Realising long-term transitions towards low carbon societies: impulses from the 8th Annual Meeting of the International Research Network for Low Carbon Societies

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Realising long-term transitions towards low carbon societies

Impulses from the 8th Annual Meeting of the International Research Network for Low Carbon Societies

Wuppertal Spezial 53

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Preface

The International Research Network for Low Carbon Societies (LCS-RNet) is a network of researchers and governments from the G7 tasked to provide contributions to national climate policies. Its basic operational concept is to facilitate international dialogue between science, policy and society on the profound, broad-based transition of social systems to reduce GHG emissions and, by doing so, stabilise the climate.

The 8th Annual Meeting of the LCS-RNet was held from 6th to 7th September 2016 in Wuppertal, Germany, and was co-hosted by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) and the Wuppertal Institute for Climate, Environment and Energy (WI), with support from Deutsche Forschungsgemeinschaft (DFG) and the Japanese Ministry of the Environment (MOEJ).

This meeting was particularly important in the context of the follow-up to the G7 meeting in Elmau, the Conference of the Parties COP21 in Paris and the preparation of COP22 and the 6th Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC). Specifically, the success of the Paris Agreement has paved the way for a transitional pathway towards complete decarbonisation involving society at large. The international debate has shifted to the question of how to achieve low carbon societies and the work and knowledge of the LCS-RNet has become even more significant in terms of the contribution it can make to achieving this global aim.

While members of the LCS-RNet have provided their expertise for international climate negotiations since the network's establishment in 2008, a particularly significant contribution was the position statement[1] published prior to COP21. In this statement, the LCS-RNet brought together 213 experts and scientists (amongst them 71 authors, chairs and co-chairs of the IPCC working group III, senior development economists and five former ministers) from 47 countries demanding an active climate policy underpinned by strong instruments. The objective was to demonstrate how scientists from various disciplines, sharing diverse cultures and from countries at different development stages, can express common views about the conditions for triggering climate action in the current economic context.

With the remarkable success of COP21 and the achievements of COP22, the world took a significant step forward in terms of "action" for achieving low carbon societies. This was reflected by the discussion, "How to achieve long-term transitions towards full decarbonisation" at this year's annual meeting of the LCS-RNet. Key issues in the discussions were: a) how to tackle any future anticipated non-linearities and disruptive interferences with decarbonisation policies; b) how to match strategies for economic and wealth development with the global investment programme of energy transition, climate mitigation and adaptation; c) how to align these strategies with the overall Sustainable Development Goals,

1 The position statement is downloadable in several languages at http://lcs-rnet.org/lcsrnet_meetings/2015/10/1489

with a focus on cities as well as basic industries as major arenas; and
d) the increasingly important role science has to play in providing well-founded solutions and sound strategies for action.[2]

This publication presents the contents of this year's annual meeting by taking a closer look at specific aspects of each key issue. Most of the speakers have provided short articles summarising the content of their presentations. This conference documentation intends to make the speakers' experiences and ideas available to a broader audience and invite and engage non-participants in discussions about how to achieve long-term transitions towards full decarbonisation.

Acknowledgements

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We would also like to express our special appreciation to BMUB and MOEJ for their generous support of LCS-RNet activities.

We greatly value the support and recommendations provided by governments and LCS-RNet contact points. Particular thanks are due to WI for their strong leadership in planning the meeting and for their hospitality in Wuppertal.

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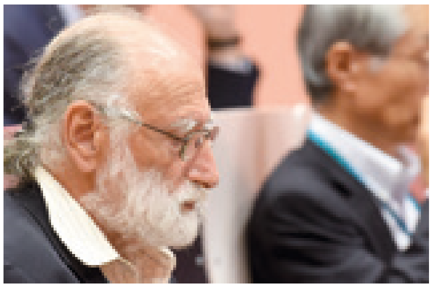

2 Detailed proceedings including summaries and key findings of all sessions and the table of presentations have been compiled in the Synthesis Report of the 8th Annual Meeting, which is available for free download at http://lcs-rnet.org/publications/#lcsrnet_annual_meeting_report.

Table of contents

Editorial: Key issues for the implementation of the Paris Agreement and the long-term transformation towards low carbon societies . . . 6

How to trigger the non-linear transformation towards full decarbonisation? . . . 9

What disruptions are looming in the areas of environment, energy and geo-policy? What strategies could counter them? . . . 10

Governance levels and scientific paradigms for deep decarbonisation pathways . . . 12

Modelling 1.5°C scenarios: scientific challenges and consequences for policymaking . . . 15

Germany's Energiewende as a model for change? Problems, disruptions and policies . . . 20

Energy transitions in Japan - a historical perspective . . . 23

Life cycle thinking for sustainable consumption and production . . . 27

Small-scale energy projects in the global south . . . 30

The German-Japanese Energy Transition Council - a role model for international cooperation on energy transition? . . . 33

How to design economic and climate policy to finance the transition to low carbon economies and respond to today's economic and social challenges? . . . 36

Developing new economic instruments . . . 38

A new deal for Green Growth? Hedging against the risks of 'secular stagnation' . . . 41

Fighting climate systemic risk: from carbon pricing to monetary instruments . . . 45

Financing urban climate action: is the issue really creditworthiness? . . . 48

Climate-related development finance and the Paris Agreement - challenges and opportunities for the work of the OECD Development Assistance Committee . . . 51

How to motivate cities to pursue low carbon and sustainable development? . . . 54

Visions for post-carbon cities . . . 56

The triple dividend of urban resilience transition . . . 61

InnovationCity Ruhr as an example of a transformative approach . . . 65

Improving land use to make cities low carbon and climate-resilient: the Silang-Sta. Rosa subwatershed, the Philippines . . . 69

Deep decarbonisation – the role of industries . . . 74

Industries and companies as non-state actors? . . . 76

Decarbonising Europe's energy-intensive industries . . . 79

Rethinking basic materials production . . . 83

Enabling CO_2 reuse value chains: the importance of geographical conditions . . . 86

Deep decarbonisation in industries: what does it mean for India? . . . 88

Science in the context of the SDGs and climate policy after Paris . . . 92

Science, technology and innovation as means of attaining the Sustainable Development Goals . . . 94

The role of the IPCC in achieving the climate targets and the Sustainable Development Goals . . . 97

Imprint . . . 99

Editorial

Key issues for the imp Paris Agreement and the transformation towa

Despite a growing number of international crises, including civil wars and international conflicts, terrorism, increasing numbers of refugees and a rise of populist movements in many parts of the world, 2016 was also a year of hope with regards to national and international policies to counter climate change. In particular, the rapid adoption of the Paris Agreement and the numerous activities in countries around the globe relating to the implementation of their Intended Nationally Determined Contributions (INDC) have created a strong momentum and increased the focus on action towards creating low carbon societies.

This encouraging emphasis on climate mitigation action is urgent, as the window of opportunity for the globe to remain below the 2°C (or preferably 1.5°C) warming threshold is closing fast. To prevent increasingly dangerous levels of warming, greenhouse gas emissions must not only stabilise but also decline rapidly towards levels close to zero by the middle of the century in all countries of the world. It is, therefore, important that all nations commit now to ambitious targets and are serious about redesigning their economies to become increasingly less carbon-intensive and to set them on track for rapid decarbonisation.

The recent achievements in climate policy clearly highlight the relevance of the Low Carbon Society Research Network (LCS-RNet). The network has, from its foundation in 2008, acted as a forum aimed at fostering research and policymaking to jointly achieve the necessary transformation towards low carbon societies and decarbonised energy systems in both developing and developed countries.

Consequently, this publication documents the range of contributions to the LCS-RNet's 2016 Annual Meeting in Wuppertal, Germany, covering the most relevant strategies and arenas for successfully enabling the transformation towards low carbon societies in countries around the world:

- In line with the tradition of an international network of national scientists and policymakers, the problem of governing the necessary long-term transitions in the context of possible known and unknown adverse developments is discussed in the papers in the first section of this publication. States need to develop their own appropriate strategies by means of scientific tools such as national scenario analyses of energy systems and GHG emissions. The broad application of such tools enables better-informed national discussions and policymaking, as well as the creation of the long-term societal momentum around positive visions necessary for shaping the significant structural changes in most countries. Examples from Germany and Japan, two countries which are already undergoing serious changes in their energy systems, support these findings. Based on the competence of its members, the LCS-RNet is planning to put increased emphasis on facilitating the international exchange of the national planning of transitions, e.g. by supporting the collaboration among the international scientific community working on national energy and emission scenarios.
- Realising long-term fundamental changes in our economies will mean substantially changed investment patterns. Building renewable electricity generation instead of fossil power plants, electric vehicles, low energy buildings and smart cities requires public and private investors, as well as financing institutions, to change their policies. Therefore, the second section of this publication discusses policy instruments and strategies for financing the transition to low carbon economies while, at the same time, responding to today's economic and social challenges, which includes providing employment and income for all.
- The final sections of the report cover three crucial arenas related to the long-term transformation of our societies towards achieving global decarbonisation whilst significantly contributing to the Sustainable Development Goals (SDGs).

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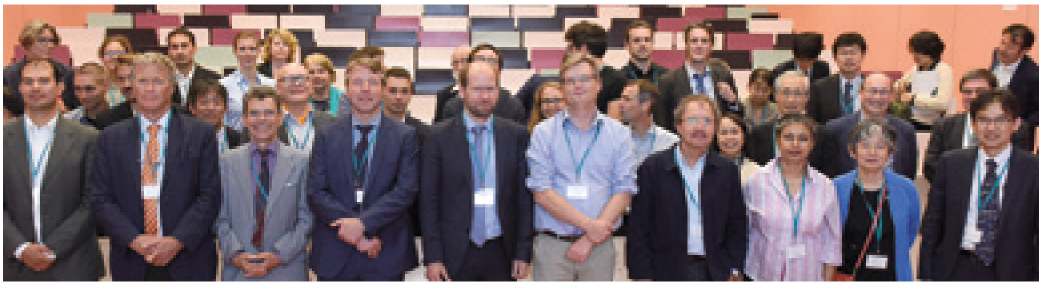

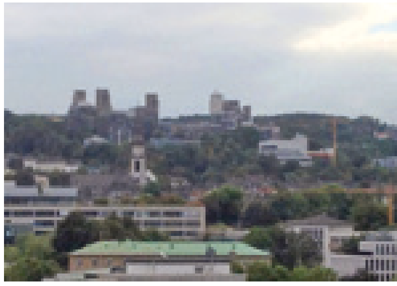

The first arena is cities. Much of the change and necessary investment for low carbon societies must take place, be planned, be financed and be built in cities. At the same time, cities around the globe are witnessing sustainability problems ranging from air pollution to unemployment and challenges in providing adequate housing for their growing numbers of citizens. Therefore, the cities desperately need visions, solutions and the means to leverage investment in low carbon infrastructures that also solve other key sustainability issues. This unique position, encompassing problems as well as solutions, highlights the role of cities not only as places of long-term transformation but also as important non-state actors of climate policy.

The second arena is industry, particularly the energy-intensive processing industries that produce the materials needed to construct the material fabric of our societies. These basic industries are at the core of society's metabolism and are responsible for a large and growing share of global emissions, with material use expected to further increase. However, significant decarbonisation of these industries is particularly difficult as far-reaching innovations are often needed. In addition, many of these industries are protected from climate policy measures by their national governments as they face fierce competition in world markets. Consequently, significant success in reducing their emissions can only be achieved by international cooperation regarding relevant policies. Actors from these and other businesses can also be important as providers and supporters of solutions.

Finally, science itself is an important arena when it comes to long-term transitions towards low carbon societies. As the IPCC has already emphasised in its work, science as a whole must become more solutions-oriented, because the transitions needed will rely heavily on research providing solutions for technological as well as societal problems. To enable science to fulfill the demands made by society, new paradigms may be required to maintain independence and traditional strengths while improving societal relevance.

By delivering insights into cutting edge science applied to achieving the long-term transitions towards low carbon societies, this publication aims to contribute to international as well as national policymaking. The topics discussed here are among the most important issues for progressing solutions for climate change and sustainable development. The necessary transitions will only be achieved by tackling the huge issues of long-term policymaking and the reform of economic policy to direct investment into low carbon societies. At the same time, it will be important to achieve all the Sustainable Development Goals, as well as motivating further actors and capacities from cities, industries and business, as well as from the scientific community.

Climate change will remain an urgent issue for global policies and can only be solved through the joint efforts of national and international policy with the strong support of citizens, NGOs, business and the scientific community. As a contribution to these challenges, the LCS-RNet will continue to bring together science, policy and society within developing and developed countries for the support of long-term transformations towards low carbon societies.

Stefan Lechtenböhmer and Katharina Knoop
(Editors of this Wuppertal Spezial)

How to trigger the transformation towa full decarbonis

The Paris Agreement heralds a new era for the definition and implementation of pathways for deep decarbonisation towards low carbon societies. Success in their implementation will depend on the ability to overcome the challenges of non-linear, disruptive developments which could take myriad forms, from financial crises to the introduction of new technologies for extracting hydrocarbons. The associated implications, e.g. for policymakers and companies, need to be understood and strategies to counter disruptive developments must be developed. The following articles show that the potential options for implementing low carbon pathways and the management of these challenges often rely on the enhanced involvement of non-state actors, including cities, industries and civil society.

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ation?

What disruptions are looming in the areas of environment, energy and geo-policy? What strategies could counter them?

Disruptions that could interfere with a low carbon pathway could take myriad forms, from financial crises to the introduction of new technologies for extracting hydrocarbons. This article presents several unconventional strategies for maintaining the viability of a low carbon pathway despite potential disruptions. The first strategy would endow a supra-authority with the power to impose draconian changes to achieve rapid decarbonisation. The other strategies are "bottom up" approaches and envision various levels of citizen engagement, from private ownership of renewable energies and infrastructure to the payment of national dividends to the creation of small "Carbon Communities" of households or commercial entities, which would profit when their goals are met. If we want to foster commitment to a low carbon pathway, then we should ensure people can directly and tangibly benefit from that pathway.

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Disruptions that could interfere with a low carbon pathway could take myriad forms, ranging from financial crises to the introduction of new technologies for tapping Arctic resources to the rise of national leaders calling for the greater use of domestic hydrocarbons. For example, in his Presidential campaign, Donald Trump vowed to increase coal mining and cancel the Paris Agreement signed by China and the US in September 2016 – this agreement was a rare act of cooperation in a relationship fraught with tension. The heating up of hostilities between these two countries, the world's largest emitters of CO_2, could be an additional diversion.

Disruptions are certain to emerge. The question is, what strategies would maintain the viability of a low carbon pathway in the face of these distractions? The strategies would have to either prevent society wandering off the pathway or make the pathway itself more attractive than any alternatives. The usual approaches for coaxing sustainable behaviour include emphasising the dangers of hydrocarbons and providing consumers with information. This is, however, conventional thinking. The following two approaches are unconventional: they would require a fundamental break with past ways of thinking about how our societies work, and, while their objectives - radical decarbonisation - are the same, they present divergent socio-economic and political implications.

The first approach would be the appointment of a powerful figure (or committee) such as a "Climate Tsar" who would have complete jurisdiction over a policy field and the ability to make sweeping changes, such as the shutting down of coal plants. The installation of a Climate Tsar might be easier in authoritarian systems than in democracies, but even democracies have deployed such figures, such as the Energy Tsar appointed by US President Nixon to deal with the 1970s oil crises. Nixon wanted this figure to have "absolute authority", which the Tsar demonstrated when he implemented fuel rationing during the Arab oil embargo.

As the effects of global warming become more egregious, states might consider the expediency of bypassing democratic procedures. The disadvantages of this approach, however, are manifold and include violating democratic notions of justice and legitimacy. While the Climate Tsar strategy is top-down, the other approach, "Power to the People", is bottom-up and would allow private persons to directly and tangibly benefit from pursuing a low carbon pathway. The Power to the People strategy has three variants: **(1)** citizen ownership of low carbon power generation and transmission; **(2)** national dividends; and **(3)** "Carbon Communities".

1. Citizen ownership. In some countries, citizens are already becoming the owners of solar installations, wind turbines and other forms of renewables. In Denmark, 85% of wind power is privately held. In Germany, about 50% of renewables is owned by citizens and cooperative groups. In contrast, in the US less than 3% of wind and 1.1% of solar is in private hands. Citizen ownership of transmission infrastructure is also underway in Germany, where investors are guaranteed a 5% return. The German government openly admits that the objective of this programme is to garner public acceptance. As other examples of overcoming public opposition have demonstrated, people are more willing to embrace technologies and infrastructure if they directly benefit. If we want to make certain the low carbon course remains a priority and is attractive despite potential disruptions, then one strategy would be to ensure that the population enjoys tangible benefits. Obstacles to the greater ownership of renewables and infrastructure include outdated and cumbersome laws and tax codes; in many countries, these would have to be re-crafted.

