Dynamic Governance of Clean Energy Markets - Lessons from successful cases

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Martin Jänicke,

Freie Universität Berlin, Germany
Tel. +49 308325315, E-mail-hauptman@zedat-fu-berlin.de

Abstract: This explorative paper describes selected cases of the acceleration of technical progress in climate policy. The examples come from highly developed industrial countries such as Germany, Great Britain or Japan, as well as emerging markets such as China and India. These are cases involving not only renewable energies, but also energy efficiency (the latter being considered more difficult). The author's objective is to find out, which factors have caused this dynamic development. The paper comes to the conclusion that the interplay of feedback mechanisms – which has been described as "virtuous cycle" – gives a plausible theoretical explanation only, if to the market cycle and innovation cycle the policy cycle is added. Climate policy should not only define ambitious targets but also address all three feedback mechanisms.

Keywords: Climate policy, innovation, renewable energy, energy efficiency

"The ambitious target for 2022 of 20,000 MW or more will be dependent on the 'learning' of the first two phases…(A)fter taking into account the experience of the initial years, capacity will be aggressively ramped up to create conditions for up scaled and competitive solar energy"
(Government of India, 2009)[10].

1. Introduction

Climate-friendly technologies are experiencing unusually dynamic growth. And competition for such technologies in industrial policy has not only spread to developed industrial countries, but also emerging markets such as China and India. Competition for leading positions in the global market for these future technologies is currently the most powerful driving force of climate protection. In this context examples of an unexpected acceleration of the diffusion of low-carbon technologies can often be observed in different countries. This explorative paper tries to find out, how this acceleration can be explained and which conclusions for government action and climate policy can be drawn.

2. Selected examples and applied method

The paper will present and discuss empirical successful cases, involving not just renewable energies [13, 23], but also energy efficiency policies (the latter being considered more difficult for governments)[19].The examples presented are cases in which an ambitious climate policy has successfully forced the diffusion of a low-carbon technology, thereby triggering an acceleration of the innovation process [16]. The applied method is case analysis of best practice and a bottom-up explanation of possible causes. Both unfavourable developments and limiting factors are methodically disregarded.

Dynamic Governance of Green Markets (Low-Carbon Technology)

Freie Universität Berlin

Case	Country	Market effects	Innovation effects	Political feedback
Green electricity	Germany	Rapid diffusion, export success	Secondary innovations	Target made much more strict
Green electricity (wind, solar)	Spain	Rapid diffusion, export success	Secondary innovations	Announcement that target will be exceeded
Wind power	China	Very rapid diffusion, export success	Secondary innovations	Target made much more strict
Photovoltaic	India	Increased diffusion	Major R&D subsidies	Option of making targets more strict
Wind power	Denmark	Rapid diffusion export success	Secondary innovations	Target made more strict (with a delay)
Photovoltaic	Japan	Rapid diffusion export success	Secondary innovations	Target made more strict (with a delay)
Building energy efficiency	Germany	Increased diffusion	Major secondary innovations	Acceleration in making targets more strict
GHG Emission / Energy efficiency	Great Britain	Increased diffusion	Promotion of innovation	Target made more strict
Energy efficiency	Ireland	Increased diffusion	Promotion of innovation	More extensive programme
Product energy efficiency (Top Runner…)	Japan	Rapid diffusion	Major secondary innovations	Stricter standards

