalyse this transition and shape the social, economic and political response to the transition. The latter is important, as policy aims have to be translated into action which may be in contravention of the political economy and will have the natural propensity to defend the status quo unless the status quo is in systemic crisis. The paper relies on the transition management discourse presented in Mersmann, Olsen et al. (2014) to provide the framework to answer this question and to analyse lessons learned regarding success factors in and indicators of transformational change. It builds the case for state-owned companies (SOC) in South Africa to lead this transition, increasing understanding of how SOCs can become levers of the LCT and of the tools they can deploy to enable the transition while not compromising their commercial viability. The ultimate objective is to use the experience of the SOC to illustrate the complexity of choosing the economic agent to lead the LCT and of the levers that can be deployed by governments to support such an agent of change.

> *“The government has committed itself to reducing the country's carbon emissions by 34% in 2020 and 42% by 2025 compared to a business as usual scenario.*

The structure of the paper is as follows: Section 2 discusses the theoretical framework of sustainability transition pathways and applies them to the South African context to identify the type of transition relevant to South Africa and subsequently to argue for SOC leadership of the transition. Section 3 establishes the case further by focusing on the drivers for this leadership, the existing initiatives of SOC towards the transition and the barriers they face. Section 4 captures the lessons and concludes the paper.

2. SOUTH AFRICA'S LOW-CARBON TRANSITION PATHWAY

2.1 Perspectives on transition

A transition is a fundamental shift or change in functional systems, cultures and practices that involve not only new technologies, but also concomitant changes in markets, user practices, institutions, policies and cultural discourses. Transitions involve multi-level changes through which society or an important societal subsystem fundamentally changes (Gulati, Scholtz and Fakir, forthcoming). In recent years we have seen the emergence of a growing body of literature providing perspectives on how a transition takes place:

- the transition management model (Smith and Kern, 2009 and Kern and Smith, 2008), which deals with a gradual process of transformation for achieving an alternative governance model for conserving and protecting environmental resources,
- the systems innovations approach, which involves displacing old technology systems and mainstreaming new ones (van Heyningen 2011),

- the strategic niche management model (Kemp et al., 1998; Raven and Geels, 2010), which advocates regime shifts by forming successful technologies to serve as building blocks for broader societal transfer processes and sustainability,
- the multi-level perspective (MLP) approach (Geels 2002 and 2011), which looks at technological transitions at the levels of niches (micro-level), regimes (meso-level) and socio-technical landscapes (macro-level), with each level having its own characteristics and configurations of actors,
- the socio-ecological conversion perspective, in which transitions occur between different societal energy regimes (sources and dominant conversion technologies of energy) and are accompanied by co-dependent ecological changes (Fischer-Kowalski et al. 2012), and
- social movements as a signifier for a move towards a radically different means of organising society (Eadson 2012).

Additionally, transition theory provides a discourse on how differences in the timing and nature of multi-level interactions can give rise to different forms in which transitions from one regime to another can occur. The typology suggested by Smith, Stirling and Berkhout (2005) deals with the ways in which different actors within and outside current regimes are able to take action and to influence others to take action to affect the pace of a transition. They characterize regime change as a function of the extent to which the resources enabling regime adaptation come from inside or outside the incumbent regime and the extent of co-ordination for the deployment of these resources (Berkhout, Smith and Stirling. 2003 and Foxon, Pearson and Hammond, 2008). This gives rise to four possible ways (Figure 3) of achieving a managed transition to a low-carbon future. They are:

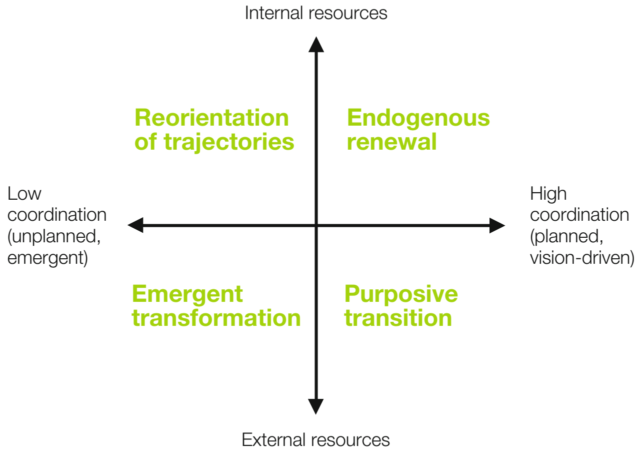
a) *Reorientation of trajectories* as a result of a series of uncoordinated responses, even if selective pressures for change are high. The regime is only able to respond to external influences in small steps, mainly by drawing on internally available resources. These responses are not of sufficient scale or quality to bring about significant changes. This is more likely in places with strong lock-in systems that allow for incremental innovation and change which, over time, may accumulate into a more stable trajectory.