2. National dividend. A second variation of Power to the People envisions citizen ownership on a much larger scale, such as paying a national dividend to every citizen if national carbon targets are met. This would include enhancing carbon sinks and decarbonising the energy mix. One problem with this concept, however, is that many people might feel disconnected from the actual achievement of the targets, and there would be the risk of free riding. For example, some citizens might believe the targets would still be achievable even if they personally cheated, such as by using their petrol-fuelled vehicles.

Achieving carbon targets can be construed as a public good that requires collective action. However, as political scientists and economists have long observed, collective action problems are best solved by small groups. Why? Because in small groups, it is easier for people to monitor what others are doing and, if they are not complying, to sanction them. These insights have proven effective in a wide variety of settings, from protesting against military occupation to the preservation of fishing lagoons. In the lagoon example, fishermen know when their neighbours are using the wrong types of nets. How could this approach be used for fostering intense commitment to a low carbon pathway?

3. Carbon communities. In the third variant of the Power to the People strategy, small Carbon Communities would be offered a meaningful payment for meeting their carbon targets; failing to meet the target would incur a fine. To simplify matters, assume that carbon trading with other communities is not allowed; each small group must meet its own targets. As this is unconventional thinking, let us also provide them access to each other's energy data and sink capacity. The community should be small enough to make monitoring feasible; for example, neighbours would easily notice if someone leaves on the lights or cuts down trees.

On a more positive note, monitoring would not have to entail active checking. In addition to direct pressure, merely knowing that you might get caught driving your car could nudge you to take the bus. Such communities would be rewarded for working cooperatively, such as planting trees together, car-sharing and undertaking other activities that enhance the environment and create social capital. OECD residential households contribute roughly 25% to emissions, but industry emits even more, so we could also consider small Carbon Communities of companies or factories.

In all the strategies illustrated above, human nature plays a central role. Due to habit and path dependencies, humans are reluctant to change. However, if change is delayed for too long, then the difficult decisions might be taken by supra-authorities such as Climate Tsars. As the effects of global warming become more obvious, we may see this happening around the world. By adopting the Climate Tsar approach, societies would be forced to remain on the low carbon course despite potential disruptions. However, the Power to the People strategies could ensure the determination of societies to stay on the low carbon pathway because they would take ownership and be direct beneficiaries.

Governance levels and scientific paradigms for deep decarbonisation pathways

Since the climate issue has become prominent on the political and scientific agenda, research on low carbon scenarios and policies have developed along different lines. These can be differentiated according to the level of governance they explore (global, regional, national or subnational) and the research paradigm on which they rely (based on models, on policy scenarios or on sectoral and urban studies). The Paris Agreement heralds a new era for the definition and implementation of deep decarbonisation pathways. Success in their implementation will depend on the ability of policymakers and scientists to navigate in an effective manner across these four levels of governance and three research paradigms.

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Introduction

The Paris Agreement is a first step in the implementation of a multi-level governance of the climate challenge. As a universal agreement it involves all Parties to the UNFCCC; as it is based on Nationally Determined Contributions it supposes the implementation of consistent national decarbonisation strategies; and, finally, as an open structure it allows for the role of non-state actors, such as communities and industrial companies. Different scientific approaches or paradigms enable light to be shed on the strategies that can foster the development of low carbon societies: economic models explore the cost-effectiveness dimension; national scenarios take account of local conditions and acceptability constraints; and sectoral or urban studies explore the technical details at community or industry level. While success in the energy transition requires the ability to navigate along these governance levels and research paradigms, we briefly analyse below some insights from the different approaches.

Global modelling of low carbon scenarios

For nearly quarter of a century – since the beginning of the 1990s – the energy modelling community has focused on the issue of climate policies while developing quantified low carbon energy scenarios. Structured in different networks, such as the Energy Modeling Forum or the International Energy Workshop, this community has, over time, developed different models belonging to the Integrated Assessment Models family.

Four governance scales x three research paradigms

	IAMs - Integrated Assessment Models	NATIONAL DECARBONISATION SCENARIOS	SECTORAL & URBAN TRANSITION STUDIES
GLOBAL/ INTERNATIONAL	• IPCC • IAMC • AMPERE/ADVANCE • GECO 2015...	Deep Decarbonization Pathways Studies 2014 & 2015	• New Climate Economy Reports 2014 & 2015 • Low Carbon Technology Partnership (WBCSD)
REGIONAL/ EUROPEAN LEVEL	• 2030 EU INDC • 2050 Energy Roadmaps ...	?	?
NATIONAL	• National E3 MODELS • MARKAL-TIMES	Trajectories of Energy Transition, e.g. Energiewende in G., National Debate in Fr.	?
SUB-NATIONAL / COMMUNITY	?	?	• McKinsey MACCs • LUTI models (TRANUS, NEDUM) ...

Fig. 1: Differentiation of deep decarbonisation pathways according to the level of governance they explore and the research paradigm on which they rely - Source: Own figure

The insights from these models have been widely used in the work of the IPCC's Working Group 3 "Mitigation" in its various reports. The models themselves are often used by international organisations to build their climate and energy policies.

Beyond the methodological and algorithmic differences, all these models are based on the same principle, i.e. the search for economic solutions to the fight against climate change. The term "economic" should be taken here to imply a cost-benefit or cost-effectiveness approach to the problem. The cost-benefit approach is based on determining the optimal level of global emissions. The cost-effectiveness approach assumes that (a) the objective is given exogenously by a political power informed by climate science and (b) the task of economists is to indicate how to respond to cost. The second approach has gradually become dominant because it is the one that best meets the needs of dialogue with other scientific communities, notably climatologists.

While recognising the caution that must accompany the foresights, modelling exercises on energy and climate can build rational visions of the future. They respect the consistency of energy balances by region and the global supply and demand balance, based on considering the drivers and constraints currently identified. Three strong conclusions can be drawn. The first is that the world is not threatened by a global energy shortage, at least not in the foreseeable future. In the words of Pierre-Noël Giraud: "for energy, we do not have a resource problem, but a garbage problem [to store the waste that is CO_2]." The second is that there is a huge gulf between the BaU scenarios and the Carbon Constraint scenarios: the future will depend on which policies are implemented. The third is that these contrasting worlds correspond to very different geopolitical, technological and industrial settings.

National "deep decarbonisation pathways"

The dividing lines in the struggle against climate change can indeed be identified by global models. Does this indicate "mission accomplished" for energy economists? Certainly not, as the hardest task is the implementation of the decarbonisation strategies within the actual systems. The Paris Agreement neatly marks the entry into this new era as this implementation commences. It should also be recognised that the construction of national policies cannot rely exclusively on a comprehensive economic approach. This is because the decarbonisation pathways depend on the national conditions, constraints and opportunities as they are perceived by people and governments - not simply as they are described in the models. By way of example, compare the diverse energy transition plans in France and Germany, two countries which, back in the 1990s, had similar energy systems.

Following certain national initiatives, such as the French Debate on energy transition in 2013, several research networks prepared the ground for the construction of national scenarios in preparation for the Paris conference. In particular, the Deep Decarbonization Pathways Project (DDPP) facilitated local teams to prepare scenarios for the 16 most emitting countries, representing three-quarters of global energy emissions. The aim of this exercise was to enable the main parties in the negotiation to have acceptable images of their own future in a decarbonised world. This study provided a sound basis for the analysis of the main "decarbonisation wedges" to be accomplished by 2050.

The results identify a common triptych that is strategic for all countries. Deep decarbonisation requires (1) the maximisation of energy efficiency in key sectors (building, transport, industry); (2) the decarbonisation of the electricity system by mobilising renewable energy and, where necessary and possible, nuclear energy and the capture and storage of CO_2 in power plants; and (3) the penetration in all sectors of low carbon energy sources, particularly electricity in transportation. However, despite these common foundations, the study also identifies very different trajectories and options across sectors and countries, illustrating the diversity in national conditions.

Decarbonising industries and cities

The inclusion of non-state actors in the Paris Agreement reflects the rising importance of industries and cities in climate policies. For a long time, different industries have launched various projects with the aim of lowering their emissions. While the New Climate Economy Report explores the economic consequences and the opportunities created by the climate transition, the World Business Council for Sustainable Development has prepared, in view of COP21, its Low Carbon Technology Partnership Initiative, with a set of nine industrial monographs. However, the most promising perspectives could be enlightened by more systemic approaches, such as the Fourth Industrial Revolution explored by the World Economic Forum, which provides elements for an innovation-based Schumpeterian framework for climate transition.

Similarly, as far as cities and communities are concerned, many innovations have still to be explored. Most of these innovations will probably have to be simultaneously technological, societal and institutional. From zero-energy buildings to smart transport systems and low carbon cities, the range of possible futures is wide open. Innovation in these areas will require new technologies, but also new citizen/consumer behaviours, new actors and business models, and new institutions and public regulations. Even if many systems and components develop on a global scale, it is nevertheless probable that different models of the sustainable low carbon city will coexist in the future, according to local physical and political conditions. In a “try fast, learn fast” strategy, the initial diversity of solutions will probably enhance the probability of success.

Conclusion

Despite the useful beacons provided by forecasting models, the road to low carbon societies remains highly uncertain because success will depend more on the ability to combine different types of knowledge and innovation capacities than on deploying miracle technological solutions. This implies, firstly, multidisciplinary approaches to energy and climate transitions and, secondly, a high level of interaction between scientists, engineers and all categories of stakeholders.

References

Alazard-Toux, N.; Criqui, P.; Devezeaux de Lavergne, J. (2015): Decarbonization Wedges Report. http://www.allianceenergie.fr/Etudes-et-rapports.aspx

C40 Cities (2016): C40 Cities - Global Leadership on Climate Change. http://www.c40.org/

DDPP (n.d.).: Deep Decarbonization Pathways Project. http://deepdecarbonization.org/

ICLEI (n.d.).: ICLEI: Local Governments for Sustainability. http://www.iclei.org/

IEW (n.d.).: International Energy Workshop. http://internationalenergyworkshop.org/

IPCC (2014): Climate Change 2014: Mitigation of Climate Change. Working Group III Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK and New York, NY, USA. http://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_full.pdf

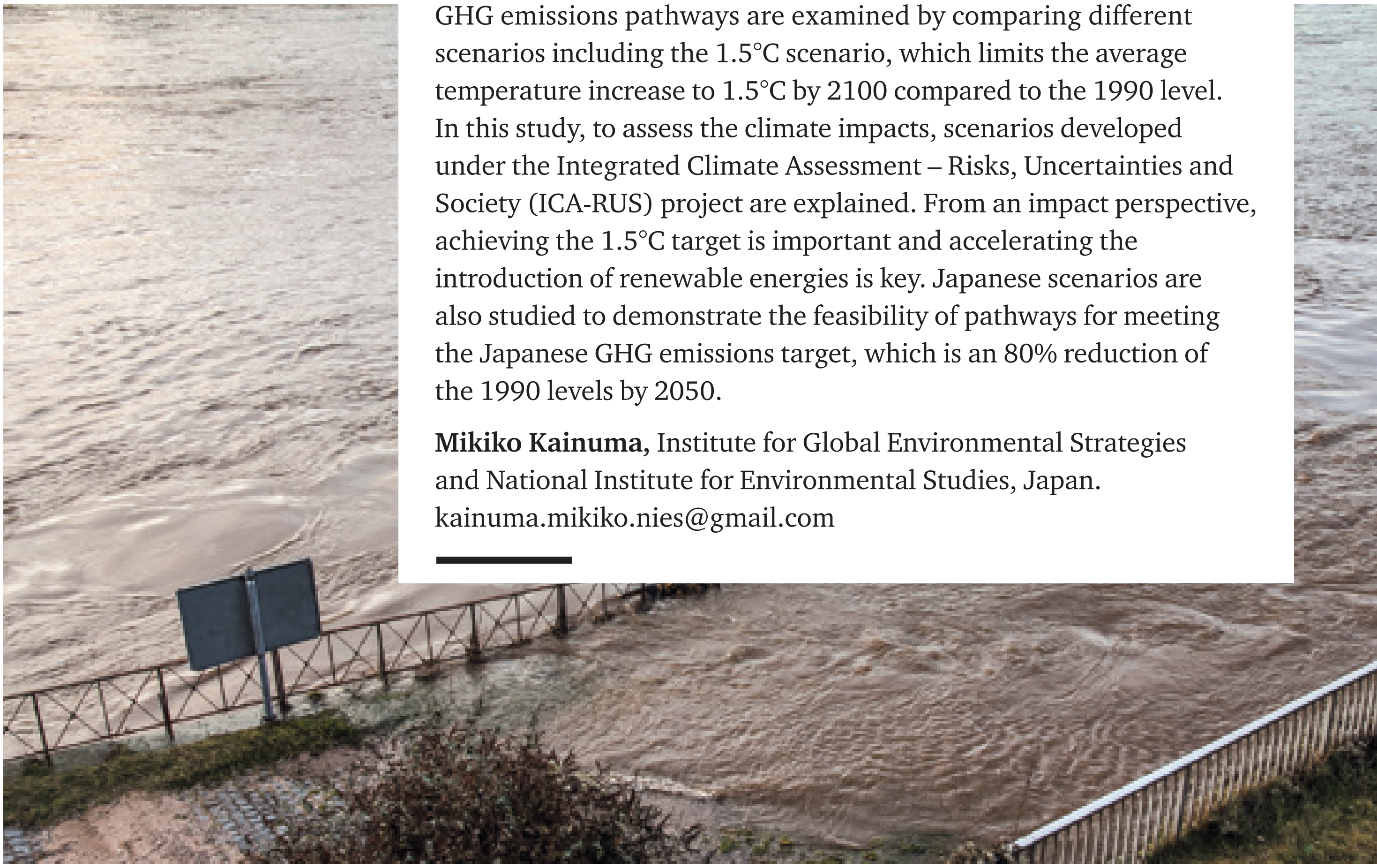
New Climate Economy (n.d.).: New Climate Economy: Commission on the Economy and Climate. http://newclimateeconomy.net/

Stanford University (2016): Energy Modeling Forum. https://emf.stanford.edu/

WBCSD (n.d.).: Low Carbon Technology Partnerships Initiative. World Business Council for Sustainable Development. http://lctpi.wbcsd.org/

World Economic Forum (n.d.).: Agenda in Focus: The Fourth Industrial Revolution. http://weforum.org/focus/the-fourth-industrial-revolution

Modelling 1.5°C scenarios: scientific challenges and consequences for policymaking



GHG emissions pathways are examined by comparing different scenarios including the 1.5°C scenario, which limits the average temperature increase to 1.5°C by 2100 compared to the 1990 level. In this study, to assess the climate impacts, scenarios developed under the Integrated Climate Assessment – Risks, Uncertainties and Society (ICA-RUS) project are explained. From an impact perspective, achieving the 1.5°C target is important and accelerating the introduction of renewable energies is key. Japanese scenarios are also studied to demonstrate the feasibility of pathways for meeting the Japanese GHG emissions target, which is an 80% reduction of the 1990 levels by 2050.

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Introduction

Governments agreed at COP21 to limit the increase in the global average temperature to well below 2°C and pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels (UNFCCC, 2015). 162 countries submitted Intended Nationally Determined Contributions (INDCs) by 25 April 2016, which will make a substantial contribution to shaping the GHG emissions pathways. However, the current INDCs are inadequate for limiting global warming to below 2°C /1.5°C and for avoiding serious climate impacts.

It was also agreed that the INDCs would be reviewed to assess their overall impact on stemming the rise of global temperature. Based on such reviews, countries are expected to strengthen their intentions to reduce GHG emissions and to submit new INDCs every five years to meet the global 2°C /1.5°C goal.

Taking measures to drastically reduce GHG emissions needs considerable effort from different aspects. Scenarios can provide alternative GHG emissions pathways and model their impacts over a long period of time in the future, which provide useful information for policymakers. Such scientific outputs could support countries in making their intended contributions even more ambitious.

