Eco-Innovation In Technology For A Sustainable Economy

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Abstract- *Economic sustainable development is an inherent requirement for the transformation of a country to a Green economy. This research paper is devoted to analyze the sustainable development-green economy nexus. This paper establishes that green power which integrates sustainability, innovation and power into one concept, will become a decisive factor for global change. By merging insights from political science, economics and innovation research, it develops a multidimensional, multilevel concept of green power that takes both resources and processes into account. An empirical evaluation of the current distribution of green power in global environmental governance illustrates that India and China, in particular, as well as Brazil and Costa Rica are drawing near in clean technology and renewable energy. Association of Gross domestic product (GDP) and Environmental Performance has also been studied to provide a lucid view about the inter-linkages between sustainable development and green economy.*

Keywords- Innovative technology, Multidimensional, Global environmental governance, Green power potential.

I. INTRODUCTION

The green power potential of a country is a central factor in the transformation to a green economy. 'Green economy' is the new buzzword in global environmental governance. The Rio+ conference in June 2012 reflected the trend to focus on the economic system. While many actors, organizations and policymakers are hoping that the establishment of a green economy will be a relatively easy goal to attain, there is neither a clear vision of what it actually is yet nor how to get there. The most commonly used definition of a green economy comes from a United Nations Environmental Programme (UNEP) report, which states that a green economy leads to "improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities" .This means that it is low carbon and resource efficient as well as socially inclusive, thus following a multidimensional view of sustainability.

A country's green power potential that is central to the transformation to a green economy. This paper highlights the indicators that have the required green power to induce and shape this change. Existing concepts of power in political science and economics do not suffice to explain the shifting power and the development of multifactor, multilevel, global environmental governance in this regard. The increase of environmental pressures and global attention to environmental problems moves environmental issues from the sidelines toward the centre of global governance. It can be assumed that those countries with green power will be those who manage and shape change. Moreover, if they enforce their green power in an effective manner, their position in the international system may strengthen. With green issues becoming more relevant to the competitiveness of countries, environmental governance and green power are likely to become core interests in some countries.

The concept of "green power" entails a combination of sustainability, innovation and power. Its starting point is a multidimensional understanding of power that is both resources based and process based. Thus, green power is more than economic dominance in the realm of green technology and more than the amount of natural resources in a given country. Drawing on a political science understanding of power as well as the economics and innovation literature, this paper develops the concept of green power.

II. POWER AND INNOVATION

Power remains a contested issue in political science. In economics, however, power has been a somewhat neglected issue. Neoclassic economists tend to exclude power as an explanatory factor of international trade and finance, deeming it irrelevant as long as it is not intentionally aimed at coercing other states. States applying hard power strategies use coercion, threat, rewards and monetary or military resources to get others to do what they otherwise would not do. This is similar to one-dimensional economic approaches that focus on the size of an economy. From this macroeconomic perspective, the capacity of a country to shape and possibly dominate the world economy is the only relevant form of

power. Some authors add GDP per capita, population and, sometimes, innovation in technology/research and development (R&D) expenditure to measure economic strength, thus moving toward hard power and national power concepts. In contrast to economic power, economic dominance is about the real resources that a country can muster relative to other countries in the exercise or projection of power.