b) *Endogenous renewal*, with high levels of coordination between regime members (firms, supply chains, customers and regulators) making conscious efforts to respond to perceived competitive threats to the regime by drawing on internally available resources. Although there is no system-wide overhaul, innovation enables certain aspects of the regime to change faster than others.

c) *Emergent transformation* with uncoordinated responses based on resources and capacities lying outside the incumbent regime. Thus the regime changes through external pressures or windows of opportunity without any internal organization between actors or members of the regime.

d) *Purposive transitions* with high levels of co-ordination and drawing on external actors for resources, networks and knowledge to afford changes, but deliberately intended and pursued from the outset to reflect an explicit set of societal expectations or interests. High internal co-ordination to ensure alignment and the ability to absorb external support will be crucial in effecting the sector of systems-wide transformational change. The role of the state is key and has to ensure a strong alignment between itself, private players and the myriad of state and civic agencies working on a transition problem.

Figure 1. Typology of transitions (from Smith, Stirling and Berkhout 2005)



Conversely, the typology suggested by Geels and Schot (2007) believes that co-ordination arises by aligning the visions and activities of different groups, and hence cannot be regarded as lying on a single axis to characterize transitions (Foxon, Pearson and Hammond, 2008). Instead, they propose a different typology of transitions, based on differences in the timing and nature of multi-level interactions, as follows (Geels and Schot, 2007; Foxon, Pearson and Hammond, 2008):

a) *Transformation path*. This occurs when actors in the existing regime modify the direction of development paths and innovation activities in response to moderate landscape pressures and niche-innovations that have not yet been sufficiently developed.

b) *Reconfiguration path*. Groups of innovations, developed in niches, are initially adopted in the regime to solve local problems, subsequently triggering further adjustments in the basic architecture of the regime.

c) *Technological substitution*. This occurs when a disruptive change or shock(s) at the landscape level destabilizes the existing regime, enabling previously developed niche-innovations to break through and replace the existing regime, despite the efforts of the regime to respond and adapt.
d) *De-alignment and re-alignment path*. This occurs when divergent, large and sudden changes at the landscape level lead to de-alignment and erosion of the existing regime. However, because niche innovations are not sufficiently developed, multiple niche innovations co-exist and compete for resources until one becomes dominant.

2.2 Low-carbon transition pathway in South Africa

Cheap and abundant coal has made South Africa an energy-intensive economy with a high degree of reliance on fossil fuels. Currently, about 77% of the country's primary energy needs are covered by coal. 86% of the electricity generating capacity in the country is based on coal (Eskom 2011), and around 34% percent of the country's petrol and diesel is manufactured from coal.

The problem is not limited to energy generation: coal has also formed the backbone of South Africa's industrial policy to harness the country's rich mineral endowment. This has had two implications. First, it has led to the creation of a broad and loosely defined Minerals Energy Complex (MEC) that has developed inter-linkages with parts of the economy that lie outside of mining and the electricity sector, such as finance, manufacturing and service industries. The MEC collectively accounts for close to 20% of South Africa's GDP (NPC 2013; Fine and Rustomjee 1996) and is the largest source of export revenue, contributing 60% of the country's exports.

Secondly, technologies, institutions, business strategies and user practices have evolved in a manner that has locked the country into an energy and carbon-intensive economic pathway. This lock-in is systemic and mutually reinforcing: the technology lock-in delays the adoption of more efficient technologies, thereby causing the institutional lock-in (in line with the processes described by Markusson and Haszeldine, 2010; Unruh, 2000, 2002), and the institutional lock-in makes it difficult to direct investment to new, more carbon-efficient classes of infrastructure.

Introducing an LCT in South Africa risks producing a strong confrontation between the incumbent carbon-intensive technology and infrastructure lock-in at the system level on the one hand, and the emerging low carbon technologies on the other. It faces strong political and business opposition (WWF 2011 in Gulati, Scholtz and Fakir, forthcoming). An LCT strategy has to work within an MEC paradigm to enable the systemic change. This means that the LCT is not a radical process but an incremental one. Low-carbon solutions are only 'add-ons' in the form of pilot projects or limited project-based interventions. Drawing upon transition theory, such a transition is an attempt to reorient trajectories, as suggested by Smith, Stirling and Berkhout (2005) or to create a transformation path, as suggested by Geels and Schot (2007).