In this study, GHG emissions pathways are examined by comparing different scenarios including the 1.5°C scenario, which limits the average temperature

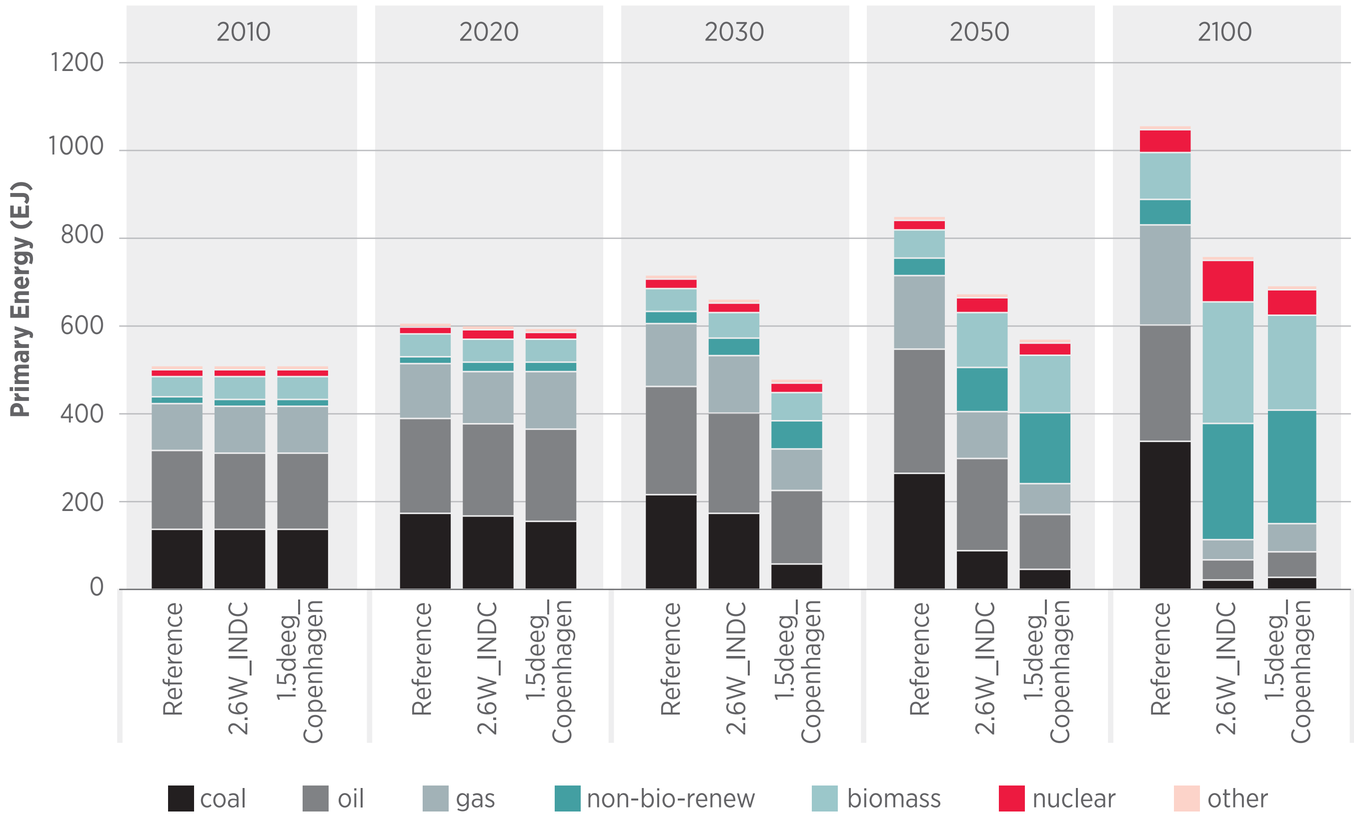


Fig. 1: Global primary energy consumption under different scenarios - Source: Own figure based on (Fujimori and Masui 2015)

increase to 1.5°C by 2100 compared to the 1990 level. In order to assess the climate impacts, scenarios developed under the Integrated Climate Assessment–Risks, Uncertainties and Society (ICA-RUS) project are explained. Japanese scenarios are also studied to demonstrate the feasibility of pathways for meeting the Japanese GHG emissions target, which is an 80% reduction of the 1990 levels by 2050.

Assessing GHG emissions for 1.5°C pathways

The AIM/Global [CGE] model is used to assess a 1.5°C pathway (Fujimori and Masui 2015). In addition to the 1.5°C scenario, which encompasses the Copenhagen emissions pledges in 2010 and mitigation policies to meet the 1.5°C target, four other scenarios have been developed to analyse different energy mixes and economic impacts. The Shared Socio-economic Scenario 2 (SSP2) is used as a reference scenario. The SSPs are part of a new scenario framework, established by the climate change research community to facilitate the integrated analysis of future climate impacts, vulnerabilities, adaptation and mitigation (Riahi et al. 2016).

The world moves towards using an increased share of renewables under the 1.5°C scenario. As the availability of renewables in 2030 is limited, the amount of primary energy consumption in 2030 in the 1.5°C scenario becomes much lower than that in the 2.6W_INDC scenario (INDCs in 2030 and 2.6W/m^2 in 2100) because of CO_2 constraint (**Figure 1**).

The amount of primary energy consumption in 2100 in the 1.5°C scenario is 65% of that in the reference scenario. This is due to energy efficiency improvements and the availability of renewables. CO_2 constraint may cause a decrease in primary energy consumption around 2030.

Although the 1.5°C scenario may cause a decrease in GDP compared to the reference scenario, absolute GDP will increase. Global GDP in 2100 in the reference, 2.6W_INDC and 1.5°C scenarios will be 6.15%, 5.89% and 5.70% more than in 2010, respectively. Compared to the reference scenario, global GDP in 2100 will be 4.2% lower in the 2.6W_INDC scenario and 7.5% lower in the 1.5°C scenario. As the GDP estimate does not take the economic impacts of climate change into account, GDP in the 1.5°C scenario could be higher in 2100 than in the reference scenario.

Impact analysis under several scenarios

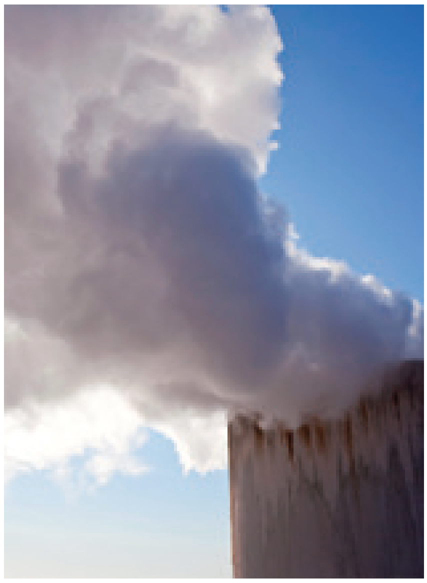
Scenarios under the ICA - RUS (Integrated Climate Assessment – Risks, Uncertainties and Society) project propose strategies for global climate risk management. From a long-term perspective, the construction of rational strategies for dealing with uncertain climate risks is needed. Six management strategies are examined in the report by assessing the impacts of climate change under different scenarios (ICA-RUS 2015).

Figure 2 shows the percentage change in economic assets exposed to flooding. The impact on assets exposed to flooding in Asia is the highest in all scenarios.

GHG emission mitigation efforts lower the impacts, especially in the T15S30 scenario which aims to stay below 1.5°C in 2100.

Japanese low carbon scenarios

The Japanese emissions pathways toward 2050 have been assessed using the AIM/Enduse model. Scenario analysis suggests that by 2030 implementation of the INDCs could have consolidated the transition from the baseline trajectory, mainly derived from improvements in energy efficiency and the decarbonisation of electricity. Even if nuclear power is constrained or totally phased-out by 2030, the 2030 target would be technically feasible if the additional deployment of renewable energies can be achieved. However, as these pathways require a rise in carbon prices to more than 160 US$/t-$CO_2$, effective policy supporting mechanisms would be needed. In the long term, the pathways which meet both the 2030 and 2050 targets also appear technically feasible, although additional efforts beyond the 2030 target would be required. Moreover, these pathways require the rapid and huge transformation of the energy system after 2030, including the large-scale deployment of variable renewable energies, carbon capture and storage, the improvement of energy efficiency and electrification (**Figure 3**). Early actions and policies before 2030, in-



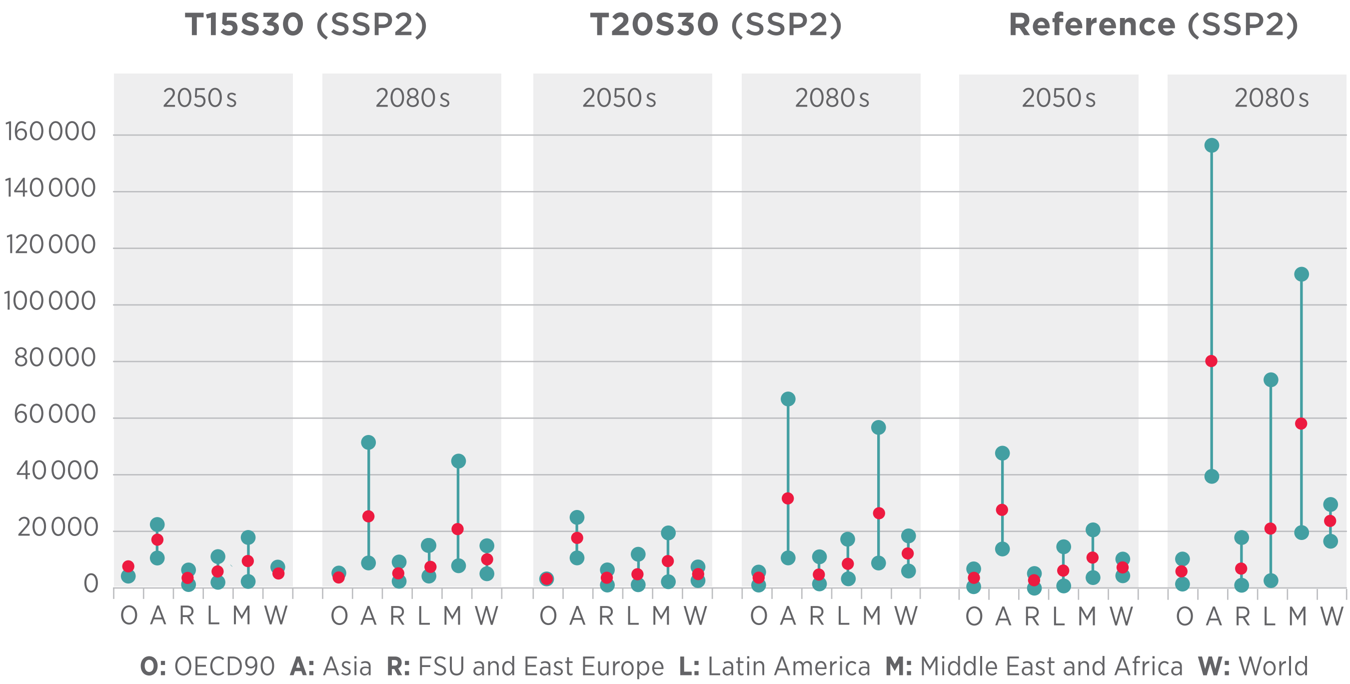


Fig. 2: Percentage change in economic assets exposed to flooding (2050 & 2080) - Source: (ICA-RUS 2015)

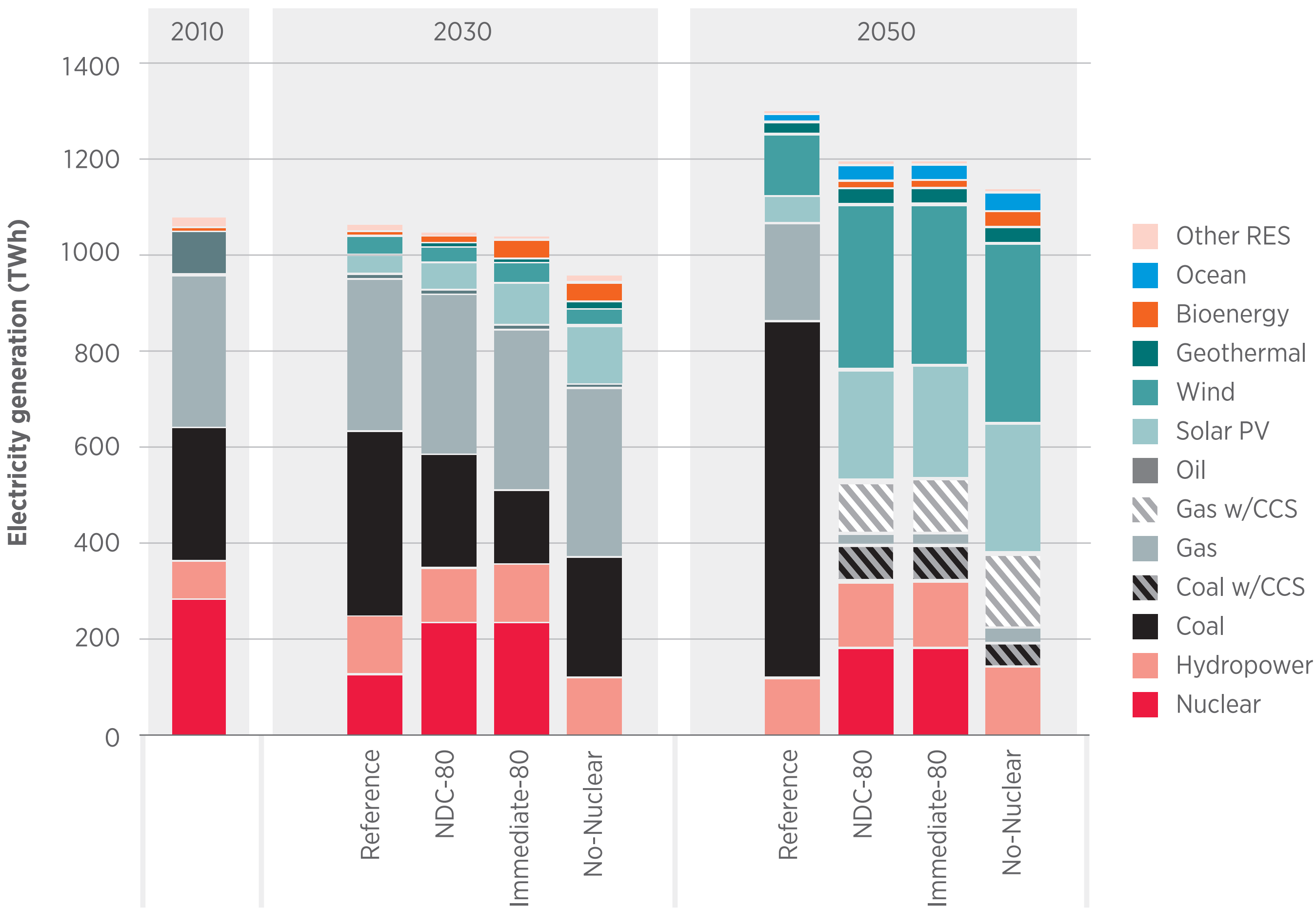


Fig. 3: Electricity generation in 2010, 2030 and 2050 in Japan - Source: (Oshiro 2016)

cluding RD&D of innovative technologies and development of the market, would be crucial for making these options commercially available.

Challenges to achieving the 1.5°C target

While the implementation of the INDCs is a meaningful step towards reducing global GHG emissions by 2030, in isolation this will not lead to further GHG cuts. To meet either the 1.5°C or the 2°C target, the INDCs would have to be revised and additional long-term countermeasures implemented. Therefore, the transition towards a low carbon society demands greater and early efforts designed and implemented in a concerted and consistent manner.

Below is a list of actions which must be urgently addressed.

- Radical international agreements and monitoring mechanisms under the UNFCCC

To ensure the implementation and verification of the INDCs, countries need to set up processes within their own legal systems and gather reliable, transparent data. Accelerated negotiations are required to reach agreements on unresolved issues, such as compelling countries to commit to drastic emission reduction targets and designing and implementing more ambitious policies that meet the expectations of low carbon societies.

- Strong policy push, legal framework and financial incentives to ramp up investment in low carbon technology

Direct governmental support for low carbon technology R&D is required to meet the energy demand for renewables by 2030. Otherwise, energy supply would have to be lowered in the 1.5°C scenario, which may cause a decrease in GDP. While investment in low carbon systems must be boosted through strong incentives, investment in high carbon systems must be disincentivised and legally challenged.

- Establishment and scale-up of low carbon infrastructures

Low carbon infrastructures, such as public and efficient transportation systems for both long-distance and intra-city movements, facilities networks for EV charging and the supply of other low carbon energy carriers, logistical chains for the procurement and supply of equipment and spares for low carbon technologies, smart grid systems and systems for recycling and sustainable waste management, need to be urgently established. This should enable most people to access such energies, technologies and systems at low marginal costs.

- Networks to spread local and city level decarbonisation through local governments and leaders

The world's cities account for 70% of global energy demand. Initiatives such as C40, WMCCC and ICLEI have demonstrated that networks and actions involving local government

leaders and civil society organisations have made commitments to implement low carbon policies. Developing such networks can result in faster mitigation implementation at local levels.

- Inter-disciplinary climate modelling and research to estimate real costs and benefits

Science-based policy is crucial for promoting the transition toward low carbon societies. Although many climate studies have warned about serious and irreversible impacts, current policies cannot meet the targets required to prevent serious climate impacts. More research is required to link the scientific and policymaking communities. Interdisciplinary climate research, which combines natural sciences and engineering with economics and other social sciences, would help to emphasise the costs and benefits, and thereby communicate both the urgency and the desirability of reducing GHG emissions.

References

Fujimori, S.; Masui, T. (2015): Assessment of INDCs using AIM/CGE [Global]. Presented at the 21th AIM International Workshop, Tsukuba, Japan.
http://www-iam.nies.go.jp/aim/aim_workshop/aimws_21/presentation/s08_04_masui.pdf

ICA-RUS (2015): Alternatives Left to Humanity Faced with Global Climate Risks (Ver.1).
Project report 2015, S-10 strategic research project. ICA-RUS project.