Relational power concepts have been criticized for neglecting the structural dimension of power. Structural power refers to the ability of an actor to influence and shape the rules and framework that make up the global political economy in which other actors have to operate. According to Strange, four different structures together form the global political economy: the security, financial, productive and knowledge structures. Thus in Strange's concept, the ability to shape the knowledge structure directly relates to technological power and innovation. Structural power may be less clear in terms of time and space, but it also has a relational side to it. An important subtype of structural power relevant for a country's green power potential is business power or – more concretely – technological power. In international political economy (IPE), business power refers to the capacity of companies to influence domestic and international policy and regulations (Falkner 2008: 29). It "limits the ability of states to impose solutions that may be environmentally desirable but threaten to violate the fundamental interests of business" (Falkner 2008: 30). Economic networks present one form of this power. Technological power is another specific form of business power in environmental policy. Companies have technological power if they have privileged access to technical information and if they can steer technical innovation processes due to their expertise and their material resources. This technological power is particularly relevant for the advancement of environmental innovations and thus for a country's green power. The different power concepts discussed show that simple one-dimensional concepts may not capture power adequately. In both economics and political science, different multidimensional concepts have therefore been developed. Drawing on the insights of these studies, this paper uses a tripartite understanding of power as a starting point that is able to incorporate political and economic power. The differentiation into instrumental, structural and discursive power combines resources and processes and allows for direct and indirect forms of power. Economic power – like political power – is multidimensional. Innovation is an important element of economic power, particularly for a green economy. Therefore, the next section turns to the relevance of eco-innovation and climate innovation for power.

III. ECO-INNOVATION AND CLIMATE INNOVATION AS FORMS OF POWER

Innovation is central to economic power. It counts as the key to competitiveness, growth and often also as a central element to the transformation of economies toward more sustainability. This section will show that turning eco-innovation into green power depends on certain key features, which may differ between industrialized countries, emerging economies and developing countries. Primarily, these are the technological capabilities, the absorptive capacity, the degree of integration into global green value chains and the political framework. More advanced countries tend to have more economic power and capabilities for innovation. These capabilities, in turn, are partly dependent upon the relative power of value chains. Value chains may function as locations and channels for innovation, setting new standards in green technology and green practices.

Environmental or eco-innovation is defined as: all forms of innovation activities resulting in or aimed at significantly improving environmental protection. Eco-innovation includes new production processes, new products or services, and new management and business methods, whose use or implementation is likely to prevent or substantially reduce the risks for the environment, pollution and other negative impacts of resources use, throughout the life cycle of related activities. Climate innovation is a subset of environmental innovation. It aims at mitigating climate change and adapting to its impacts and includes bottom-up and social innovations. In the literature, the mitigation side often prevails. Studies primarily analyze energy efficiency, renewable energy, carbon taxing and carbon capture and storage. Whether a country can benefit from a first mover advantage by eco-innovation – and thus increase its economic green power – depends on five general factors (Walz 2011):

1) the characteristics of the technology
2) the competitiveness of the industry cluster
3) the demand for new technical solutions
4) innovation-friendly regulations
5) technological capabilities and trade performance.

Technological capabilities include the knowledge and skills necessary as well as institutional structures and intra-firm linkages. Similar to innovation in general, eco-innovation and climate innovation occur primarily in industrialized countries. The technology transfer mechanisms under the United Nations Framework Convention on Climate Change, such as the Clean Development Mechanism, reflect this. Increasingly, the traditional North–South transfer of technology and knowhow no longer applies to all eco-innovation. Emerging economies are catching up and are even among the world leaders in some fields now. For the relationship between environmental innovation and power,

these developments imply, first, that the distribution of global economic power in terms of environmental innovation is shifting. This may help emerging economies catch up, which is environmentally and politically desirable. A country or firm has caught up if it has reached the current technological frontier in green technology and eco-innovation without surpassing it. While key factors differ from case to case, absorptive capacity (i.e., the ability to recognize and apply new information) is arguably the most important element in catch-up processes.

The leading firms in industrialized countries with a highly skilled labour force and a large amount of specialized and tacit knowledge generally have high absorptive capacities. Absorptive capacities for sustainable technologies and technological capabilities differ substantially between emerging economies. The absorptive capacities of the least and less developed countries are generally smaller than those of emerging economies and late-coming industrialized countries. Second, more environmental and climate innovation in developing countries and emerging economies means a greater contribution to controlling global environmental problems such as climate change. It also increase a country's green power. While emerging economies have more means to access eco-innovations, poorer developing countries face a number of challenges such as a lack of indigenous eco-innovation capabilities. Emerging economies more often succeed in diffusing existing eco-innovations, adapting them locally and later developing their own. This bolsters their green power potential. Third, power shifts within value chains are slowly taking place. While lead firms distributing knowledge are still mostly headquartered in industrialized countries, technological upgrading is taking place in the emerging economies. There is evidence that countries such as China and India are now hosting some lead firms, thus building their own supply chains in the electronic appliances and automotive sectors.