3. SOC LEADERSHIP OF THE LCT

Even the reorientation of trajectories is not proving to be easy. When power is distributed evenly and consequently markets function effectively, the market influences the reorientation. When power is distributed unevenly and is concentrated in the hands of relatively few individuals or in smaller groups, the transition depends predominantly on these few individuals and groups (Decker, 2012). South Africa being a developing and immature economy where economic power resides in the hands of a few that are locked into the carbon-intensive trajectory, there is a risk that the reorientation will prove superficial.

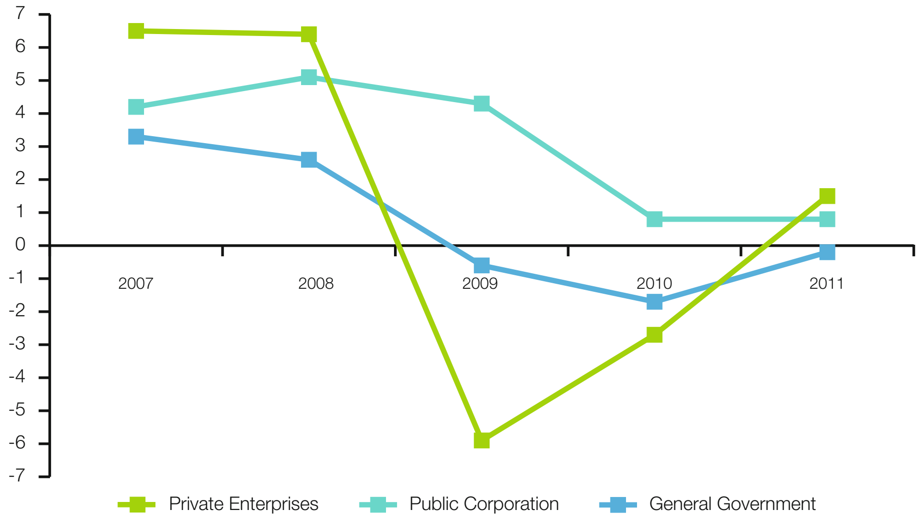
High levels of planning, co-ordination and coalition-building from within the system is required to suggest a change in the direction of development pathways and accompanying technologies and infrastructure, standards or policies. This can only be achieved by an actor within the incumbent regime that can bring together multiple actors both from within and outside the current system to influence policy and investments in the direction of new endeavours while balancing the interests of the MEC and prioritizing the country's socio-economic goals.

South Africa is faced with the dilemma of simultaneously growing the economy, alleviating poverty, bridging inequality and drastically reducing unemployment. The country has one of the world's highest levels of inequality (National Planning Commission 2012) and an unemployment rate of 25 to 37 per cent (Scholtz and Gulati 2013). Additionally, the country is currently in a low growth trap (National Planning Commission 2012).

There are few such actors in South Africa. The SOCs, given their mandate to balance commercial and developmental objectives, intellectual and implementation leadership, and more importantly facing business risks from climate change and related mitigation policies, are best placed to fulfil this role. Of particular significance here are Eskom, the vertically integrated electricity public utility that generates approximately 95% of the electricity used in South Africa, with 86% of electricity capacity being based on coal; Transnet, the rail, port and pipeline company; and South African Airways (SAA), the national flag carrier and the largest airline in South Africa. These SOCs are the mainstays of the developmental state approach of the country and are tasked with delivering the country's development agenda.

SOCs account for ~8.5% of the country's GDP (Russell, Gass and Cunningham, 2002). They are key to the country's objective of achieving socio-economic development through investments, having contributed positively to investments even during sharp economic contractions (see Figure 1) and to the building up of capital: financial (revenues), manufactures (through the supply chain), social (through energy access and improved transportation services) and human (skills and employment). Additionally their ownership of key network infrastructure and service industries is significant to the well-being of citizens, as well as to the competitiveness of both upstream and downstream private-sector companies and industries, especially exporting ones. Some SOCs continue to have significant research and development (R&D) capacity, as well as industrial capability. Clearly, early planning and measures for LCT by SOCs may delay the need for drastic and costly measures for the country as a whole.

Figure 2. Contribution to overall investment growth, 2007–2011 (values in percentages)



Source: National Treasury, 2011

While the SOC can be subject to intense political interference and beset with multiple goals and objectives, they do have some relative autonomy and ability to introduce niche innovation within an existing system. Finally, since they were at the heart of the process of embedding South Africa's economy into a carbon-intense techno-economic pathway, they can also be enlisted to reorient it, provided there are clear incentives and that the outcome is growth and economic development.