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2.1. Germany

Germany has proven to be a major player in climate policy. The unexpected acceleration of the speed of diffusion of renewable energies (and other low-carbon products) was the consequence of extensive measures introduced by the new Federal Government in 1998, a coalition of Social Democrats and the Green Party. There was a significant increase in the existing feed-in tariffs for renewable energies. As a result, an unexpected growth of renewable in the power sector took place. And also the Kyoto target of reducing greenhouse gases by 21% by 2012 was exceeded already by 2007. In 2000, the Federal Government was still focusing on the target of increasing the proportion of electricity generated by renewable energies by at least 20% by 2020. The growth effect triggered by this policy made it possible to raise the target in 2009 to at least 30%. A higher target of “at least 35%” was specified after the Fukushima catastrophe in 2011 [3]. A figure of 38.6% is officially expected [7]. The sector itself is predicting 47% for the same year [1]. The main reason for this new approach was the particular dynamism in the innovation process, indicated (for example) by the fact that the forced promotion of the new energies after 1998 triggered a sharp increase in new patents in this area. The effectiveness of solar and wind power has been constantly increasing. There have been major reductions in production costs. In 2010, this leading industry on the world market created / secured 370,000 jobs [5].

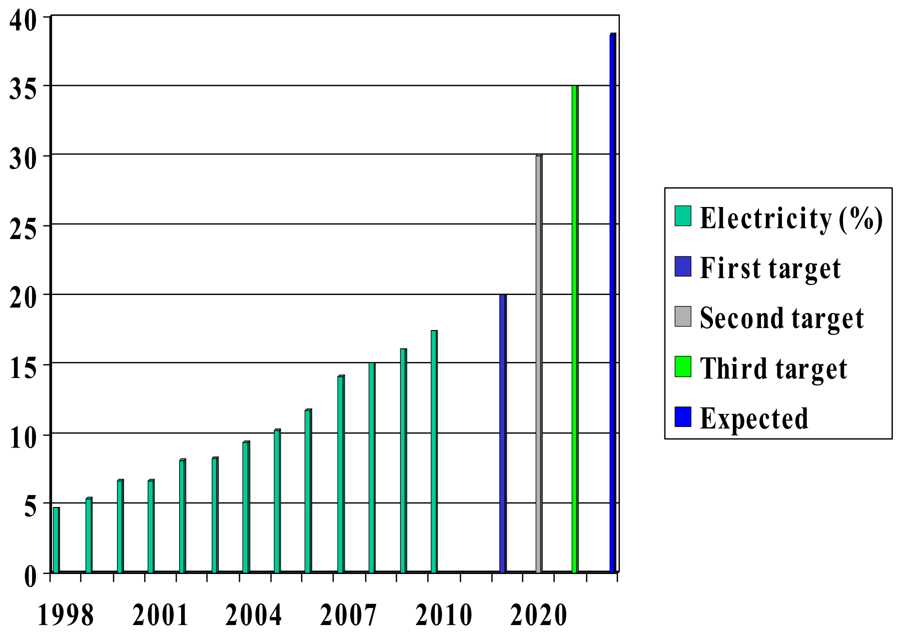

Figure 1: Share of Green Power in Germany 1998-2010 and targets for 2020

2.2 China

One might think that this dynamism was only possible in highly developed industrial countries, but China as an emerging market also offers some striking examples. The development target for solar power for 2020 has been increased five times. In the wind power sector, China may have started out with European technology, but is now becoming increasingly independent. Setting ambitious development targets, the country has triggered a dynamic in wind power that has almost overwhelmed it. This is perhaps best expressed in this sequence of targets set for 2020 [8][21][22]:

- 20 GW was the target in 2004
- 30 GW was the target in the long-term programme for renewable energies in 2007
- 100 GW was formulated as the new target shortly afterwards
- 150 GW was set as the "unofficial" target in 2010.