Oshiro, K. (2016): Assessment of Japan's NDC and long-term goal: Contributions of Asia-Pacific Integrated Model (AIM).
Presented at the Japan-India Policy Research Workshop, India Habitat Centre, New Delhi, India.
http://www.iges.or.jp/files/research/climate-energy/PDF/20160830/2.pdf

Riahi, K.; van Vuuren, D. P.; Kriegler, E.; Edmonds, J.; O'Neill, B. C.; Fujimori, S.; et al. (2016):
The shared socioeconomic pathways and their energy, land use, and greenhouse gas emissions implications:
an overview. Global Environmental Change (in press).
doi: 10.1016/j.gloenvcha.2016.05.009.

Takahashi, K. (2015): Assessment of Global Climate Risk Management Strategies: Introduction to the interim research report of the ICA-RUS project. Presented at the 21th AIM International Workshop, Tsukuba, Japan.
http://www-iam.nies.go.jp/aim/aim_workshop/aimws_21/presentation/s03_03_takahashi.pdf

UNFCCC (2015): Adoption of the Paris Agreement. FCCC/CP/2015/L.9/Rev.1. Paris: United Nations Framework Convention on Climate Change.
http://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf

Germany's Energiewende as a model for change? Problems, disruptions and policies[1]

The crucial mid-point of the German Energiewende has been reached: after academics from the Öko-Institut formulated the concept during the 1980s, in September 2010 the Energiewende became the government's official energy target for 2050. The Energiewende initially provoked a fierce debate about nuclear energy, which will now be phased out irrevocably by 2020. There remain, however, significant problems to resolve, such as adherence to the ambitious climate change objectives, the socially acceptable phase-out of coal-fired power, the implementation of the Energiewende in the transport and building sectors, as well as the issue of how to fairly share the initial higher costs and the pre-financing of the Energiewende.

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Introduction

The German Energiewende is embedded in two global mega trends: the new global focus on energy efficiency as "Efficiency First" (IEA) and the remarkable decreasing trend in the cost of electricity generation from wind and PV sources. The consequent combination of the fostering of energy efficiency and the acceleration of the market introduction of renewable electricity generation will increase the possibility of global energy transition becoming both technically and economically feasible. Successful national examples and international cooperation could act as a launching pad for this outcome.

"Revolutionary targets" based on scientific consensus

In 2010, Chancellor Merkel's conservative government agreed on the "Future Energy Concept", which sets "revolutionary targets" (Chancellor Merkel) for the reduction of GHG emissions. According to the coalition agreement, by 2050 overall GHG emissions will be reduced by 80% - 90% compared to 1990 levels. Specifically, this target will be reached by determining both an 80% share of renewable electricity and a 50% reduction of primary energy (Deutsche Bundesregierung 2010).

A broad variety of long-term energy scenarios for the Energiewende have been published in recent years, demonstrating that these targets are not simply political wishful thinking but are technically feasible (Sonnenschein and Hennicke 2015). This scientific consensus is fairly new for Germany and acts as an important driver for the political and public acceptance of the Energiewende.

Status and achievements of the Energiewende

- By 2015, nine nuclear power plants had been shut down. The further nuclear phase-out (comprising the shutdown of eight more nuclear power plants by 2022) is not contested by any relevant group in society, nor by any political party.
- Gross power generation from renewable energy sources increased from 20 TWh (3.6%) in 2000 to nearly 160 TWh (27.3%) in 2014 (AG Energiebilanzen 2015).
- Learning effects and cost digression for electricity from PV and wind energy exceeded expectations: in 2013 the average cost for electricity from PV was 7.3 ct/kWh and from wind (onshore) 5.6 ct/kWh (Pescia and Graichen 2015).

1 This article is based on the publication (Sonnenschein and Hennicke 2015)

- With 400,000 employees, the gross employment in the renewable energy sector reached an all-time high in 2012. Despite the significant crisis in the solar economy, employment in the sector is fairly stable, with about 370,000 people employed in 2013 (DIW Econ 2015).

- Even though net electricity exports increased to 34 TWh in 2014, CO_2 emissions decreased in overall terms after having reached an intermediary increase between 2009 and 2013.

- Compared to 1990, GHG emissions decreased by more than 250 Mt CO_2eq to about 99 0Mt CO_2eq (estimation for 2014).

- There is broad public acceptance of the Energiewende. In a 2015 opinion poll, 93% of Germans stated that they believe the further use and expansion of renewable energy sources to be important or very important (Agentur für Erneuerbare Energien 2015).

- In 2011 the total municipal value added by renewable energies was EUR 6.95 million and this value is expected to almost double by 2020 (Hirschl et al. 2012).

- The increasing number and variety of decentralised actors is remarkable, comprising hundreds of energy cooperatives, 100% renewable municipalities, regional and KMU networks and a growing number of prosumers. As estimated, nearly 50% of the installed renewable power generation of the Energiewende has been financed by farmers and private individuals, but only about 5% by the four big power companies (Müller and Holstenkamp 2015).

Selected remaining challenges

- Primary energy consumption decreased only slightly, from 14,905 PJ in 1990 to 13,132 PJ in 2014 (AG Energiebilanzen 2015). The German government's reduction targets for 2020 (11,504 PJ) and for 2050 (7,190 PJ) require a paradigm shift towards an accelerated energy saving policy.

- The lack of energy saving is predominantly caused by the absence of ambitious Energiewende policies in the building and transport sectors. Germany is still far from doubling the annual deep renovation rate of the building stock, which is necessary for reaching the long-term primary energy reduction target of 80% in the building sector. The level of ambition is even lower in the transport sector.

- In order to reach the GHG reduction target of 40% by 2020 and at least 80% by 2050, a complementary and gradual phase-out of coal, and in particular of lignite, in the German power mix is necessary.

- There is a critical public debate about increased electricity tariffs for households and SMEs, as well as about the exemptions granted to too many industry players who are not facing the pressure of international competition.

- The management challenges of fluctuating power generation from PV and wind have now been mastered. However, considerable challenges remain, especially in the further development of flexibility in the system (e.g. sector coupling, DSM, storage and cogeneration).

- The construction of new wind parks and electricity grids faces local resistance. Encouraging public participation and citizen financing mechanisms is crucial, in order that the broad support for the Energiewende is not jeopardised.

- Particularly for the implementation of energy efficiency policies, new governance structures should be established. A federal Energy Efficiency Agency and an Energy Fund might be necessary (Thomas et al. 2013). However, the top down enforcement and the success of federal efficiency policies depend on a strong collaborative effort with regions and cities, which can be characterised by "polycentric governance" (Elinor Ostrom).

Outlook: communicating the promising narrative of the Energiewende

There is no historical blueprint for a unique project such as the "Energiewende". It is a huge societal transformation experiment with unavoidable ups and downs, but with a highly promising message for the future: the "Energiewende" is meant to be a contract between generations. The rebuilding of the whole energy system is designed and financed by the current generation to safeguard our children's and grandchildren's generation against fundamental risks caused by using fossil fuels and

nuclear energy. In contrast, a successful German Energiewende will not only create new business areas and qualified jobs, but will also increase competition within the 'green business race' – particularly in the leading markets for efficiency technology and renewable energy.

Nevertheless, the German Energiewende cannot be copied as a general blueprint for energy transition in other countries, as the socio-economic, political and geographic conditions vary enormously from country to country. Despite this, the Energiewende has certainly provided many specific insights and the lessons learned from the Energiewende are currently making a significant contribution to energy transitions in other countries by helping them to avoid mistakes, as well as informing and inspiring international cooperation and engagement.

References

AG Energiebilanzen (2015): Evaluation Tables of the Energy Balance for Germany 1990 to 2014. Berlin. http://www.ag-energiebilanzen.de/index.php?article_id=29&fileName=ausw_25082015_engl_ov.pdf

Agentur für Erneuerbare Energien (2015): Umfrage zur Akzeptanz Erneuerbarer Energien 2014. https://www.unendlich-viel-energie.de/mediathek/grafiken/umfrage-akzeptanz-erneuerbare-energien-2015

Deutsche Bundesregierung (2010): Energiekonzept für eine umweltschonende, zuverlässige und bezahlbare Energieversorgung. Berlin: Deutsche Bundesregierung.

DIW Econ (2015): Die Beschäftigungseffekte der Energiewende: Eine Expertise für den Bundesverband WindEnergie e.V. und die Deutsche Messe AG. Berlin. http://diw-econ.de/wp-content/uploads/2015/04/20150414-diw-econ-beschaeftigungseffekte-energiewende-expertise1.pdf

Hennicke, P.; Welfens, P. J. J. (2012): Energiewende nach Fukushima: Deutscher Sonderweg oder weltweites Vorbild? München: Oekom-Verlag.

Hirschl, B.; Heinbach, K.; Aretz, A.; Salecki, S. (2012): Effekte der Ausbaupläne für Erneuerbare Energien bis 2020 auf Arbeitsplätze und Wertschöpfung. Berlin: Institut für ökologische Wirtschaftsforschung (IÖW). https://www.ioew.de/fileadmin/_migrated/tx_ukioewdb/Effekte_der_Ausbauplaene_fuer_EE_bis_2020_auf_Arbeitsplaetze_und_Wertschoepfung.pdf

Müller, J. R.; Holstenkamp, L. (2015): Zum Stand von Energiegenossenschaften in Deutschland: Aktualisierter Überblick über Zahlen und Entwicklungen zum 31.12.2014. No. 20. Arbeitspapierreihe Wirtschaft & Recht. Leuphana Universität Lüneburg. https://www.buendnis-buergerenergie.de/fileadmin/user_upload/downloads/Studien/Studie_Zum_Stand_von_Energiegenossenschaften_in_Deutschland_Leuphana.pdf

Pescia, D.; Graichen, P. (2015): Understanding the Energiewende: FAQ on the ongoing transition of the German power system: Background. Berlin: Agora Energiewende. https://www.agora-energiewende.de/fileadmin/Projekte/2015/Understanding_the_EW/Agora_Understanding_the_Energiewende.pdf

Sonnenschein, J.; Hennicke, P. (Eds.) (2015): The German Energiewende: a transition towards an efficient, sufficient green energy economy. Lund, Sweden: Internat. Inst. for Industrial Environmental Economics. https://epub.wupperinst.org/files/6107/6107_Energiewende.pdf

Thomas, S.; Hennicke, P.; Bierwirth, A.; Hauptstock, D.; Kiyar, D.; Suerkemper, F.; et al. (2013): Vorschlag für eine Bundesagentur für Energieeffizienz und Energiesparfonds (BAEff): Wie die Ziele der Energiewende ambitioniert umgesetzt und die Energiekosten gesenkt werden können. Wuppertal: Wuppertal Institut für Klima, Umwelt, Energie GmbH. http://www.effizienzwende.de/download/documents/5161_BAEff.pdf

Energy transitions in Japan - a historical perspective

A low carbon energy system is key for reducing GHG emissions, as well as for achieving a global low carbon society. In the long history of energy statistics recording in Japan, two opportunities for transforming the energy system can be identified. One energy transition was triggered by the oil crisis, from oil to non-oil, and another was the shifting of energy sources from nuclear to fossil fuel following the Fukushima accident. However, both these transitions were symptomatic reactions to energy crises. A potential way of achieving real transition is to focus on making the energy transition in Japan's cities.

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Introduction

It is essential to reduce greenhouse gas (GHG) emissions to achieve a low carbon society in the future. Sources of GHG emissions can be divided into six classifications: 1 energy use; 2 industrial processes; 3 agriculture; 4 waste; 5 Land-Use Change and Forestry (LUCF); and 6 bunker fuels. Of these categories, the highest share of GHG emissions result from energy use. In 2014, 89.1% of GHG emissions were produced by energy use, demonstrating that low carbon energy systems are key for reducing GHG emissions, as well as for achieving a low carbon global society (GIO et al. 2016).

Historical changes in Japan's energy mix

GHG emissions from energy use are related to primary energy consumption and levels of economic activity. **Figure 1** summarises energy consumption by primary energy source in Japan from 1880 to 2015.

Energy consumption in Japan has increased with economic growth. Until around 1880, energy consumption in Japan mainly consisted of traditional biomass such as fuel wood and charcoal. Subsequently, coal use started to grow and coal remained a major source of

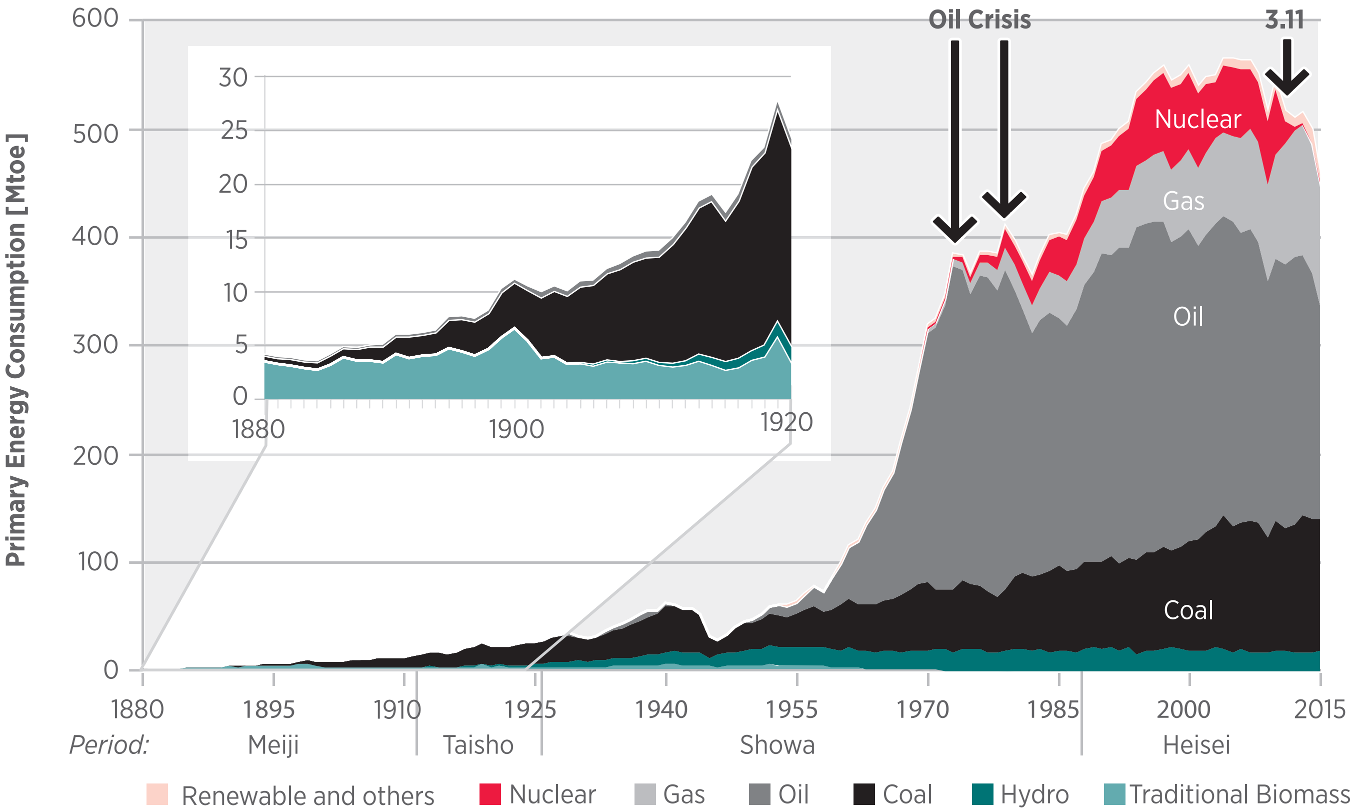

Fig. 1: Energy consumption by fuel from 1880 to 2015 *Yr. 2015 is an estimation* - **Source:** *British Petroleum 2015* **and** *Institute of Energy Economics Japan 2016*