3.1 Drivers, risks and threats

There are three main dynamics for SOCs leading the LCT: risks to SOCs' economic and physical assets, regulatory pressures and financial barriers. Volatility in the supply and price of fossil fuels and related commodities increases the economic vulnerability of SOC businesses. Additionally, the assets of SOCs that are in the business of infrastructure development are at risk from climate change. Infrastructure assets have long operational lifetimes and are sensitive to the existing climate at the time of their construction, as well as to climate variations over the decades of their use (HM Government, 2011). A substantial proportion of infrastructure being built currently and proposed in the next five years by the SOCs will therefore be at climate risk, and adapting infrastructure and operations planning to the impacts of climate change will be critical.

On the regulatory side, climate change and emissions reductions are beginning to drive the regulatory agenda both domestically and internationally. On the domestic front, the National Climate Change Response Paper sets out the country's climate change and adaptation goals. In keeping with the provisions of this chapter, the government has proposed measures such as a carbon tax and the determination of a carbon budget accompanied by sectoral emission reduction outcomes. A domestic carbon tax would have severe implications for Eskom, which, as pointed out earlier, generates approximately 95% of the electricity used in the country, the majority of which is coal-based.

Further, the National Development Plan (NDP), which envisages that by 2030 South Africa's transition to an environmentally sustainable, climate change-resilient, low-carbon economy will be well under way, suggests that public infrastructure investments that need to be recouped over an extended timeframe must take account of the risk of a significantly increased cost of carbon. The environmental impacts of public-sector investment and spending need to be fully costed to promote the principle of full-cost accounting as a corporate governance standard. Parastatals and the Department of Public Enterprises need to include environmental indicators in the criteria for evaluating investments in bulk infrastructure.

On the international front, international carbon taxes and border tax agreements are continuously being explored. At one point, the European Union's aviation emissions policy proposed that airlines that land in or take off from the EU will be required to buy carbon credits under the its Emissions Trading Scheme. Initially this policy proposed taxing emissions from flights even outside of European airspace. This was later dropped in April 2014. Implemented in its original form, this policy posed financial risks to SAA. In the event that SAA could not lower its emissions, it would have had to pay penalties against its carbon emissions for all flights to the EU.

Finally, there is increasing pressure on the financial services industry and institutional investors to facilitate greater access to capital and risk protection for low-carbon activities, and even to move away completely from investments in carbon-intensive activities. This was evident in South Africa when the World Bank provided a concessionary loan for the Medupi coal-fired power station and came under significant pressure over its funding of it. The future may see an increasing trend for funding to be allocated to countries and firms that integrate environmental and social issues into their planning and investment processes.

3.2 The leadership role of SOC

The government has initiated several measures towards introducing an LCT, including in the sectors that the major SOCs operate in. For example, the Integrated Resource Plan (IRP) for electricity, which provides the medium- to long-term roadmap for power-capacity expansion in the country, has an implicit carbon reduction parameter that promotes the diversification of the generation mix to lower-carbon-emitting technologies, including the addition of 17,430 MW of renewables-based electricity generation by 2030 (Department of Energy, 2013). Subsequently, it has undertaken a competitive procurement process to acquire 3,920 MW of 17,430 MW from the private sector (Papapetrou, 2014). In the short to medium term, however, coal will continue to be the mainstay of electricity generation.

In the transport sector, emissions reductions are being proposed on the basis of measures such as modal shift, demand reduction and efficient vehicle technologies (Department of Environmental Affairs, 2013). Alternative low-carbon fuels such as biofuels are envisaged to have a mere 2% penetration level in the national liquid fuels pool. Clearly, a genuine transition of South Africa's energy system will take decades (Mwakasonda and Winkler 2005).

However, SOCs recognize the need to develop and deploy new carbon-reducing technologies resulting in a real transition, albeit in a manner consistent with South Africa's developmental objectives. It is for this reason that they have embarked on innovation – or niches, as transition theory would call them – that capitalise on their inherent strengths, building local capacity and associated industries that will meet such objectives.

These initiatives are supported by the Climate Change Policy Framework for SOCs (Department of Public Enterprises, 2012), developed by the Department of Public Enterprises (DPE) to guide SOCs on climate change initiatives. The key objectives of the policy framework are to enable SOCs to respond effectivly and sustainably to the challenges and opportunities presented by climate change by integrating climate change considerations into the planning, operations and procurement of SOCs and encouraging innovation by SOCs (Department of Public Enterprises, 2012). A key consideration is to optimise the development impacts of SOCs' engagement with climate change challenges.