More research is required to find out whether this applies to the green sector as well. If it does, it affects the current and prospective shape of the green economy due to the fact that new standards are being set in emerging economies as well. While technological capabilities, absorptive capacity and the integration into green value chains are central for turning eco-innovation into green power, these factors' effectiveness greatly depends on the political frameworks guiding them. The coherence of environmental, energy and innovation policy is very important for the full exploitation of green power potential. It requires smart governance. Smart governance is also necessary to limit the unintended effects of eco- and climate innovation, such as rebound effects and the green paradox. The debate on what to do about these effects is ongoing, albeit without a consensus. I, therefore exclude the governance of rebounds and other unintended effects from an explicit measurement, simply designing a general category of smart governance.

IV. GREEN POWER AND GREEN POWER POTENTIAL

A country's ability to deal with climate change, to develop renewable energy sources and to secure a share of the global environmental commons is very likely to become a central issue of this century – together with financial crises, economic and security policy. Existing concepts cannot capture what kind of power enables both state and non-state actors to manage green change. This paper's review of the different conceptions of power makes it clear that any kind of conceptualization of green power needs to consist of a variety of features. The "green" in green power targets environmental governance, including energy efficiency and renewable energy. Green power can be understood as:

- multidimensional
- relational
- active or passive
- the share of the global commons a country possesses as well as its ability to make use of this possession in international negotiations and to attract external funding for its protection economically innovative in terms of
- the technological capabilities in green technology and eco-climate innovation
- the degree of integration in green value chains
- the absorptive capacity for environmental innovations
- the ability for smart governance of innovation, environment and energy.

This concept of green power takes both state and non-state actors into account. It thus provides a complex picture of the different parts that make up the power of a country in global environmental governance. Green power is politically and economically multidimensional and includes resources and processes. First, the differentiation between instrumental power, structural power and discursive power is useful for an assessment of the power of global value chains in relation to other actors. For the purposes of this paper, soft power is understood as a type of discursive power. Green instrumental power includes methods of direct influence – for instance, the EU's decision to introduce a carbon tax on aircrafts despite resistance from Chinese, Indian and Northern American airlines. It also includes indirect forms, such as the EU's establishment of a new roadmap and a second commitment period of the Kyoto Protocol. Generally, green

instrumental and discursive power can be applied in the same way as institutional and discursive power is to environmental governance.

Green structural power connects the concept of business power from international political economy with the concept of technological capability found in the innovation literature. It is always composed of the actions of state and nonstate actors, especially companies. The technological capabilities of a country such as the expenditure on R&D and the structure of the local innovation system provide the basis for this. The actions of governments and companies regarding rule setting and governance of innovation, trade and environmental and energy policy complement the picture. Since green power is relational, the context and behaviour of others in each specific sector matters, both nationally and internationally. Markets and political conditions may shift as may technological leadership from company to company or from country to country.

Second, the economically innovative elements of green power provide the connection between innovation, sustainability and conventional power concepts. Their assessment will be particularly interesting in the North–South context because catching up may change the distribution of power in environmental governance. It is likely that the country or company that manages to first develop and/or lead in highly relevant technologies for the green economy will not only gain a significant global market share, but will also increase its global economic and political influence. Third, it would be short sighted to limit green power to the natural resource base of a country and its capacity to make smart use of such power economically and politically. The mere possession of natural resources tends to lead to political difficulties, as a large body of research on the resource-curse debate shows. Moreover, the development of payment systems for ecosystem services and trust funds for protecting the global commons in various countries – such as Brazil, Indonesia and Ecuador suggests an interaction level and power relations beyond simple national power. Still, this dimension is a necessary part of green power. Fourth, a country's ability to execute smart governance of its environment, energy and innovation so that steering mechanisms and incentive schemes do not contradict each other and measures are actually implemented is important.