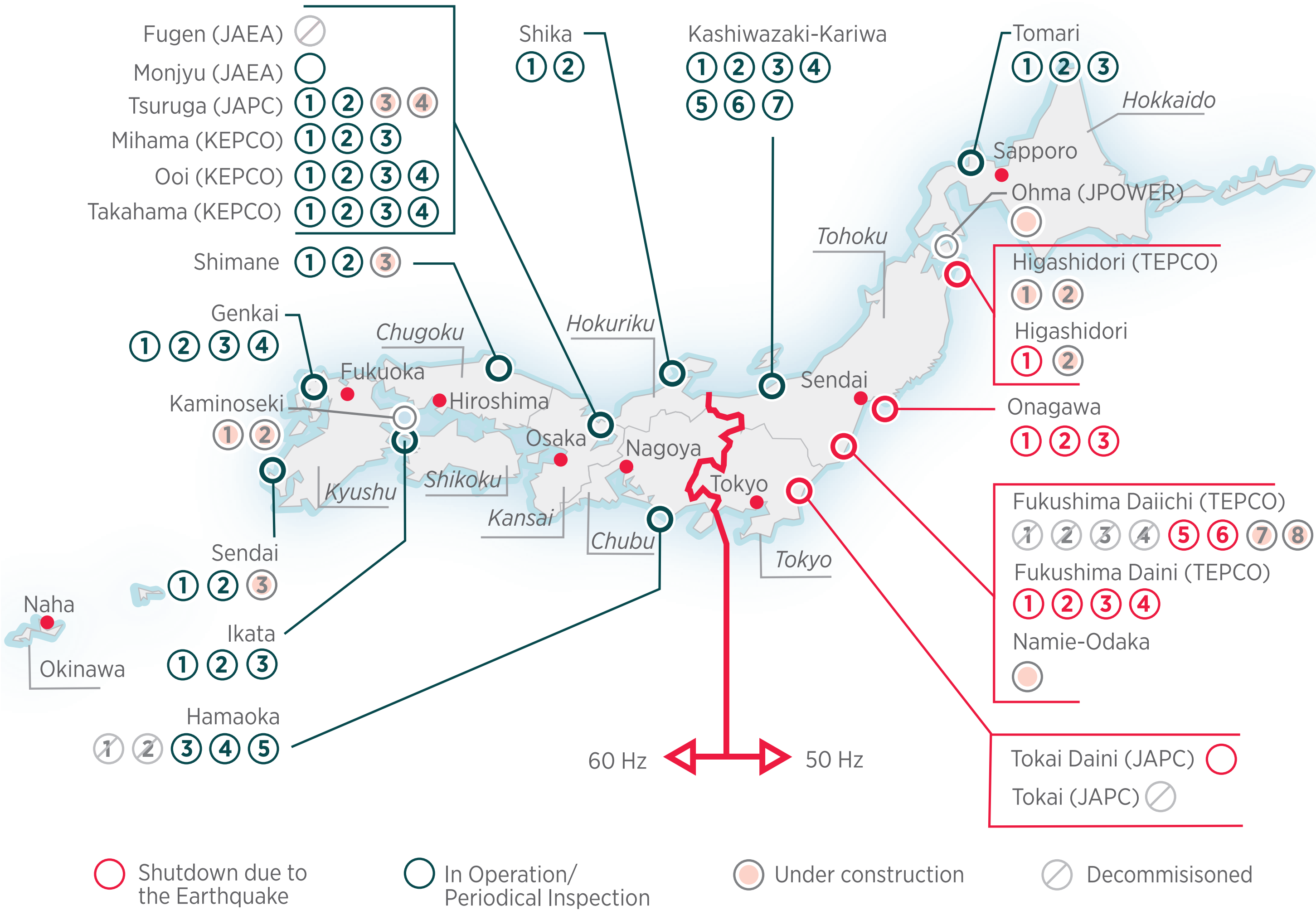

Fig. 2: Nuclear power situation in Japan - Source: Own figure based on (Institute of Energy Economics Japan 2016)

energy supply in Japan until the end of World War II. Before the two oil crises, in 1973 and 1979, energy consumption, especially oil consumption, increased with the growth of the economy. With the emergence of the bubble economy in the second half of the 1980s, energy consumption started to increase again due to an upturn in economic activity, the adoption of energy-consuming life-styles and new preferences for large cars, such as the land cruiser. After the bubble economy burst in second half of the 1990s, the prolonged economic slump in Japan led to the suppression of energy consumption, and total energy consumption levelled out at around 23,000 PJ. The bankruptcy of the Lehman Brothers and the subsequent recession affected not only economic activity but also energy consumption, with energy consumption dropping 7% from its 2008 level to 21,554 PJ in 2009.

After the oil crisis, nuclear power became a key technology for electricity supply in Japan. However, on March 11, 2011, Japan suffered a big earthquake and tsunami and the nuclear power plants in the northern part of the main island of Japan were shut down. On that day, 55 nuclear power plants were in commercial operation and 12 plants were under construction, as shown in **Figure 2.** The total installed capacity was 49,165 MW and the capacity under construction was 16,318 MW. Okinawa EPCo had no nuclear power and no future construction plans. After the earthquake, 15 plants were shut down. Tohoku EPCo shut down all its nuclear power plants

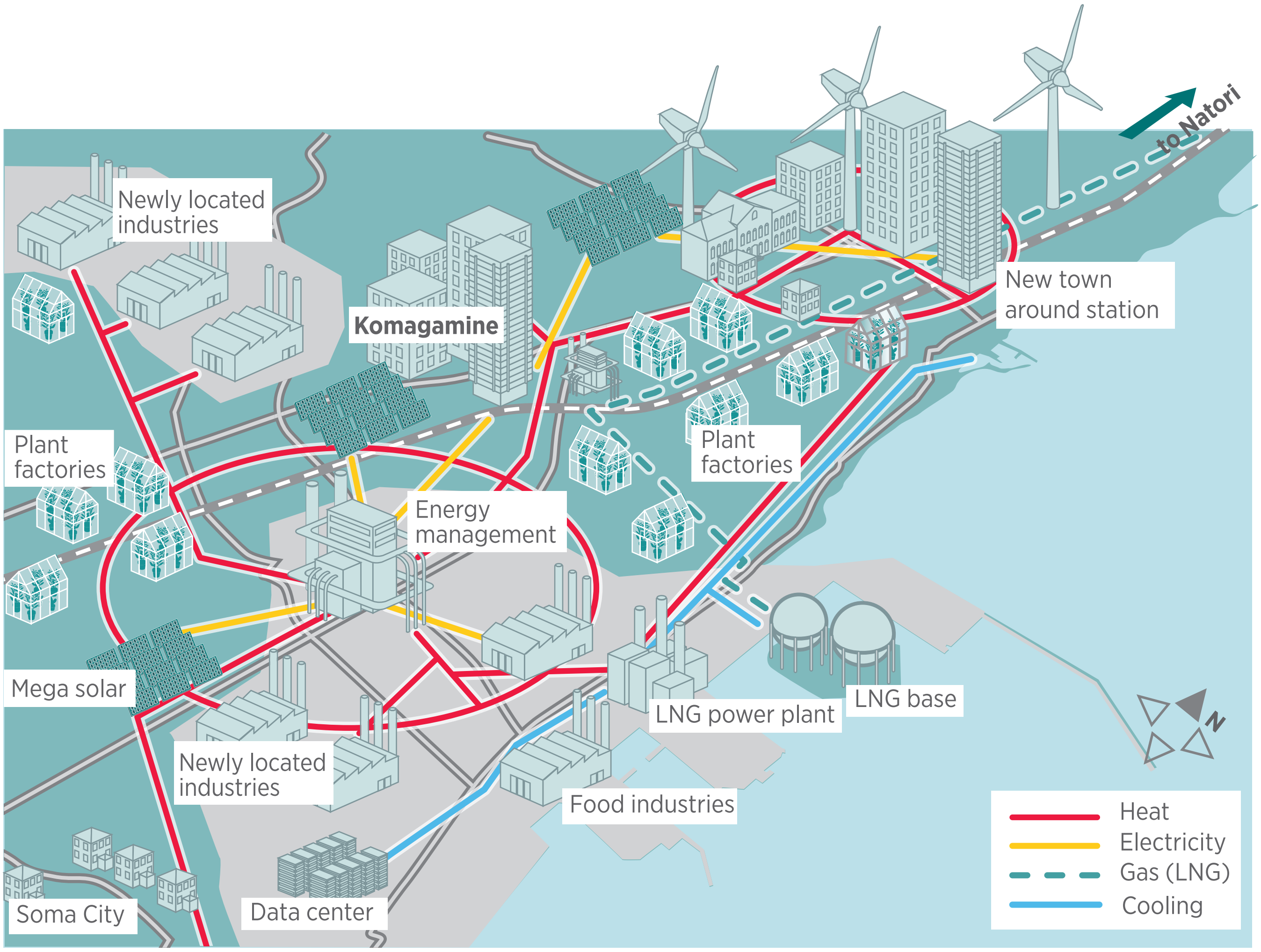

Fig. 3: Innovative development for Shinchi Town - Source: Own figure

(Onagawa: 2,174 MW and Higashi-dori: 1,100 MW). TEPCO also shut down some of its nuclear power plants due to the earthquake, but only those plants on the Pacific side (Fukushima Daiichi: 4,696 MW and Fukushima Daini: 4,400 MW).

Opportunities for energy transition in Japan

In the 135 year history of energy statistics recording in Japan, there is evidence of two opportunities for energy transition: after the oil crisis and after the earthquake of March 2011.

The oil crisis triggered the promotion of non-oil energy sources, such as gas and nuclear, and made energy saving activities, including the replacement of energy efficient machines or appliances, popular. Although this transition brought another type of energy system into Japan, i.e. the electrified society, the transition is not yet complete because, even now, oil accounts for around 45% of the primary energy consumption in Japan.

Accidents in Fukushima following the March 2011 earthquake led to the shutdown of the nuclear power plants for thorough safety examinations and, as a result, nuclear power was entirely replaced by fossil fuel in 2014. However, some nuclear plants have been restarted since 2015 following safety examinations and government approval.

In terms of energy transition in Japan, despite the diversification of fuel sources promoted after the oil crisis, oil has consistently remained the dominant energy source from 1965 to the present day. Before the oil crisis, the growth in energy demand was mainly for oil, but since the oil crisis the diversification of energy sources has resulted in both the suppression of oil consumption growth and the increase of gas and nuclear power supply. In a similar way, before the Fukushima accident, nuclear power was one of key sources of electricity generation and its capacity grew in line with the Basic Energy Plan designed by the Ministry of Economy, Trade and Industry (METI). Currently, with a few exceptions including Fukushima Daiichi and Fukushima Daini, nuclear power plants are exploring the possibility of restarting production following the complete examination of their facilities.

How to make a real energy transition in Japan?

In the past, Japan experienced two energy system transitions - triggered by the oil crisis and the Fukushima nuclear accident. However, these two transitions were symptomatic reactions to energy crises.

Some cities in Japan are now initiating new projects for achieving energy transition. Shinchi town, located in the northern part of the Fukushima Prefecture, changed its city development plan after the Fukushima accident. **Figure 3**

shows the future development plan for Shinchi town. The city has LNG tanks and industry parks, and has recently started developing a new town area around Shinchi Station. Using these resources, the city is trying to shift traditional city development sustained by oil and fossil fuel generated electricity to an innovative development plan sustained by natural gas and renewable energies.

This transition will take time and requires the wider cooperation of stakeholders, including policymakers, citizens, business sectors and researchers. However, a potential way of achieving real transition is to focus on making the energy transition in Japan's cities.

References

British Petroleum (2015): Statistical Review of World Energy June 2015. No. 64. https://www.bp.com/content/dam/bp/pdf/energy-economics/statistical-review-2015/bp-statistical-review-of-world-energy-2015-full-report.pdf

GIO; CGER; NIES (2016): National Greenhouse Gas Inventory Report of Japan 2016. CGER-REPORT I128-2016. Ibaraki, Japan: Ministry of the Environment Japan (MOEJ), Greenhouse Gas Inventory Office of Japan (GIO), Center for Global Environmental Research (CGER), National Institute for Environmental Studies (NIES). http://www.cger.nies.go.jp/publications/report/i128/i128.pdf

Institute of Energy Economics Japan (Ed.) (2016): EDMC Handbook of Japan's & World Energy & Economic Statistics 2016. Japan: Energy Conservation Center.

Life cycle thinking for sustainable consumption and production

Sustainable consumption and production requires systemic or holistic thinking to come to fruition. Life cycle thinking prevents the shifting of problems from one life cycle stage to another, from one impact to another, from one region to another, from one generation to another or from one sustainability aspect to another. This is essential for maintaining the overall benefits of any action. Using examples and experiences from Thailand, the application of life cycle-based tools for sustainable consumption and production is illustrated. Carbon footprint, water footprint, environmental labelling, sustainability assessment and green GDP are some of the tools that have been successfully used. A further crucial aspect discussed is the need for capacity-building to enable the development and application of such tools.

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Introduction

Sustainability is an overarching goal for the survival of the planet and sustainable consumption and production are key aspects. This has been recognised by the United Nations 2030 Agenda for Sustainable Development, particularly in Sustainable Development Goal 12: "Ensure sustainable consumption and production patterns". Sustainable consumption and production requires the consideration of multiple dimensions in a holistic manner. Consequently, life cycle thinking is a very important concept in sustainable consumption and production to avoid shifting problems between the life cycle stages of any product, process or service, between various impacts, between regions, between generations or between sustainability pillars (Charmondusit et al. 2016).

Life cycle thinking applications in Thailand

In Thailand, like many other nations around the world, the core idea of life cycle thinking was introduced into research and policy in the early 1990s. The seed developed with cleaner production focused on processes and facilities, but expanded into considering the whole life cycle of products, processes and services. Thailand's green label was introduced in 1993; although it is a Type 1 label (**Figure 1**), it incorporates life cycle thinking into the criteria (TEI 2016). The more recently introduced carbon footprint label, which has been in operation since 2009, requires the calculation of greenhouse gas emissions across the entire life cycle of products (TGO 2016a).

The promotion of such labels initiated the idea of life cycle thinking in sustainable production. Companies have taken to applying for such labels after understanding their significance (Gheewala and Mungkung 2013). As of August 2016, about 460 products from 65 companies had green label certification and about 1,800 products from 400 companies had the product carbon footprint label. The excellent response to the product carbon footprint label led to the

further development of related labels, such as the carbon footprint of the organisation, the carbon footprint reduction label and the carbon offset and carbon neutral programmes. With active participation, these have resulted in greenhouse gas reductions from the production sector. More, however, needs to be done to promote these labels to the general public, which would also lead to sustainable consumption. Efforts have been initiated via the personal carbon neutral programme, which offers a web-based personal carbon footprint calculator and suggestions for reducing/offsetting personal carbon emissions (TGO 2016b).

The proliferation of the various carbon labels has brought the notion of life cycle assessment to the fore. Companies, which previously avoided conducting life cycle assessment studies, have begun to show greater interest in multiple impacts – no longer limited to greenhouse gas emissions. In recent years, there has been significant development in the assessment of another important impact – freshwater use (Gheewala et al. 2014). Thus, two of the major advantages of a life cycle thinking approach – avoiding problem shifting between life cycle stages and between impacts – are being realised. In addition, strong participation from industry is ensuring that the effects are evident in sustainable production and will, in due course, manifest themselves in sustainable consumption (when public awareness is adequately raised).

In addition to environmental impacts, social and economic assessments are also being conducted to address the issue of sustainability. With support from the government, many national level projects have been initiated for major agricultural supply chains in Thailand that cover not only environmental impacts, but also social and economic impacts. Most of the major companies in Thailand participate in such initiatives, which are conducted through consultation and cooperation. Commodities such as palm oil and sugar have been studied in addition to other agricultural commodities such as rice, rubber, etc., and other industry sectors (Musikavong and Gheewala 2017; Prasara-A and Gheewala 2016; Sawaengsak and Gheewala 2017; Silalertruksa et al. 2015, 2017).

Fig. 1: Environmental labels in Thailand – green label and carbon footprint label - Source: (TEI 2016) and (TGO 2016a)

Capacity-building for life cycle sustainability assessment in Thailand

Recognition by the government of the importance of life cycle thinking in sustainable consumption and production, as well as the acceptance of this approach by industry, has led to the need to develop adequate skilled human resources to conduct such assessments. To this end, a national research network, the "Food, Fuel and Climate Change (FFCC) Research Network" has been initiated, where tools for life cycle sustainability assessment such as life cycle assessment, carbon footprint, water footprint, ecological footprint, biodiversity footprint, material flow analysis, consequential LCA, social LCA and cost benefit analysis are being developed to support the government and industry in using life cycle thinking towards sustainable consumption and production (Gheewala et al. 2016). It is hoped that this group will provide solid support to the government in policymaking and to industry for the implementation of life cycle thinking towards the broader goal of sustainable consumption and production. In addition, the success of this pilot activity should be replicated and greater capacity developed over the years when the application of life cycle-based sustainability assessment tools becomes mainstream.

Concluding remarks

Life cycle thinking is essential for moving towards sustainable consumption and production because it prevents problem shifting:

- to other life cycle stages
- to other environmental issues
- to other sustainability pillars
- to other countries
- to future generations

As the experience in Thailand has shown, many mechanisms need to be considered in order to move towards a low carbon society by reducing greenhouse gases, such as awareness raising, environmental labelling and so on. However, carbon reduction should not be considered in isolation, but in conjunction with other environmental impacts and other sustainability pillars. Therefore, a holistic, life cycle-based approach is imperative for sustainability assessment.

References

Charmondusit, K.; Gheewala, S.; Mungcharoen, T. (2016): Green and sustainable innovation for cleaner production in the Asia-Pacific region. Journal of Cleaner Production 134, Part B, 443–446. doi: 10.1016/j.jclepro.2016.06.160.

Gheewala, S.; Mungkung, R. (2013): Product carbon footprinting and labeling in Thailand: experiences from an exporting nation. Carbon Management 4(5)547–554. doi: 10.4155/cmt.13.52.