> *“Alternative low-carbon fuels such as biofuels are envisaged to have a mere 2% penetration level in the national liquid fuels pool. Clearly, a genuine transition of South Africa's energy system will take decades (Mwakasonda and Winkler 2005).*

SAA has set up an aviation biofuels programme that targets bio-jet fuels to provide 10% of its requirements by 2017 (roughly 35 million litres) and 50% of its requirements by 2020 (roughly 350-500 million litres). After exploring various pathways for the production of bio-jet fuels, SAA has, in partnership with some global players, launched Project Solaris to develop sustainable jet fuel from the nicotine-free tobacco plant variety called Solaris (SkyNRG, 2014). Solaris-based jet fuel will meet the Roundtable of Sustainable Biomaterial's CO_2 life-cycle reduction threshold of 50% as a minimum. When produced in an optimized supply chain, set-up savings are expected to reach up to 75%, compared to fossil jet fuel (SkyNRG, 2014). Besides SAA's environmental goals, the project will support the national objectives for economic and rural development.

Like SAA, Transnet is also exploring solutions to enhance its energy security while reducing both energy costs and emissions. Under its Climate Change Plan, it has started the ground work to diversify its energy sources through renewable energy projects from 2017, substitute grid electricity with gas-fired electricity from 2023, and introduce second-generation biofuels in the form of biomass to liquid diesel from 2023 (Transnet 2014). It is also engaged in testing fuel cells and developing reverse energy locomotive technology.

ESKOM is engaged in robust research and development (R&D) activity for the development and deployment of new carbon-reducing technologies. It is focusing on concentrating solar power (CSP) based on central receiver technology (CRT) and biomass co-firing. ESKOM believes that, though CRT is comparatively less mature than other CSP technologies such as parabolic trough technology, it is better suited to a large utility like Eskom. Therefore, it is currently developing a demonstration plant with the aim of ensuring a full understanding of the technical, financial and operational risks associated with this technology before eventual full-scale commercial replication in the Eskom fleet. On the biomass co-firing aspect, ESKOM has explored co-firing pathways through sustainably sourced biomass. Following a trial of biomass co-firing at an existing coal-fired power plant, it is seeking to develop the torrefaction technology[1] further through the development of a torrefied wood pellet-processing plant (Singh 2014). It is also seeking to become a participant in laboratory benchmarking for torrefied biomass for this purpose and to further the development of product standards (Singh 2014).

3.3 Instruments and barriers

Besides the above 'niches', the SOCs are using various instruments to reorient their business pathways, including adopting integrated sustainability reporting (ISR). Internal processes and measures to improve the efficiency and use of electricity, the management of water, waste and other critical resources that impact on the productivity and profitability of the enterprise are gaining priority. They have also signed up to the Carbon Disclosure Project (CDP), a useful enabler of driving internal change and the monetisation of progress against specific targeted sustainable indicators. While ISR and CDP can be superficially viewed as simply a box-ticking exercise, these tools are in fact more than just compliance-focused, since they play a strategic and purposive role for the transition by providing the leverage for internal transformation, raising sustainability consciousness and creating new measures and indicators of the profitability and longevity of SOC business models.

Going forward, the SOCs need to extent their innovations, piloting and scaling up low-carbon technologies to break the fossil fuel-based lock-in of national energy innovation systems that has tended to focus on using fossil fuels (more) efficiently, for example, in the form of hybrid vehicles or energy efficiency. This has resulted in the country becoming a world leader in fossil fuel-based technologies (Scholtz and Gulati 2013), such as Sasol's coal-to-liquid fuel plants, a technology commercialized nowhere else in the world. Sadly the country's National Development Plan 2030 reinforces this trend, since many of the 'techno fixes' it refers to focus on the reduction of the carbon footprint by existing and future coal-powered power stations through retrofitting, clean coal technologies and further investigation of the feasibility of carbon capture and storage (Satgar 2014).

> *"Experience shows that technological change advances more rapidly when the public sector takes the lead in both research and development (R&D) and the practical application of new technologies.*

Transnet and Eskom already have well-established primary R&D centres. The skills and financial resources of the SOCs, including their ability to attract international collaborations and finance flows, can potentially deliver cost containment. As their learning processes continue and intensify, the niches they create can grow and eventually evolve into dominant systems that have broader socio-economic benefits.

1 Torrefaction is a process whereby biomass is heated without oxygen, thereby breaking its fibrous structure, removing moisture and volatiles, and giving it coal-like physical properties (Singh 2014). The torrefaction gases are combusted, and the thermal output is used in the drying of the biomass (Singh 2014).