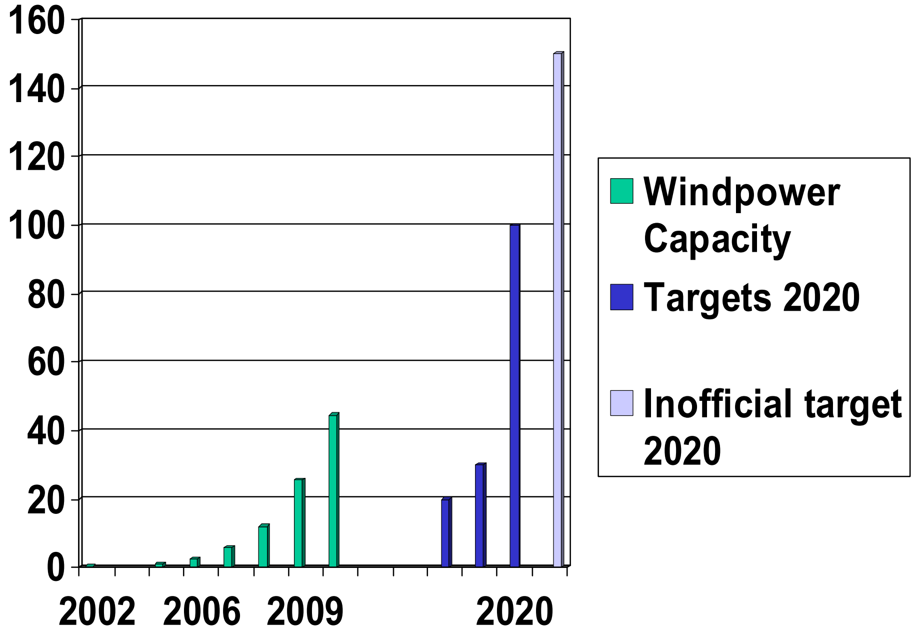

Figure 2: Wind Power Capacity in China 2002-2009: Trend and Targets 2020

The unexpected development dynamic has therefore led to constantly higher targets for 2020. target of 150 GW for the same date. According to the Chinese Renewable Energy Industries Association, it may be possible to exceed even the target of 150 GW (Global Wind Energy Council 3. 2. 2010). However, given annual growth rates of over 100%, it is unsurprising that the Chinese government is aiming to limit this extensive growth. There are now around 70 Chinese manufacturers achieving some success on the global market [21]. China's significant research and development efforts are supporting the secondary innovation process and economies of scale when it comes to renewable energies (similar technological success is also being achieved in the further development of flue gas desulphurisation technology in China).

3. Selected examples of the acceleration of technical progress in energy efficiency

Are the successful renewable energies on which innovation research has been based so far a lucky special case in climate policy that is not representative of the situation as a whole? Isn't the promotion of energy efficiency, which is progressing much slower in the EU (for example), more difficult in principle? Isn't “green growth" much easier to achieve than the corresponding reductions required? Perhaps so, but nevertheless, without wishing to deny the varying levels of difficulty faced in environmental policies, there are still areas of common ground: the examples of energy efficiency policies below indicate that the positive feedback mechanisms of an ambitious climate policy can also apply here. The common denominator is a climate strategy based on technology that establishes and develops markets for energy-efficient innovative products. These products range from economical electrical equipment to building technology to contracting.

3.2 Great Britain

The acceleration of technical conversion to climate-friendly energy technologies has also been forced at a policy level in other EU countries. Great Britain, the second European leader in climate policy, has a climate policy advantage similar to Germany – the generation of electricity from coal was phased out early on for political reasons by former Prime Minister

Margaret Thatcher. This took a little of the shock value away from ambitious climate targets. Since then, the country has far exceeded its relatively high Kyoto target for the reduction of greenhouse gases (minus 12.5% by 2012). A reduction of 25% was achieved in 2010. Great Britain was the first industrial country to set a legally binding GHG reduction target of "at least 26%" for 2020 (80% for 2050) in the 2008 Climate Change Act. In May 2009, the target was increased to 34%. In May 2011 the new Conservative-led UK government adopted a GHG reduction target of 50% relative to 1990 levels for the period 2023-27.