Gheewala, S.; Silalertruksa, T.; Jakrawatana, N.; Mungkung, R.; Musikavong, C.; Prapaspongsa, T.; Prasara-A, J. (2016): LCA for Food, Fuel and Climate Change in Thailand. Kasetsart Engineering Journal (30, Special Issue)73–83.

Gheewala, S.; Silalertruksa, T.; Nilsalab, P.; Mungkung, R.; Perret, S.; Chaiyawannakarn, N. (2014): Water Footprint and Impact of Water Consumption for Food, Feed, Fuel Crops Production in Thailand. Water 6(6)1698–1718. doi: 10.3390/w6061698.

Musikavong, C.; Gheewala, S. (2017): Assessing ecological footprints of products from the rubber industry and palm oil mills in Thailand. Journal of Cleaner Production 142, Part 3,1148–1157. doi: 10.1016/j.jclepro.2016.08.117.

Prasara-A, J.; Gheewala, S. (2016): Sustainability of sugarcane cultivation: case study of selected sites in north-eastern Thailand. Journal of Cleaner Production, Special Volume: Green and Sustainable Innovation for Cleaner Production in the Asia-Pacific Region, 134, Part B,613–622. doi: 10.1016/j.jclepro.2015.09.029.

Sawaengsak, W.; Gheewala, S. (2017): Analysis of social and socio-economic impacts of sugarcane production: A case study in Nakhon Ratchasima province of Thailand. Journal of Cleaner Production 142, Part 3,1169–1175. doi: 10.1016/j.jclepro.2016.08.148.

Silalertruksa, T.; Gheewala, S.; Pongpat, P. (2015): Sustainability assessment of sugarcane biorefinery and molasses ethanol production in Thailand using eco-efficiency indicator. Applied Energy 160,603–609. doi: 10.1016/j.apenergy.2015.08.087.

Silalertruksa, T.; Pongpat, P.; Gheewala, S. (2017): Life cycle assessment for enhancing environmental sustainability of sugarcane biorefinery in Thailand. Journal of Cleaner Production 140, Part 2,906–913. doi: 10.1016/j.jclepro.2016.06.010.

TEI (2016): Green Label. Thai Environment Institute. http://www.tei.or.th/greenlabel/

TGO (2016a): Carbon Footprint of Products. Thailand Greenhouse Gas Management Organization (Public Organization). http://thaicarbonlabel.tgo.or.th/products_is/products_is.pnc

TGO (2016b): Web-based Thai Carbon Footprint Calculator. Web-based Thai Carbon Footprint Calculator. http://carbonmarket.tgo.or.th/carbonfootprint/thai/index.php

Small-scale energy projects in the global south

Small-scale energy projects in the global south can help to ensure access to energy and potentially enable productive use activities – but do they also contribute to decarbonisation? This article presents findings from an impact evaluation of 30 projects in Latin America, Africa and Asia. Decentralised and small-scale solutions can play an important role in avoiding carbon-intensive development pathways. However, quantification of their environmental benefits remains difficult. Furthermore, considering that a large proportion of the rural population – especially in Sub-Saharan Africa and South Asia – still lacks access to energy, low carbon development has not yet become a top priority.

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Small wind power generation system in rural area of Peru
Source: WISIONS / Soluciones Prácticas (ITDG)

Introduction

In 2004, for the first time non-OECD countries produced higher levels of carbon dioxide emissions than OECD countries and the gap is expected to widen further in the future (U.S. EIA 2016). Facilitating the transformation of the energy systems in these countries into sustainable low carbon systems is an important goal for the international community. However, the challenge is not only to transform the existing energy systems to provide modern energy services to the 2.7 billion people globally who still lack access to clean energy (OECD/IEA 2016) but also, at the same time, to avoid the drawbacks associated with conventional energy sources – such as harmful emissions, noise pollution, high fuel costs and supply insecurities. Small-scale renewable energy systems, often decentralised, have the potential to play a central role in sustainably meeting the energy needs of these people at a local level. However, these technologies still face a range of social, economic and structural challenges, requiring not only further technological development but also a deeper understanding of both the success factors and the barriers to accomplishing widespread dissemination (Terrapon-Pfaff et al. 2014).

"WISIONS of sustainability" is an initiative by the Wuppertal Institute supported by the Swiss-based foundation ProEvolution. It was launched in 2004 to promote practical and sustainable energy projects. The WISIONS initiative supports the introduction of innovative sustainable energy systems in developing countries through its supporting scheme SEPS (Sustainable Energy Project Support) by helping local partners to identify successes and bring them to scale through regional networks, marketing and demonstration. To ensure the sustainable character of the projects supported by SEPS, their selection is based on the following set of criteria: technical viability, economic feasibility, local and global environmental benefits, replicability and marketability, potential for poverty reduction, social equity and gender issues, local involvement and employment potential, sound implementation strategy and dissemination concept. Since 2004, over 100 projects and capacity development activities have been supported. The small-scale projects cover a broad range of energy applications in different contexts in more than 40 countries. By evaluating the outcomes and impacts of 30 of these projects, this research aims to provide a better insight into whether these projects contribute to environmental and climate protection and low carbon development.

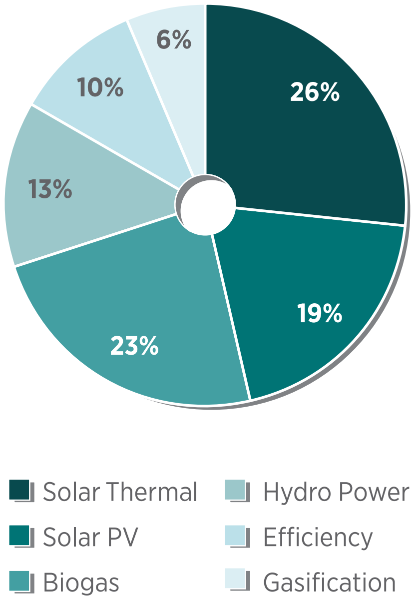

Fig. 1: Technology distribution within the evaluation sample - Source: Own figure

Pico Hydro Power project in rural area of Sri Lanka
Source: WISIONS / Janathakshan (GTE) Ltd.

Evaluation approach

The original evaluation sample comprised 52 renewable energy projects, all of which were initiated between 2004 and 2010 and had been completed for at least 2 years at the time of the review in 2015. A very good response rate of 63% resulted in an actual evaluation sample of 30 projects.

Figure 1 shows the technology distribution within the evaluation sample. Solar power (45%) is the dominant technology, followed by biogas (23%) and hydropower (13%).

The evaluation approach was a semi-structured in-depth survey using telephone interviews with organisations that had implemented and monitored the initial project activities. In addition, four international networks in the field of wind, hydro power and biomass/biogas were monitored. These are also supported by WISIONS. Secondary data, such as project documentation, field visits and the in-depth analysis of selected projects, were also incorporated.

The main advantages of the chosen survey approach are its time-effectiveness and its suitability for addressing questions of decision-making and for the provision of information on impact and sustainability (World Bank 2003). These advantages outweigh the possible limitations that this method entails: the difficulties of quantifying and generalising the results, as well as the possibility of the interviewees providing biased information.

Evaluation results

The impact evaluation shows that 70% of the projects were fully functioning and a further 17% were partly functioning in 2015, meaning that more than 50% of the original technical components and/or services were operational 4 to 11 years after their initial implementation. Only 13% of the projects had ceased to function by the time of the evaluation.

In the evaluation of environmental benefits (levels of greenhouse gas (GHG) emission reductions/replacement of unsustainable energy sources) it became obvious that quantification was impossible without detailed field studies. However, results support the assumption that additional GHG emissions were avoided and unsustainable energy sources were replaced. Improvements in energy efficiency resulted in the reduction of energy demand for the respective tasks, i.e. energy efficient improvements in street lighting in India. Moreover, substituting firewood and diesel motors with renewable energy sources such as solar or hydro power has resulted in lower GHG emissions.

Small-scale energy projects also succeed in disseminating sustainable energy technology. 77% of the evaluated projects reported that they contributed to replication within the project area and 54% supported replication outside the project area. Moreover, in almost three quarters of the cases (73%), the awareness of sustainable energy technology increased. 50% of the small-scale projects also supported the development of institutional frameworks and policy formulation to expand the dissemination of sustainable energy technology. These findings highlight the indirect effects on low carbon development and are difficult to quantify in terms of GHG emission reductions. However, when considering long-term development, they are extremely important for the socio-technical transition towards wider access to a sustainable energy system.

In addition to the results of the project impact evaluation, the experience of the WISIONS initiative shows that practitioner networks can increase awareness and support replication by enabling knowledge exchange. The networks facilitate knowledge sharing between local practitioners and other relevant stakeholders to develop local expertise in specific focus technologies, contributing ultimately to the broader dissemination of decentralised renewable energy technologies. Networks can give practitioners a voice in the energy access debate. Practitioners are key stakeholders for supporting sustainable energy solutions. They work in the field and within local communities, which provides them with in-depth knowledge, daily lessons and hands-on training (Dienst et al. 2016).

Lessons learned

The results show that decentralised and small-scale energy solutions can play an important role in preventing carbon-intensive development. While the quantification of their effects in terms of reducing GHG emissions is often difficult, these solutions can help to pave the way for renewable energy development and energy efficiency in developing countries.

Sustainable small-scale energy systems can help to avoid fossil fuel dependent pathways in countries where gaining secure access to energy for the whole population is a priority in the energy sector. It is with good reason that "access to affordable, reliable, sustainable and modern energy for all" is one of the 17 Sustainable Development Goals (SDGs) for 2030, adopted by the member states of the United Nations in September of 2015 and the driving force behind the United Nations Sustainable Energy for All (SE4All) initiative (OECD/IEA 2016). However, reducing GHG emissions should be considered as a co-benefit that should be emphasised when planning and implementing sustainable small-scale energy projects at local level.

Furthermore, the results of the study highlight the fact that most of the projects studied have triggered replication and have helped to disseminate sustainable energy production. They have also supported policy formulation, helping to create a suitable environment for long-term sustainable development.

Solar Cooker in Morocco
Source: WISIONS / Simply Solar

With regards to long-term development, practitioner networks strengthen the capacity of their members through collaboration, knowledge exchange and advocacy by fostering dialogue and sharing knowledge with relevant stakeholders. As such, these networks can also play a central role in avoiding carbon intensive development pathways.

References

Dienst, C.; Ortiz, W.; Terrapon-Pfaff, J.; Gröne, M.-C. (2016): Energy Practitioner Networks: Linking knowledge and skills for sustainable energy solutions. Wuppertal: Wuppertal Institut für Klima, Umwelt, Energie.
http://www.wisions.net/files/uploads/Networks_WISIONS_2016.pdf.

OECD/IEA (2016): World Energy Outlook: Modern Energy for All. Organisation for Economic Co-operation and Development/International Energy Agency.
http://www.worldenergyoutlook.org/resources/energydevelopment/.

Shell Foundation (2014): Access To Energy.
http://www.shellfoundation.org/Our-Focus/Access-To-Energy.

Terrapon-Pfaff, J.; Dienst, C.; König, J.; Ortiz, W. (2014): A cross-sectional review: Impacts and sustainability of small-scale renewable energy projects in developing countries. Renewable and Sustainable Energy Reviews 401–10.
doi: 10.1016/j.rser.2014.07.161.

U.S. EIA (2016): International Energy Outlook 2016. Washington, D.C.: U.S. Energy Information Administration.
http://www.eia.gov/forecasts/ieo/pdf/0484(2016).pdf

World Bank (2003): Monitoring and Evaluation in Rural Electrification Projects: A Demand-Oriented Approach. Joint UNDP/World Bank Energy Sector Management Assistance Programme (ESMAP). Technical Paper series no. 037. Washington, D.C.: World Bank Publications.
http://documents.worldbank.org/curated/en/247841468764070661/Monitoring-and-evaluation-in-rural-electrification-projects-a-demand-oriented-approach

The German-Japanese Energy Transition Council - a role model for international cooperation on energy transition?

The German-Japanese Energy Transition Council (GJETC) has been established to support the energy transition in Japan and Germany. In an initial two year period, energy experts from both countries will discuss how to better face energy challenges and how to learn from each other. A study programme comprising five thematic studies from renowned research institutes will support the work of the Council.

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Introduction

Despite their differences in energy policies and supply, Japan and Germany are facing similar challenges: how to reorganise energy supply and demand into a system which, in the long term, will be reliable and low in risk, resource-efficient and climate neutral. At the same time, this ecological modernisation should maintain, or even strengthen, international competitiveness. To better face these challenges in the future, a bi-national energy transition council between the two high-tech countries of Germany and Japan was established in April 2016 – the German-Japanese Energy Transition Council (GJETC).

Methodology/ongoing activities

The aim of the GJETC is to demonstrate that, despite the different starting points of Germany and Japan, the national energy transitions in these two countries can be more successful if they learn from each other's respective strengths and are also transparent about their own weaknesses, to avoid making similar mistakes. If the implementation of an energy transition in these two high-tech countries is socially and economically sound, it could lead not only to a doubling of success, but also serve as a blueprint for other industrialised and emerging countries.

Solutions that fit both Germany and Japan - despite their differences - will be considered more robust and credible by others.

Various consultation and discussion platforms at governmental, parliamentary, scientific and business level already exist. This project, therefore, aims to strengthen the variety of successful single, topic and technology-specific activities through a continuous and systematic synopsis of strategic knowledge, an analysis of economic opportunities and a system-oriented approach towards the energy transition.

The specific aims of GJETC include:

- An institutionalised exchange between experts from both countries to highlight new and long-term strategies for implementing an ambitious energy transition based on good examples from both countries.
- The identification and analysis of current and future issues on developments in policy frameworks, markets, infrastructure and technologies for the energy transition in both countries.

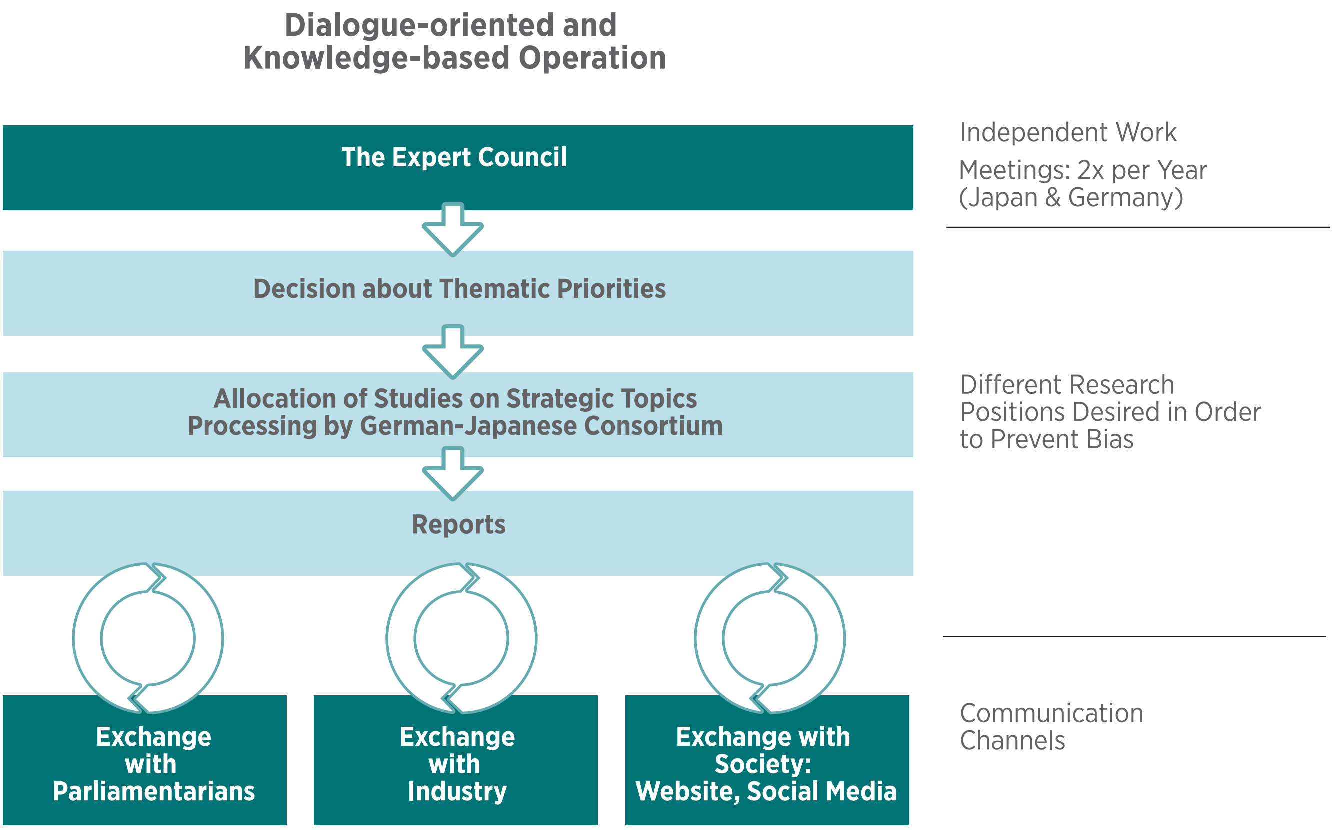


Fig. 1: Set up and intended output of the GJETC - Source: Own figure

- Concentration on strategic and systematic analysis and the development of policy advice focused on problem solutions, while respecting the different framework conditions and energy policies in both countries.