Experience shows that technological change advances more rapidly when the public sector takes the lead in both research and development (R&D) and the practical application of new technologies. The public sector can provide a platform to introduce resource-efficiency measures and to leverage its procurement power to create synergies between innovation, market growth and environmental protection (OECD, no date). In particular, public-sector spending can stimulate the market for sustainably produced goods and services, for example, by shifting more rapidly to cleaner technologies (ibid.). Such procurement can also help achieve financial savings on a whole-of-life cost basis (ibid.). Increases in investments by the public sector also have distributional effects and lasting consequences such as addressing future systemic risks and encourage private-sector spending, thereby enhancing production capacity and job creation.

Going forward, the SOCs can operate at all three levels of transition management (Loorbach 2010):

- The strategic level, by enabling the creation of a common national vision, goals and agenda for LCT;
- The tactical level, by bringing together multiple stakeholders for the formation of effective national climate change and related policies and to enable the processes of agenda- and consensus-building; and
- The operational level, through the promotion, piloting and scaling-up of low-carbon solutions, as well as by leveraging their knowledge, financial clout and procurement processes to change production, consumption and institutional behaviour.

However, this will not be easy. First, the SOCs have assets that are locked into high-carbon pathways and cannot immediately be replaced. There will be residual sunk costs arising from moving away from high-carbon infrastructure. The retrofitting of assets may either not be feasible or may require substantial additional investments which may not be in keeping with the future investment plans of the SOCs.

Second, low carbon alternatives may be limited or may take time to be implemented until the SOCs can manage the strategic level of creating the common vision for the LCT under transition management. Third, funding for such assets may compete with existing business plans: given that many low carbon technologies are capital-intensive and pose higher risks, financing may prove to be a barrier even for new investments. Fourth, additional investments will be required for adaptation and to accelerate research into, and the development and demonstration of, advanced low-carbon alternatives. Fifth, existing and proposed climate change-mitigation policies such as the planned carbon tax may have implications for the SOCs' future investment plans.

At the same time, it is possible that, while being homogenous macro agents of change, the SOCs would differ in their micro-perspectives depending on their business interests, and they may also differ in the modalities of their respective transition processes. For example, reliance on Eskom for the provision of base-load electricity to power Transnet's operations poses risks for Transnet, given the rising costs of Eskom's energy supply and the carbon-intensive nature of its generation. But Transnet's plans for the diversification of its energy sources would lead to the loss of a high-paying consumer, impacting on Eskom's revenues and therefore on its ability to pay for the energy transition. Similarly, unless fuel source and supply can be scaled up, the pursuit of biofuels by both SAA and Transnet and biomass-based energy generation may lead to competition between SOC for feedstock.

The most important barrier, however, would be the increasing lack of trust in the ability of the SOCs to provide affordable and quality basic services and maintain the country's competitiveness as an investment destination. Eskom and SAA are in considerable financial stress. Eskom is under serve criticism, as the country is facing electricity shortages again after the blackouts of 2007 and 2008. Given the focus on the development of large fossil fuel-based power plants and the delays associated with such plants, this shortage is expected to continue over the next five years. For example, Eskom's 4764 MW Medupi coal-fired power station is four years behind schedule.

Though ESKOM is not a role model for operational efficiency, the fact remains that the current shortage of electricity is largely the result of past government policy that led to chronic under-investment in the electricity sector, a policy of not allowing even routine maintenance of power stations to 'keep the lights on' and the present policy hiatus. The integrated resource plan (IRP) has not been finalized, and the focus of policy is on large, bulky long-term projects, rather than meeting the immediate electricity-related needs of the country. These investments will only entrench the high-carbon lock-in and further imperil attempts to consider the LCT as providing serious investment options with the possibility of multiple co-benefits.

4. LESSONS AND CONCLUSION

Transitions theory provides an understanding of the difficulties that will be faced in overcoming the technological and institutional lock-in of existing regimes, but it does not provide prescriptions or road maps for how a country must go about tackling these difficulties or for how the transition should be managed in terms of the direction it should take and its pace (Gulati, Scholtz and Fakir, forthcoming). Every country's political economy is different, and different LCT trajectories will be encumbered by the national context in which the country finds itself in.