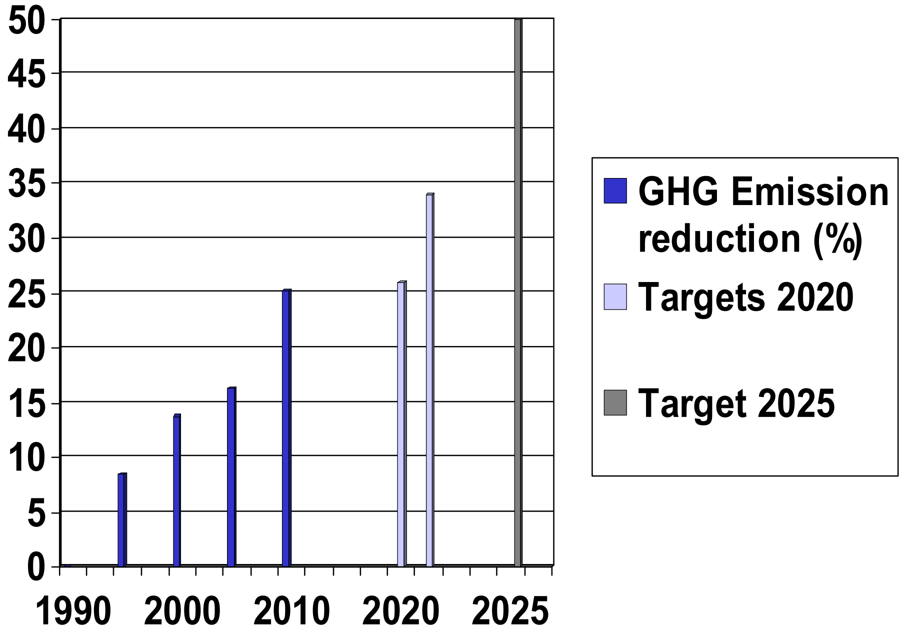

Figure 3: Greenhouse Gas Emission Reduction in UK 1990-2010 and Targets 2020/2025

In addition to the increased use of gas, British success has mainly been achieved in energy efficiency. Great Britain's aim was to improve energy efficiency by 9% by 2016. Later on a figure of 18% was expected. All new buildings are expected to be "zero-carbon" in Great Britain by the same year [19]. The measures implemented include the successful Energy Efficiency Commitment, which requires the energy industry to implement measures to encourage private customers to save energy. More than half the savings have come from heat insulation measures. The Mark Group, a strong supplier on this market, extended its activity to the U.S. Another effect of this policy was the rapid market success of economical electrical equipment.

3.2 Japan

The example of the Japanese "Top Runner" programme is well known, classifying the most energy-efficient top model in a product category as the benchmark for a binding standard. The motto "Developing the world's best energy-efficient appliances" also demonstrates real ambition in terms of industrial policy [17]. Most of the 21 regulated products (there are now 23) have reached the top standard ahead of schedule or exceeded it, leading to the definition of a new Top Runner standard each time. According to Nordqvist, this has led to a *cycle of standard setting – compliance period – evaluation and revision – and renewed standard setting* [18]. For example, computers were meant to be consuming 83% less electricity on average by 2005. This target was reached already in 2001. A second standard was set for 2007. Again the expected reduction of 69% has been surpassed (minus 81%). Now a third standard for 2011 was set with an expected reduction of 78% [17]. The more modest target for cars for

2010 (minus 23%) had already been reached five years earlier. Furthermore, a new standard was defined with the aim of further savings of 29% [17]. The Top Runner programme is generally considered to be highly successful. It promoted competitiveness for the corresponding products. Despite fears, it has not resulted in higher production costs.

4. Theoretical interpretation

At the heart of the subject under discussion here lies the dynamic interaction between functions in the technical system of innovation [2, 11, 16, 24]. In SRREN the IPCC has described this as an interaction between the market cycle and the technical innovation cycle [13]. The positive feedback has been described as "virtuous cycle". It may be the most promising phenomenon in climate policy.