The Council's work is focused on the scientific exchange of knowledge in the field of energy sector issues and on mutual learning. Based on good and successful examples from both countries, new and long-term perspectives for an ambitious energy transition will be developed. The Council meets twice a year, alternately in Germany and Japan. Following several meetings with high-ranking representatives from politics, science and civil society in Japan and Germany, a comprehensive organisational concept for the Council has been developed. For an overview of the Council's work see **Figure 1.**

In the first phase of the project, ten Council members from each country were appointed (including three associated members each) and research questions for five studies were formulated, which will be elaborated by leading institutions in the field. The results of this study programme, as well as further analyses by the scientific secretariats, will support the Council's work. Results will be documented continuously and made available for policymakers, businesses and civil society.

Source: GJETC / Photo by Lisa Eidt

On the German side, the Wuppertal Institute supports the Council's work as the scientific secretariat. In Japan, this role is filled by the renowned Institute of Energy Economics Japan (IEEJ). Prof. Dr. Peter Hennicke, former president of the Wuppertal Institute and co-initiator of the German-Japanese Energy Transition Council, is functioning as co-chair in cooperation with his Japanese colleague Prof. Masakazu Toyoda (Chairman and CEO of IEEJ). The Council further consists of nine energy experts each from Japan and Germany. ECOS Consult is responsible for the organisational support on the German side and contributes with its long-standing competence in Japanese-German projects.

The study programme will be the key output and scientific basis of the conclusions and the communication strategy of the Council. Five studies on different relevant energy-related topics will be produced through a cooperation between a German and a Japanese research institute. The five strategic topics to be analysed in the study programme are:

Study Programme: Consistent and User-friendly Study Format

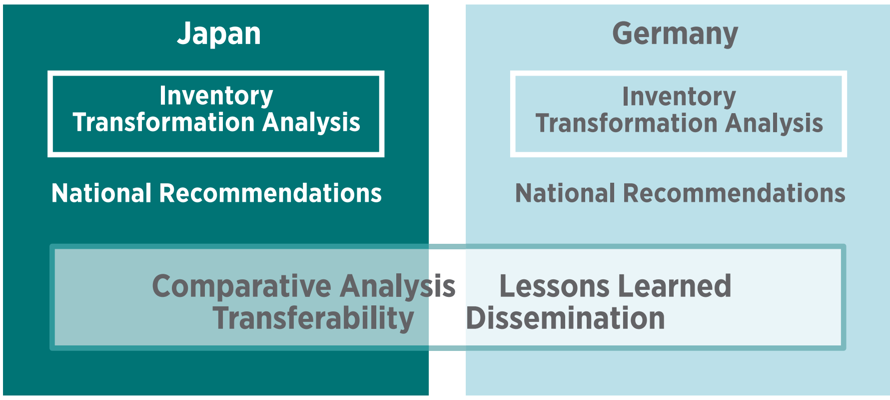


Fig. 2: Format of the Study Programme - Source: Own figure

1. Energy transition as a central building block of a future industrial policy – comparison and analysis of long-term energy transition scenarios.
2. Strategic framework and socio-cultural aspects of the energy transition.
3. New allocation of roles and business segments of established and new participants in the energy sector currently and within a future electricity market design.
4. Energy end-use efficiency potential and policies, and the development of energy service markets.
5. Development of technical systems and new technologies on the pathway to an energy transition.

In addition to the specific issues within these topics, each study should examine the strengths and weaknesses of both countries in a transparent manner and from the perspectives of renowned research institutes. This should ensure the credibility of the studies and the confidence of representatives from politics, the private sector and civil society.

Each study, therefore, contains three work packages:

1. The analysis of the specific topic by a German institute (concerning Germany) and a Japanese institute (concerning Japan), providing results of analysis in relation at least to the questions listed below for each country, following a joint structure.
2. Mutual commenting: the German institute comments on the Japanese analysis and vice versa. Subsequently, both institutes create a synopsis of similar results or understanding, as well as of divergent results. An initial analysis of potential reasons for divergent results is also expected.
3. Conclusions on joint or differentiated policy recommendations and business opportunities will be prepared. Open research questions will also be identified.

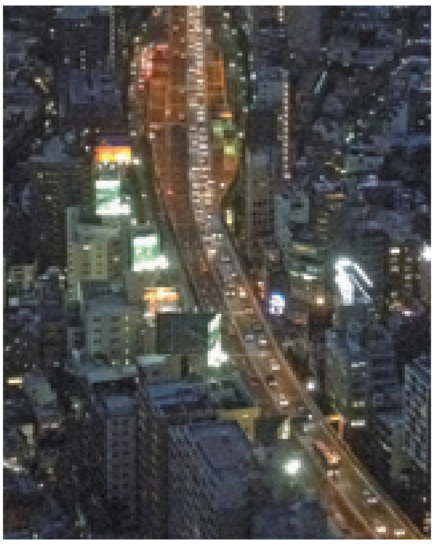
For an overview of the study programme format please see **Figure 2.**

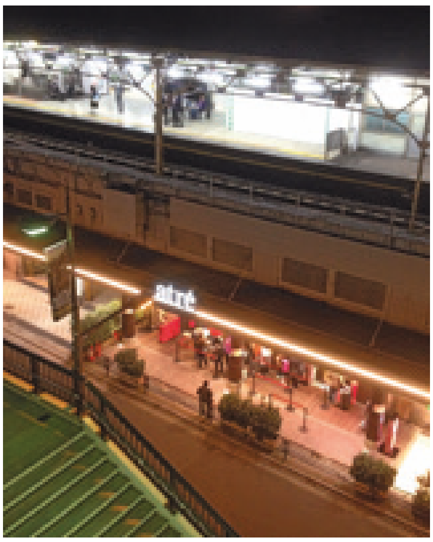
Conclusion/outlook

The first meeting of the GJETC took place in Tokyo, Japan on 27th/28th September 2016. The meeting was a success and significant interest was shown by researchers and politicians. The call for the five studies for the study programme was launched in October 2016 and the studies are expected to be finalised in October 2017.

References

GJETC (n.d.).: German-Japanese Energy Transition Council. http://www.gjetc.org/





How to design econom
policy to finance the
carbon economies and
economic and soc

ic and climate transition to low respond to today’s ial challenges?

Reinvesting in our societies to achieve greenhouse gas emission reduction targets and the Sustainable Development Goals and achieve the transition to low carbon economies needs huge financial commitment. The major challenge is not how to source the funds, but rather how to design the economic instruments necessary to direct the sources of finance. Currently, three kinds of low carbon financial mechanisms are being implemented or discussed: “carbon markets”, the “real pricing” of carbon for taxation purposes and subsidy elimination, and the “positive pricing” of carbon reductions. Furthermore, new policies and measures to mobilise the private sector to invest in sustainable infrastructure and climate mitigation and adaptation are also under discussion. If well-orchestrated, actions for mitigating climate change can also serve as tools for responding to today’s economic and social challenges.

Developing new economic instruments

In terms of achieving greenhouse gas emission reduction targets, the biggest challenge is how to pay for the transition to low carbon/carbon neutral economies. As there are no appropriate mechanisms to mobilise sufficient capital from the global financial markets, the 2°C target will not be achieved within the current global economic/financial context. Of the three kinds of low carbon financial mechanisms currently being implemented or discussed ("carbon markets", "real pricing" of carbon for taxation purposes and subsidy elimination, and "positive pricing" of carbon reduction), the latter two might be the basis for future workable financial tools, with each one having a specific role and scope.

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Introduction

The Paris Agreement heralds incremental progress but, even if all the NDCs are rigorously implemented, by 2030 global greenhouse gas emissions will still be 15 Gt higher per annum than the level required to maintain the average temperature increase of our planet below 2°C. The major economies must considerably intensify their NDCs over the coming five year cycles and the biggest challenge is how to pay for the transition to low carbon/carbon neutral economies. The solution to this crucial aspect will not come from the UNFCCC process and the protracted negotiations on the provisioning of the Green Climate Fund (GCF). Even if the promised USD 100 billion were to be available by 2020, this would fall short of the USD 3 to 5 trillion/year (or maybe more) needed to finance the energy and infrastructure transition, electrification of transport, extensive reforestation, low carbon agriculture, CCS and other critical mitigation investments – not to mention the undetermined but undoubtedly enormous costs of adaptation. Although these figures are currently imprecise and need to be fine-tuned, it is widely recognised that the overall figure will be in the trillions, not billions. The challenge, therefore, is to "move the trillions" towards the low carbon transition.

Three potential low carbon financial mechanisms

The 2°C target will not be achieved in the current global economic/financial

context. Most governments struggle with large debt and persistent deficit; their resources are limited. There are no appropriate mechanisms to mobilise sufficient capital (in the region of USD 220 trillion) from the global financial markets, where a huge excess of liquidity is kept in speculative circuits away from productive investment. Decarbonisation faces additional barriers because it demands strong upfront financing with slow returns, which is hard to obtain under the current fiscal, cultural and technical circumstances dominated by the culture of "financialisation". So-called market forces alone cannot drive the system to where we need it to deal with the climate challenge. This problem affects not only low carbon investment, but global macroeconomics as a whole.

Three kinds of low carbon financial mechanisms are currently being implemented or discussed: (1) "carbon markets"; (2) the "real pricing" of carbon for taxation purposes and subsidy elimination; and (3) the "positive pricing" of carbon reduction. Carbon markets are recovering from recent blows and are developed on a national and sub-national scale. Nevertheless, these instruments are quite limited for achieving stipulated efficiency targets by trading under the cap. They cannot provide the massive scale of investment needed. Carbon pricing for taxation and fossil fuel subsidy elimination offers a second and potentially more powerful path. Governments are talking about eliminating fossil fuel subsidies. This is an important step for incorporating the climate change, environmental and health externalities' prices into the economy and for helping to fund the transition. However, this approach faces fierce political resistance. It is an uphill battle which must be fought and won nation by nation, as taxation systems are national and it is very unlikely the UNFCCC or even the G20 could stipulate a global carbon price in the foreseeable future.

Future financial instruments could also be built on the 'positive pricing' of carbon reduction, based on Paragraph 108 of the Paris Decision, signed by 196 governments, which recognises "the social and economic value" of "mitigation actions". This means that carbon reduction/removal has intrinsic value which could, in future, engender powerful instruments for mobilising investment in mitigation. Positive pricing – not of carbon itself but of its reduction/removal – does not replace "real" pricing for carbon taxation purposes. Both mechanisms have their own specific roles and scopes.

New financial tools

Translating the concept "carbon reduction/removal equals value" into future workable financial tools will demand a different kind of forum. It is likely that this would be created under the G20 banner and would constitute a specific "climate club" of governments, central banks, development banks and multilateral institutions capable of guaranteeing and operating "carbon reduction certificates". Government backed guarantees could enable the subsequent mobilisation of resources from the private financial system, which would include "green bonds" and other similar assets.

Imagine the scenario: a group of willing governments, central and development banks, along with multilateral institutions, form a "Climate Club" providing guarantees for specific quantities of

carbon reduction assets. The governments could eventually use carbon taxation to cover their exposure. Green bonds issued by private financial institutions could relate to and anticipate these assets. Bank loans for duly certified carbon reduction projects/policies could then be partially reimbursed in “carbon reduction certificates”. This new value, covering between 10% and 20% of the investment in mitigation actions, could become the tipping point for low carbon finance demanding high upfront investment.

The development of a Climate Club capable of operating on the basis of this recognition of a new source of value for humanity (i.e. carbon reduction/removal) would probably be a long and arduous process. Nevertheless, some immediate steps can be taken to support its long-term objectives. Current quantitative easing operations by the European Central Bank and others trying to cope with stagnation and deflation should reserve an important part of their purchasing operations for projects and actions related to carbon reduction/removal. This will stimulate the low carbon productive economy and create jobs, in contrast to other types of current operations – such as buying junk bonds – which simply drain resources and result in further financial speculation.

A second short term action is the development of a government backed AAA guarantees fund, related to the GCF, to enable private financial sector financing of mitigation projects that have high upfront investment demands. A third possibility would be to reward early and additional action. Through this fund, governments delivering additional aggregate economy-wide mitigation results, or achieving reductions earlier than stipulated in their NDCs, would receive a premium to be used exclusively for the acquisition of technology, services and products leading to subsequent GHG reduction/removal.

Conclusion

These are just some of the possible instruments for tackling the main challenge in the battle against climate change: how to pay for what will have to be a true revolution in the current globalised and “financialised” economy – an economy seemingly incapable of responding to the double challenge of climate change and insufficient productive investment which generates high unemployment and social degradation.

A new deal for Green Growth? Hedging against the risks of 'secular stagnation'

Actions to mitigate climate change can simultaneously be tools for responding to today's economic and social challenges. Therefore, measures must be implemented which reduce the gap between the propensity to save and the propensity to invest, and decrease the risks arising from overruns of upfront investment costs. Such a mechanism could consist of governments providing a public statutory guarantee for a new asset valued depending on a social value of carbon to help finance low carbon infrastructures. However, the window of opportunity for the implementation of innovative financial mechanisms capable of removing the threat of secular stagnation may rapidly close if concrete progress is not made in future climate negotiations and if a country or a club of countries do not take experimental action.

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Introduction

Despite political statements about the risks of entering the terra incognita of global warming 4°C higher than pre-industrial levels, there is the temptation amongst 'climate agnostic' decision makers to postpone action until the end of the current economic doldrums. The response to these agnostics is that succumbing to this temptation would deprive the international community of a tool for responding to today's challenges of finding robust sources of growth, reducing debt, creating jobs, alleviating poverty and fulfilling the Sustainable Development Goals (SDGs). COP21 sent a strong political signal in this direction, particularly in Article 2, which calls for the alignment of financial flows along a new trajectory of global economic development, and in Article 108 of the Decision, which calls for the 'recognition of the social, economic and environmental value of mitigation actions and their co-benefits...'

Investment risk working against the adoption of low carbon projects

To understand how climate policies can help the recovery from the current economic doldrums, we can start from the diagnosis made by many scholars and practitioners about the gap between real growth and potential growth due to the chronic excess of savings over investments. The gap between the propensity to save and the propensity to invest (Bernanke 2005) leads to difficulties in maintaining sufficient demand to permit normal levels of output and explains the warnings about 'depression economics' (Krugman 2009) or secular stagnation (Summers 2014). Furthermore, in the current 'shareholder business regime' (Roe 1994), managers are obliged to pay close attention to the short-term value of their company and do not have the freedom to use the company's net profits to maximise its long-term growth (Blanchard 2015).

The mechanism at play is characterised in **Figure 1**, which depicts the time profile of the expected operating accounts of two projects. Project A, capital-intensive, has a higher expected present value (discounted sum of lower purchase of fossil fuels minus the capital expenditure and operational costs) than project B, but it might not be selected because of its higher upfront costs. During the incubation phase of the project, a negative surprise in terms of these costs (indicated by the dashed lines) might indeed generate a deficit in the operating accounts beyond the "danger line" D, i.e. the level of deficit the decision maker does not want to cross. These negative surprises can result from the mismanagement of projects, cost increases for certain equipment or from technical difficulties in non-mature technologies.