In general, green power can be active or passive. It is active when a country or its companies actively use their abilities to influence a situation or promote and protect their innovations. This includes the creation of possibilities for action in line with its own interest. Green power is passive when these capabilities are not used or when a country abstains from acting or deciding on certain processes. This difference is captured in the notions of green power and green power potential. Green power potential captures what a country could actually do if it chose to mobilize all resources, foster innovation and take environmental decisions. Green power captures what is actually being done.

The green power concept captures the ability to induce and shape change in environmental governance through a comprehensive, interdisciplinary approach that also transcends governance levels. This is a clear advantage. Moreover, the concept will show who currently has the power for a green transformation, who has the potential and what capacities, abilities and processes this draws on. Finally, it allows for case sensitive but comparative research using both quantitative and qualitative data, as shows the next section.

V. GREEN POWER DISTRIBUTION IN CURRENT GLOBAL ENVIRONMENTAL GOVERNANCE

Given the high amount of international attention to the topic, the international climate negotiations are a suitable example for assessing the distribution of instrumental, structural and discursive green power. In a first step, this focus helps to identify relevant actors, while not categorically excluding countries inactive in the negotiations from further analysis. In a second step, these countries' green power is compared to their green power outside the negotiations, focusing on the fields of clean technology and renewable energy. The resulting picture gives a differentiated, balanced take on green power. Ample literature exists on the role of specific countries, negotiation strategies and the various factors determining unsuccessful bargaining in the international climate negotiations. The analysis of the international climate negotiations draws on policy documents of the respective countries, negotiation documents and the Earth Negotiations Bulletin for various years.

It indicates that the distribution of instrumental, structural and discursive power has changed in the last few years. For instance, in line with their share of global emissions, China, India and Indonesia now have structural veto power. This means that without their participation, a global climate deal is virtually ineffective. Consequently, the industrialized countries, particularly the US and those in the EU, are no longer the only countries with structural power. The exit of Canada, Russia, New Zealand and Japan – and possibly Belarus, Ukraine and Kazakhstan – from the Kyoto Protocol has two sides to it. Brazil's and Indonesia's structural power differs somewhat from the others because it focuses on reducing emissions from deforestation and forest degradation (REDD) and preserving the rainforests.

China and the US are in a negative balance of power in the international climate negotiations. They both have a lot of green power potential in all three dimensions, but do not use it for fear of taking a substantial first step before the other does. For the US, domestic veto players further restrain any proactive behaviour at the international level. This passive green power of both countries restricts the scope of climate negotiations. However, both actively use their green power outside the negotiations through; for example, tariff setting on solar energy components and expanding their technological capabilities. Regarding discursive power, some additional players are active in the international climate negotiations. The least developed countries (LDCs) and small island states (AOSIS) have a certain moral-discursive power as they will be hit hardest by climate change. While this led to a sense of responsibility and financial support by some industrialized countries, the framing of international equity has not turned into substantial financial commitment by all industrialized countries yet. In Doha, only the EU, Germany, France, UK, Denmark and Sweden announced concrete financial pledges up to 2015.

In relation to India, China has more discursive power, even though it did not use it in Doha. At the beginning of the Durban conference in 2011, China already cautiously signalled its participation in a post-2020 climate treaty, while India refused. India's power in the international climate negotiations is rather passive and comes about through blocking (except in the realm of technology transfer), thus setting it apart from the other three BASIC countries (an alliance consisting of Brazil, South Africa, India and China). In the climate negotiations, South Africa's power is generally smaller than the power of the other BASIC countries, but greater in relation to its region. This greater power related to its region primarily comes from the discursive dimension, as the country managed to foster transparency and participation of the LDCs and civil society organizations in Durban 2011.
The majority of the instrumental, structural and discursive green power in the international negotiations lies with a small number of industrialized countries and emerging economies. The power distribution in the climate negotiations is also relational as a whole if compared to climate governance initiatives, clean technology markets and other international bodies. Since the UNFCC needs to be seen as a body with only limited power in relation to other international institutions, the power exerted is hampered by the restricted ability of enforcement. It is now necessary to analyze the active and passive green power of these different countries in the other dimensions.