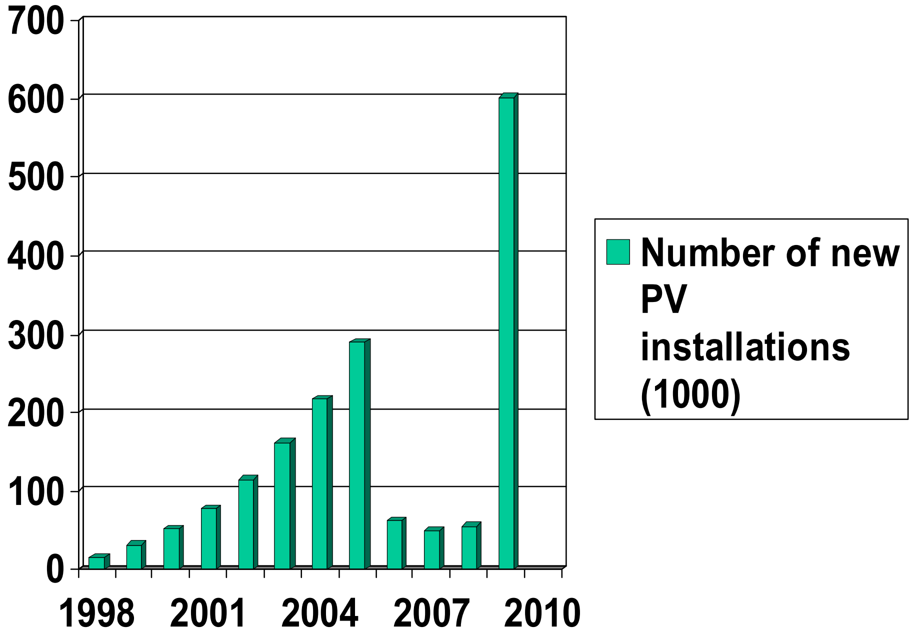

Figure 4: Number of New PV Installations in Japan 1998-2009

The dynamic interaction in clean energy innovation is essentially "policy-driven" [9]. And the OECD has stressed the importance of political leadership in "Green Growth" strategies [20]. The importance of government support can also be demonstrated by counterfactual examples: In Denmark (after 2011) and Japan (after 2005) – the political support for Wind energy / PV was stopped for some years and the investment was immediately going down [13]. When the former successful policy was taken up again (2007 / 2009) the investment followed immediately. This means that government is not only part of the "virtuous cycle", in the presented cases it is the main driving force.

Therefore the interaction of *three* dynamic processes should taken into account: firstly, policy influence on market development; secondly, the effects of the induced market dynamic on the development of innovations, and thirdly, the repercussions of the market and innovation dynamic on the policy process (Fig. 5). These three areas have an intrinsic logic, which is interestingly also reflected in the fact that their dynamic is presented as a cycle [12, 13, 16, 24]. In policy science, the *policy cycle* has been defined in stages: agenda setting – policy formulation – decision – implementation – the outcome. The final evaluation of the outcome usually leads to the setting of a new agenda [12]. The amendment of laws at the end of a policy cycle is a typical process here. In addition to product development, investments and the final offer by a company, the *market cycle* involves demand, price development and, above all, the induced demand for innovations that improve product quality and reduce manufacturing costs. This affects the third cycle, the *innovation cycle*. It comprises invention and development, market introduction (the actual innovation), and finally the diffusion of the new product that, if successful, will provide new incentives for secondary innovations. Secondary innovation improving costs and the quality of the product can also include social innovations (e. g. the creation and diffusion of the institution of “100% Renewable Energy Regions” in Germany).