The primary concern of developing countries is to reduce inequality and poverty while moving away from the low to middle-income trap. Mature economies, where poverty-related problems are less pressing, may support the LCT, which for financial reasons may not be acceptable in developing and less developed countries. The LCT finds favor in developing countries that have a carbon lock-in associated with status-quo developmental pathways if it can help realize their socio-economic developmental goals. Moreover, when poverty reduction is high on the agenda, efforts in R&D are directed towards projects aimed at satisfying the basic requirements for poverty reduction, like the provision of basic foodstuff, as well as standard merchandise which serve to satisfy the needs of the poorer strata of the population. In other words, the LCT can succeed if it is not simply a burdensome outcome of international pressures, but rather provides opportunities for socio-economic transformation.

As the case of South Africa demonstrates, the crucial issue is the alignment of LCT with broader economic policy and long-term job creation, though LCT also provides an opportunity to move the economy away from its dependence on the MEC and to transform resource-intensive growth to a more efficient pathway. However, the systemic lock-in and political economy means that the LCT would simply be a reorientation of the existing pathway. Even this reorientation would require an economic agent that can catalyze shifts from within the MEC. The choice of such a change agent would depend on the country's level of development and its ideological principles, that is, a free market versus a developmental state approach. What will be necessary is that the change agent should have a substantive footprint in the economy and should be integral to delivering future development outcomes for the state and society at large. A business case for the carbon-intensive pathway and the mitigation of climate change impacts strengthens the case for the agent being the harbinger of the LCT.

In South Africa, the SOC is such an agent. The use of SOCs to deliver on socio-economic objectives is not new in South Africa. This is also true of many developing countries. If mitigating climate change or LCT is considered to be in the socio-economic interests of the country, then SOCs automatically qualify as the change agent and can be relied upon to deliver this objective.

Obviously, the ability of the chosen change agent to prioritise LCT solutions will depend on how intrinsic the solution is for its long-term business sustainability or the extent to which its low-carbon initiatives can become a flagship initiative to meet national climate change mitigation and adaptation goals. Cost would also be an important consideration, this being largely dependent on the overall condition and stability of the economy.

In the case of South Africa, the economy is performing poorly. An LCT strategy that increases the financial burden on either the SOCs or the economy in general is unlikely to find traction. Moreover, short-term issues of economic growth will gain precedence over climate issues in relation to some of the mitigation challenges and options that the SOCs face. Therefore, international assistance by way of development finance flows targeted towards low-carbon solutions and directed through or into the relevant economic agent can be instrumental to the transition.

Specific strategies or levers used by governments to support the chosen change agent in its fulfilment of its role as the catalyst of the LCT would depend on the context within which the latter is being sought, the choice of the change agent and the historical experience of and tradition of support to the chosen agent. Support could take the form of technical collaboration, resource allocation for expanding in-house technical capacity and skills development or the provision of clear incentives through ensuring budget allocations for sectoral strategies and action plans, including target- and time-based exemptions from climate change policies that impair the business case for transition leadership by the change agent. More importantly, this support must not be a one-off event, but rather a continuous process through which developing countries can increase the level of low-carbon intervention and expand the scope and pace of the LCT over time.

Saliem Fakir is the Head of the Policy and Futures Unit at the World Wildlife Fund South Africa. The Unit's work is focused on identifying ways to manage a transition to a low-carbon economy as well as looking at the future of the food-energy-water nexus. Saliem Fakir was previously (2007-2008) a senior lecturer at the Department of Public Administration and Planning and Associate Director for the Center for Renewable and Sustainable Energy at the University of Stellenbosch. He has worked for Lereko Energy (Pty) Ltd (2006) and served as Director of the World Conservation Union South Africa (IUCN-SA) office for 8 years (1998-2005). Saliem holds a B.Sc Honours in Molecular Biology (WITS), Masters' in Environmental Science, Wye College London, and did a senior executive management course at Harvard University in 2000

Manisha Gulati is an Energy Economist with WWF South Africa. She has over 14 years of highly multi-disciplinary experience covering India and South Africa. Her core areas of work are energy, low carbon development, green economy, food energy and water nexus, and sustainability transitions. Manisha is an economics graduate from St. Stephen's College, India and holds a Master's Degree in Business Economics from the University of Delhi, India. She has several publications to her credit.

REFERENCES

Berkhout, F., A. Smith and A. Stirling. 2003. Socio-technical regimes and transition contexts. Science & Technology Policy Research, University of Sussex. Brighton, United Kingdom.

COP 17. Effects of Climate Change on South Africa. Available at http://www.cop17-cmp7durban.com/en/south-africa-on-climate-change/effects-of-climate-change-on-south-africa.html. Accessed on December 3, 2014

Department of Energy, Republic of South Africa. 2013. Integrated Resource Plan for Electricity (IRP) 2010-2030. Pretoria.