VI. GREEN POWER AT THE NEXUS OF CLIMATE GOVERNANCE, CLEAN TECHNOLOGY AND RENEWABLE ENERGY

This section analyzes the distribution of green power in global environmental governance according to a country's share of the global commons, GDP, technological capabilities and ability for smart governance according to the Environmental Performance Index (EPI). This analysis will be connected to and extend the above assessment of the distribution of instrumental, structural and discursive power. Relevant development concerning other indicators of green power will be highlighted in order to put the present results into a broader perspective, if possible. Table 1 depicts the share of the global commons of those factors identified as central to the international climate negotiations and/or relevant in at least one of the other green power dimensions. Since this paper focuses on clean technology, renewable energy and climate governance, the share in global biodiversity and marine life are excluded. The table confirms the green power of the US and Germany in terms of both their relevance for the global climate (amount of CO2 emissions both in total and per capita) and forest protection. This strengthens their position in global climate governance, both within and outside of the climate negotiations.

The four BASIC countries also have green power in both areas, but slight differences exist. While China emits the most carbon emissions globally, it is also the only country among the emerging economies to have achieved some significant progress in forestation. Brazil's total carbon emissions are lower, which has slightly reduced the pressure to act compared to China and India. However, Brazil's vast amount of rainforest and its high deforestation rate has seen the country become the focus of REDD activities and other sustainable forest management actions. The same situation also applies to Indonesia. Both countries thus have significant green power potential in this field.

Table 1: Share of Global Commons in 2010

Countries	CO2 emissions (in million tons)	Forest Area (1000 ha)	Deforestation rate (% annual change 2005-2010)
United States	5368.6	304022	+0.13
China	7258.5	206861	+1.39
EU	659.5	156865	+1.20
Germany	761.6	11076	+0.78
Norway	39.2	10065	+0.21
India	1625.8	68434	-0.42
Brazil	387.7	519522	0
South Africa	346.8	9241	-0.71
Indonesia	410.9	94432	+0.04
Japan	1143.1	24979	-0.11
South Korea	563.1	6222	+0.90

Source: International Energy Agency 2012, World Bank 2012

The instrumental power of Germany in the climate negotiations is further strengthened by their general economic power, indicated by the global GDP rank (Table 2). The US, China, Japan and the other emerging economies also benefit from their economic strength in global climate governance, particularly in the clean technology and renewable energy markets. While GDP serves as one of the indicators for instrumental power, the EPI presents one possibility to assess a country's ability for smart governance. It measures how close countries are to attaining their own established environmental policy goals in 10 policy categories relevant to environmental stresses to human health and ecosystem vitality. The EPI uses 22 indicators that are weighted, aggregated and then compared to the respective policy goal taken from national regulations and international treaties.4 In 2012, the top five performers were Switzerland, Latvia, Norway, Luxembourg and Costa Rica. Since attaining environmental policy goals is a prerequisite for smart governance of the environment, energy and innovation, it is one of the two indicators for smart governance in this paper.
Table 2 clearly shows that those countries with the most green power in the dimensions analyzed this far do not automatically have the best preconditions for smart governance. Of the industrialized countries of interest to this paper, only Norway and Germany benefit from a very strong performance. Of the BASIC countries, only Brazil counts as a strong performer;
China, India and South Africa all perform weakly. This weakens their green power in this dimension and simultaneously undermines it in the other dimensions.