The markets for climate-friendly low-carbon technologies are usually organised markets. As mentioned, they are "policy-driven", usually with a mix of climate policy and industrial policy motives. In essence, an ambitious climate strategy is a government strategy. Its successes can trigger positive feedback for the policy. Policy can also promote the innovation process directly. It can provide fundamental support via the provision of targeted R&D resources. Above all, targeted state R&D resources can support the secondary market-driven innovation process, which improves the quality and manufacturing costs of climate-friendly technology in competition. Ambitious government target specifications can also offer a stimulating long-term perspective for the process. Policy therefore stimulates the market and innovation process, and both can result in positive feedback for the policy: In addition to the intended effect on the climate, market success for low-carbon technologies also has a positive effect on employment and supplier interests, which backs up the policy. The innovation process supported by the market and government creates additional action options for a technology-based policy. More effective photovoltaic systems or energy saving technologies could justify more ambitious climate targets and market success encourages the political acceptance of this. Overall, the three cycles can work in such a way that they boost each other and enable each other to experience positive feedback. As cycles, they tend to carry the process forward to a higher level.

The innovation dynamic presented here is naturally subject to *international framework conditions:* the policy process is subject to this influence in two ways. National governments are influenced to a greater or lesser degree by global climate policy. Furthermore, a large number of governments are also subject to the conditions of innovation competition for low-carbon technologies, based on industrial policy. National suppliers in this sector are also usually exposed to international competition and the domestic markets are influenced by this combination. Even the national innovation system is not free from international influences and is often subject to competition amongst research suppliers.

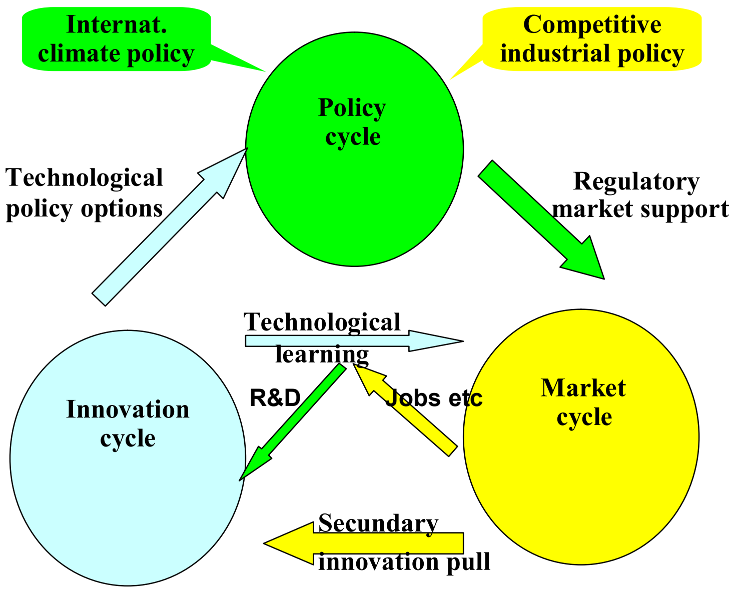

Figure 5: Policy Acceleration: The Triple Cycle of Innovation

5. Conclusion: On the governance of the innovation process

The aforementioned examples of "best practice" in climate protection suggest that there are political conclusions to be drawn here [16]. The following generalisations seem possible (with all due reservations):

- In addition to prior experience and the existence of suitable providers, the prerequisite for such processes is the existence of a government R&D research environment that supports the secondary innovation process.

- The decisive factor is then the definition of calculable climate targets at the limits of the capacity that is technically feasible for a country. The targets need to be *ambitious*. The calculability of the targets is based on the programme of implementation and its foreseeable effects.

- If the targets are implemented successfully and therefore effectively boost market growth for climate-friendly technologies, this results not only in economies of scale but also *secondary innovations*: new processes that reduce manufacturing costs and product innovations, but also social innovations.

- Market success not only generates jobs, but also interest from new suppliers, which further legitimises the ambitious policy measures and often pushes them aside. This tends to broaden the policy conditions for action and increase the level of policy aspirations. In the end, climate targets that were once the subject of dispute are often widely accepted. More far-reaching targets can even be accepted.

- The effects of international competition also play a part here: competitors from other countries can further develop the successful technology and offer these developments themselves on the global market. This gives rise to a situation in which the progress of a pioneering country is only held back by the need for constantly new innovations.

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