Department of Environmental Affairs, Republic of South Africa. 2013. South Africa's Greenhouse Gas Mitigation Potential Analysis. Main Report. Pretoria

Department of Public Enterprises. 2012. Climate Change Policy Framework for State Owned Companies. Pretoria.

Eadson, W. 2012. Review article: low carbon transitions beyond the exceptional. People, Place & Policy Online, 6(2): 101-107.

ESKOM. 2011. Generation Mix. Available at

http://www.eskom.co.za/content/Generation%20Mix.pdf. Accessed on May 16, 2012.

Fine, B. and Rustomjee, Z. 1996. The Political Economy of South Africa: From Minerals Energy Complex to Industrialisation. Johannesburg: Witwatersrand Press.

Fischer-Kowalski, Marina. Haas, W. Wiedenhofer, D. Weisz, U. Pallua, I. Possanner, N. Behrens, A. Serio, G. Alessi, M. and Weis, E. 2012. Socio-Ecological Transitions: Definition, Dynamics And Related Global Scenarios. Belgium: Institute for Social Ecology, AAU, Austria/Centre for European Policy Studies.

Foxon, Pearson and Hammond. 2008. Conceptual and Analytical Framework. Engineering and Physical Sciences Research Council. e.on. UK

Geels, F.W. and J. Schot. 2007. Typology of sociotechnical transition pathways. Research Policy 36, 399-417.

Gulati, M., Scholtz, L., and Fakir, S. Forthcoming. Climate Change and the Low Carbon Transition. In *Greening the South African Economy*, edited by Mark Swilling, Josephine Kaviti and Jeremy Wakeford.

HM Government. 2011. Climate Resilient Infrastructure: Preparing for a Changing Climate. Presented to Parliament by the Secretary of State for Environment, Food and Rural Affairs by Command of Her Majesty. UK

Loorbach, D. 2007. Transition Management: New mode of governance for sustainable development, International Books. Utrecht, the Netherlands.

Mersmann, F., K. H. Olsen, et al. (2014). From theory to practice: Understanding transformational change in NAMAs, UNEP DTU Partnership.

National Planning Commission, Republic of South Africa. 2012. National Development Plan 2030. Pretoria.

National Treasury, Republic of South Africa. Medium Term Budget Policy Statement 2011. Available at http://www.treasury.gov.za/documents/mtbps/2011/mtbps/Chapter%202.pdf

Accessed on February 17, 2012

Organisation for Economic Co-operation and Development (no date). Public Procurement for Sustainable and Inclusive Growth: Enabling reform through evidence and peer reviews. Paris.

Papapetrou, P., 2014. Enabling Renewable Energy in South Africa: Assessing the Renewable Energy Independent Power Producer Procurement Programme. WWF South Africa

Perez, C. Technological revolutions and Financial Capital: The Dynamics of Bubbles and Golden Ages, Edward Elgar Publishing: Great Britain. 2002

Russell, D. , Gass, P., and Cunningham, M. 2002. State-Owned Enterprises as Agents of Change: How state-owned enterprises can influence global climate change. The International Institute for Sustainable Development. Manitoba, Canada.

Scholtz, L. and Gulati, M. Experiences around responsible business: The South African experience. Input paper prepared for *Economic Policy Forum - Resources Policy: Energy and Environment* Organized by Observer Research Foundation on August 5-7, 2013 in New Delhi, India.

Singh, Y. 2014. Overview of Biomass Related Activities at Eskom. Presentation at IEA Bioenergy Task 32 and ESKOM Workshop on *Opportunities for Bioenergy in South Africa* on November 4, 2014. Johannesburg.

SkyNRG. 2014. Skynrg, Sunchem SA, Boeing and South African Airways officially launch project solaris to develop sustainable jet fuel from energy-rich tobacco crop. Press release. South Africa.

Smith, A., Stirling, A., and Berkhout, F. 2005. The governance of sustainable socio-technical transitions. Research Policy 34, 1491-1510.

Transnet (SOC) Ltd. 2014. Climate Change Plan: Submission to the Department of Public Enterprises. Johannesburg.

van Heyningen, P. 2011. Achieving Transitions and Transformations towards Sustainability and Low Carbon Economies in Africa: The Sustainability oriented Innovation Systems Approach. Paper for WWF SA. Unpublished.

UNEP DTU
PARTNERSHIP

UNEP

International Partnership
on Mitigation and MRV

NAMA PARTNERSHIP

United Nations
Climate Change Secretariat