Table 2: Gross Domestic Product and Environmental Performance

Countries	GDP-PPP Rank 2010	EPI Rank 2012
United states	1	49
China	2	116
Japan	3	23
India	4	125
Germany	5	11
Brazil	9	30
South Korea	13	43
Indonesia	16	74
South Africa	24	128
Norway	42	3

Source: World Bank 2011, Environmental Performance Index 2012

Concerning technological capabilities, the patents granted for environmental technology by the World Intellectual Property Organization show a clear lead by Japan, the US and South Korea, followed by Germany and China. China is the only emerging economy among the top 20 (apart from Russia), which underlines the general increase of its power in global environmental governance in this green power dimension as well. However, the dominance of European and developed Asian countries along with the US also applies to the trend of patent granting in environmental technologies over time. It supports the active green power of these countries' governments and their companies in the global market. In spite of this seemingly dominant role of the industrialized countries, some developing countries are clearly expanding their green power potential in specific sectors. Chinese and Indian companies, for example, have some technological business power in wind energy. This indicates an increase of the structural power of Indian and Chinese companies in these areas and a simultaneous decrease of European companies' and US companies' power.

We can draw some conclusions from these indicators. First, even though not all dimensions could be measured in depth here, the assessment shows that no country has yet managed to exert green power in all dimensions and/or use its full potential. Second, the US and some industrialized Asian countries, such as Japan and South Korea currently still have more green power than other countries. Germany, for example, has high technological capabilities in environmental technology and is highly integrated into global green value chains. However, these industrialized countries do not fully use their green power potential and their advantage is not as great as could be expected. Third, the emerging economies have almost reached a comparable level of green power in some fields. China in particular and, to a lesser extent, India and Brazil are catching up in some areas of climate governance, clean technology and renewable energy. Both the active power and the green potential between China and the other emerging economies differ quite strongly, as it does between the emerging economies and other developing countries. Follow-up studies are needed for a range of other developing countries and emerging economies that are showing first signs of domestic eco-innovation or are beginning to enhance their green power through more investments in clean technology.

In terms of the theoretical implications of these results, two points need to be made: First, even though discursive power is regarded as the highest form of power by Lukes (1974, 2005) and others, it looks as if it needs to be backed by significant green power in more than one of the other dimensions to be effective. It is also possible that discursive power for green change is even subordinate to instrumental and structural power. This would suggest that green power works differently to conventional political or economic power. Second, green power and the differentiation between its active and passive forms have proven to be a valuable multidimensional and multilevel concept that looks beyond pure political science. It enables the identification of

those factors that are likely to successfully manage a green transformation regardless of their global relevance in other policy fields. Moreover, the green power concept assesses their respective strengths and weaknesses in a way that facilitates theory building. Methodologically, it offers enough flexibility so that it can be adapted to specific research questions and cases, but enough comparability to allow for mid level generalizations. Additional research targeting the interplay of different dimensions and factors is required.

VII. CONCLUSION

This paper introduced a concept of green power and argued that it is central for the transformation toward any kind of green economy. As environmental issues slowly move from low politics to high politics, green power is likely to become a relevant factor for the general distribution of power in the international system. The concept of green power combines a political science perspective on power along the dimensions of instrumental, structural and discursive power with a multidimensional view of economics and environmental innovation capacities. The differentiation between active and passive green power allows for an assessment of a country's potential on the basis of its resources, capacities and actual use of power.

A first assessment of the current distribution of green power has shown that countries of the global South – particularly China and India, and to a lesser extent Brazil are catching up in certain fields such as clean technology and renewable energy. In this conceptualization of green power, small countries like Costa Rica and Ecuador emerge as relevant future actors that are otherwise easily overlooked. The US, the EU and Germany still dominate, but they are not fully using their green power potential either. The green power potential of the LDCs is relatively small as their green power is concentrated in the discursive dimension. Although the literature expects this to be one of the highest forms of power available, it seems to be subordinate to instrumental and structural power. Alternatively, a critical level of green power in more than one other green power dimension (e.g., technological capabilities or smart governance of innovation, energy and environment) may be required to render discursive power effective for change. More in depth research that targets all green power dimensions and expands the number of analyzed cases is required. Currently, a power shift that will allow the LDCs to leapfrog toward a green economy is largely unlikely.

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