This mechanism works against the adoption of low carbon projects. Carbon pricing improves their economic palatability only for those projects not stifled by the

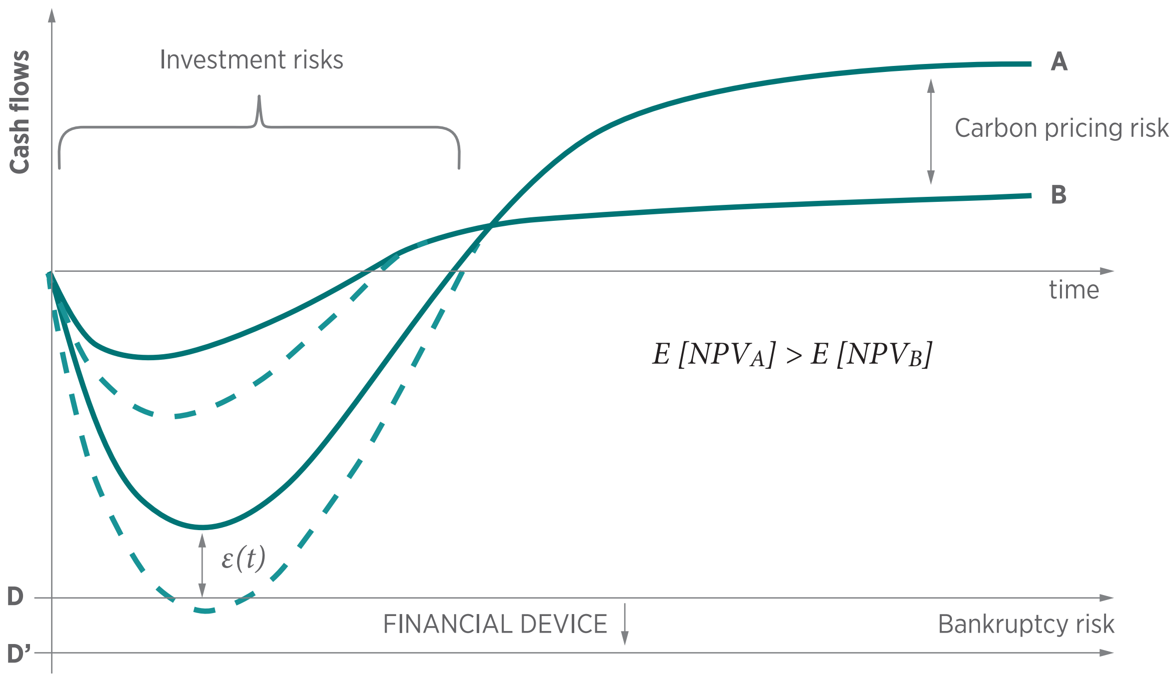

Fig. 1: Investments risks, finance and carbon pricing - Source: (Hourcade et al. 2014)

existence of the 'danger line', because they reward these projects only at the end of their construction phase. Sufficiently high carbon prices could encourage decision makers to take the risk, but the carbon prices would have to be very high because the cost ε(t) of approaching and crossing the danger line is highly non-linear and they would have to cover the "noise" of other unfavourable signals (e.g. real estate prices, oil prices and exchange rates).

To explain the link between climate policies and the overall necessity of reducing the gap between the propensity to save and the propensity to invest: the 'danger line' must be moved (from D to D') and the risks arising from overruns of upfront investment costs must be decreased. Financial devices designed to "move the trillions" towards low carbon investments (Sirkis et al. 2016) can contribute by making more long-term projects less risky and increasing the propensity to invest.

A public statutory guarantee for a new carbon asset as a mechanism for triggering the low carbon transition

It is useful to recall historical examples of links between finance and deep technological revolutions. In the 19^{th} century, the impressive deployment of the railways was unleashed by various country-specific forms of public guarantees for investments and the creation of assets on the lands adjoining the lines.

This combination reassured investors, since they would be able to recuperate valuable assets if insufficient revenue was generated from the traffic between two connected cities (Fogel 1964; Landes 1969). An equivalent realisation of this mechanism for triggering the low carbon transition is for governments to provide **a public statutory guarantee for a new asset which allows the central bank to provide new credit lines refundable with certified reduction of CO_2 emissions (carbon certificates)**. These carbon certificates (CC), allocated to low carbon projects, would be priced at a Value of Climate Remediation Assets (VCRA)[1]. The targeted credit facility would make possible bigger loans to Low Carbon Investments (LCIs) by lowering the financial risk, and would generate a new class of Climate Remediation Assets (CRAs) (see a complete description of the mechanism in (Aglietta et al. 2015; Hourcade et al. 2012, 2014).

Such a device could counter the main argument against the 'Green Growth' hypothesis (OECD 2009; World Bank 2012) i.e. the 'crowding out' mechanism (Popp and Newell 2012) to bias investments in favour of low carbon projects would crowd out other investments which could be socially and economically beneficial and would generate no positive impact on economic growth. Illustrative simulations conducted with the IMACLIM model at CIRED on Europe suggest that, in the short term, this device would boost investments and final demand by backing credit facilities with equipment and infrastructure as collateral and would accelerate the transformation of savings into productive investment. The crowding out would be against liquid financial products and speculation on real estate or raw materials.

The macroeconomic impact might be important because it implies incremental investment efforts (around 0.5% of the GDP over the forthcoming decades) with a high ripple effect, because the level of redirected investments is around 8%-9% of the gross capital formation[2]. This redirection puts the economy closer to its potential growth by reducing the savings glut and satisfies the social aims through low carbon techniques. In the long term, Schumpeter's claim that long-lasting innovation waves can take off only when their promises are supported by the 'animal spirits of finance' would become a reality. Instead of generating long-term investment shortfalls and repeated

1 This value corresponds to the social-economic and environmental value of mitigation actions and their co-benefits determined collectively at the national level as stressed within the Art 108 of the Paris Agreement. Such evaluations of the social cost of carbon (SCC) have been conducted for France (Quinet et al. 2009), the UK (Watkiss and Downing 2008)and the marginal damage costs of emissions, known as the Social Cost of Carbon (SCC) (U.S. Government 2010).

2 Simulations carried out on the basis of the World Energy Outlook of the International Energy Agency (IEA 2014) and published in (Hourcade et al. 2014).

speculative bubbles, these animal spirits would trigger the wave of 'green' innovation (Stern 2012; Stern and Rydge 2012) necessary for sustaining a long growth cycle – as did oil, automobile and mass production in the 20th century.

In addition to reducing the gap between the propensity to save and the propensity to invest, this device would help to reduce one of the major 'fault lines' of the world economy as highlighted by (Rajan 2010) an excessively export-led growth export strategy in developing countries which places them under disproportionate dependence on the ability of foreign consumers to pay. It forces them to constrain domestic demand, under-invest in infrastructure and under-value their currency. Governments are hesitant to alter this strategy because of the uncertainty of replacing the jobs lost from the export-led sectors in the domestic-oriented production sectors, and the risk of an excess protection of domestic-oriented production sectors resulting in inefficient projects. A CRA device would facilitate this strategic change if the CRAs were recognised in interbank payments, reducing the need for countries to grow their exports in order to amass a war chest of dollars. In addition to generating important north-south flows in support of the National Determined Contributions (NDCs) directed towards domestic markets and activities (Hourcade et al. 2015), it would respond to the IMF's warning about the lack of infrastructure investment (IMF 2014) and would contribute to inclusive development (World Bank 2012).

Conclusion

The Paris Agreement has opened a window of opportunity for the implementation of innovative financial mechanisms capable of removing the threat of secular stagnation. However, this window could rapidly close without concrete progress in future climate negotiations and without innovative financial experimentation by a country or a club of countries (Nordhaus 2015). It is important to act now, since overcoming path dependencies and resistance from some financial and political actors will obviously take time – as illustrated in recent history. The fact that the Roosevelt administration had to implement two "New Deal" programmes to obtain tangible results should make us think about the need to accelerate action.

References

Aglietta, M.; Espagne, É.; Perissin Fabert, B. (2015): A proposal to finance low carbon investments in Europe. France Stratégie. http://www.strategie.gouv.fr/sites/strategie.gouv.fr/files/atoms/files/bat_notes_danalyse_n24_-_anglais_le_12_mars_17_h_45.pdf

Averchenkova, A.; Stern, N.; Zenghelis, D. (2014): Taming the Beasts of 'Burden-Sharing': An Analysis of Equitable Mitigation Actions and Approaches to 2030 Mitigation Pledges. Policy Paper. Centre for Climate Change Economics and Policy Grantham Research Institute on Climate Change and the Environment.

Blanchard, O. (2015): Ten Take Aways from the 'Rethinking Macro Policy: Progress or Confusion?' iMFdirect - The International Monetary Fund's global economy forum. https://blog-imfdirect.imf.org/2015/05/01/ten-take-aways-from-the-rethinking-macro-policy-progress-or-confusion/

Fogel, R. W. (1964): Railroads and American Economic Growth: Essays in Econometric History. Baltimore: Johns Hopkins Press.

Hourcade, J. C.; Aglietta, M.; Perissin-Fabert, B. (2014): Transition to a low-carbon society and sustainable economic recovery: A monetary-based financial device. Study funded by the Caisse des Dépôts et Consignations, VINCI, BNP, and Entreprises pour l'Environnement under the umbrella of Entreprises pour l'Environnement. Cired/Cepii/CDC.

Hourcade, J. C.; Perrissin Fabert, B.; Rozenberg, J. (2012): Venturing into uncharted financial waters: an essay on climate-friendly finance. International Environmental Agreements: Politics, Law and Economics 12(2)165–186. doi: 10.1007/s10784-012-9169-y.

Hourcade, J. C.; Shukla, P.-R.; Cassen, C. (2015): Climate policy architecture for the Cancun paradigm shift: building on the lessons from history. International Environmental Agreements: Politics, Law and Economics 15(4)353–367. doi: 10.1007/s10784-015-9301-x.

IMF (2014): World Economic Outlook - Recovery strengthens, remains uneven. World Economic Outlook. Washington, DC: International Monetary Fund.

Krugman, P. R. (2009): The return of depression economics and the crisis of 2008. New York: Norton.

Landes, D. S. (1969): The unbound Prometheus: technological change and industrial development in Western Europe from 1750 to the present. Cambridge, UK: Cambridge University Press.

Lewis, C.; Pain, N.; Stráský, J.; Menkyna, F. (2014): Investment Gaps after the Crisis. OECD Economics Department Working Papers. Paris: Organisation for Economic Co-operation and Development. http://www.oecd-ilibrary.org/content/workingpaper/5jxvgg76vqg1-en.

Nordhaus, W. (2015): Climate Clubs: Overcoming Free-riding in International Climate Policy. American Economic Review 105(4)1339–1370. doi: 10.1257/aer.15000001.

OECD (2009): Declaration on Green Growth Adopted at the Meeting of the Council at Ministerial Level on 25 June 2009. [C/MIN(2009)5/ADD1/FINAL]. Organisation for Economic Co-operation and Development. https://www.oecd.org/env/44077822.pdf

Popp, D.; Newell, R. (2012): Where does energy R&D come from? Examining crowding out from energy R&D. Energy Economics 34(4)980–991. doi: 10.1016/j.eneco.2011.07.001.

Quinet, A.; Baumstark, L.; Célestin-Urbain, J.; Pouliquen, H.; Auverlot, D.; Raynard, C. (2009): La valeur tutélaire du carbone: Rapport de la commission présidée par Alain Quinet. No. 16. Paris: Centre d'analyse stratégique.

Rajan, R. G. (2010): Fault Lines: How Hidden Fractures Still Threaten the World Economy. Princeton, New Jersey: Princeton University Press. http://press.princeton.edu/titles/9111.html

Roe, M. J. (1994): Strong Managers, Weak Owners: The Political Roots of American Corporate Finance. Princeton, New Jersey: Princeton University Press. http://press.princeton.edu/titles/5547.html

Sirkis, A.; Hourcade, J. C.; Dasgupta, D.; Studart, R.; Gallagher, K.; Perrissin-Fabert, B.; et al. (2016): Moving the trillions: a debate on positive pricing of mitigation actions. http://www2.centre-cired.fr/IMG/pdf/moving_in_the_trillions.pdf

Stern, N. (2012): How we can respond and prosper: the new energy-industrial revolution. Presented at the Lionel Robbins Memorial Lectures, London School of Economics and Political Science. http://www.lse.ac.uk/assets/richmedia/channels/publicLecturesAndEvents/slides/20120222_1830_climateChangeAndTheNewIndustrialRevolution_sl.pdf

Stern, N.; Rydge, J. (2012): The New Energy-industrial Revolution and International Agreement on Climate Change. Economics of Energy & Environmental Policy 1(1)1–19. doi: 10.5547/2160-5890.1.1.9.

Summers, L. H. (2014): Bold reform is the only answer to secular stagnation. Blog Larry Summers. http://larrysummers.com/2014/09/08/bold-reform-is-the-only-answer-to-secular-stagnation/

U.S. Government (2010): Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866. United States Government, Interagency Working Group on Social Cost of Carbon. https://www.whitehouse.gov/sites/default/files/omb/inforeg/for-agencies/Social-Cost-of-Carbon-for-RIA.pdf

Watkiss, P.; Downing, T. (2008): The social cost of carbon: Valuation estimates and their use in UK policy. Integrated Assessment 8(1)85–105.

World Bank (2012): Inclusive Green Growth: The Pathway to Sustainable Development. World Bank Publications. http://elibrary.worldbank.org/doi/book/10.1596/978-0-8213-9551-6

Fighting climate systemic risk: from carbon pricing to monetary instruments

In this paper, we develop the notion of climate systemic risk as a necessary theoretical framework for the coherent use of monetary and financial instruments to fight climate change. Climate change is usually considered as a negative externality against which society can insure itself through a carbon tax or an emissions trading market. However, except under the unrealistic efficient market hypothesis, there is little chance that such a simple approach to climate policy can succeed in mitigating climate damages. A collective insurance approach to climate change must target the financial sector, as well as its articulation with monetary policy. Financial and climate fragility reinforce each other. As in the financial world, climate change constitutes a systemic risk against which specific ex ante and ex post monetary policies and financial regulations should be deployed. The Paris Agreement of COP21 ignores the policy consequences of such an approach to the climate threat, but the exegesis of the text still offers some indispensable pillars for promoting a new financial order for mitigating climate systemic risk.

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The importance of being systemic

Climate change impacts human societies and economies in both nonlinear and unpredictable ways. Tipping points can arise and irreversibly change both the state of the planet and the way we live on it. Analysis has shown that these tipping points arise from many sources: from the natural carbon cycle itself through the non-linear absorption rate of the ocean and the terrestrial biosphere, as well as its coupling with the climate[1]; and from the climate system through the rapid increase in the frequency and severity of extreme events, the melting of Greenland's ice-sheet, the abrupt change in ocean circulation, the strong increase in CO_2 and CH_4 emissions and the melting of the permafrost. Some of these changes happen slowly, accumulating unnoticed disequilibria over long periods of time; some are very sudden and unpredictable, arising at a specific geographical location on the planet, with potentially broader contagion affects.

There is thus a high level of uncertainty about the exact timing and impact of such events, not only because of the physical processes themselves, but also because they are intimately linked to human reactions and policies. Weitzman (2009) summarises this deep uncertainty with his now famous "dismal theorem": the probability distributions of many

1 The standard DICE model developed by Nordhaus (Nordhaus 1993) makes the hypothesis of a linear absorption rate of the ocean module.

whereby the rational behaviour of independent individual agents gives rise to a worse outcome for all, due to widespread market failures. An effective climate policy can, therefore, be considered as a collective insurance of society against its own potential destruction. It may only be possible to hedge climate systemic risk collectively.

climate parameters are such that the possibility of an extreme value cannot be ruled out. Uncertainty cannot be modelled through standard Gaussian centered distributions. Fat tails are a crucial element of representation of uncertainty. Indeed, the more we fail to act against climate change, the fatter the tails. Inaction is playing as a positive feedback loop against the stability of the climate system in probabilistic terms (Perrissin Fabert et al. 2014).

In such a theoretical framework, Weitzman argues that climate policies should be looking more at insurance theory than at traditional externality theory. However, the specifics and consequences of such an insurance approach are never fully developed, so the final recommendation echoes the usual anthem: “Price carbon, cap the flow of emissions, there is no other way out” (Wagner and Weitzman 2015). How can we induce from the insurance approach the definition of proper tool(s) to fight climate change? How can we insure society against an event that determines its own existence/destruction? Looking further, is the insurance analogy sufficient to stress out the climate change constraint? Or, in financial terms, how far can financial risk be hedged? In this paper, we attempt to understand the consequences of such a paradigmatic change in climate policies. To achieve this, we introduce the notion of climate systemic risk, by analogy with the notion of financial systemic risk. This notion, which was widely rediscovered to analyse the fragility of the financial sector immediately after the 2008 financial crisis, together with its policy implications for stabilising the system, can be used to partly tackle climate change issues. We discuss how it could pave the way for new types of climate policies, which would crucially complement traditional carbon pricing as well as Weitzman’s insurance approach.

Changing the carbon pricing mindset to a systemic risk one

At least two fundamental reasons can justify the transposition of this financial concept to climate. Firstly, climate change impacts are systemic in nature. They affect the whole planet, in most of its dimensions. They have the ability to profoundly change the Earth system as we currently know it. This is a first-level definition of a climate systemic risk. They also affect society along the way, either through global damage or through localised extreme events which can extend to larger areas via different channels - physical, social or financial. However, we cannot view these changes affecting societies and the Earth system as if they somehow come from the outside. These negative global effects are the product of endogenous forces. In this regard, an insurance approach, such as the one called for by Weitzman, can only be effective if it is collectively pursued. Individual insurance policies will be ineffective and could even be counterproductive in aggregate if they lead to avoidance behaviours, where each agent tries to escape the shared responsibility of the externalities. This is indeed the very nature of systemic risk: a situation

This leads us to the second reason why the notion of systemic risk is relevant for climate issues. Such a collective insurance of society is the equivalent of a value that society attributes to mitigation activities (Espagne et al. 2015). The vehicle of such a value can theoretically take multiple forms. In the world of efficient markets, and perfectly rational self-interested agents, a carbon price-only policy could serve the purpose, realigning prices and portfolios according to the collective value given to the climate externality, given anticipated scenarios of climate damage. However, in such a world systemic risk is also impossible, because it contradicts the fundamental hypothesis that markets provide the full available information about prospective climate damage scenarios.

Consequently, we face a crucial choice. Either persist with the efficient market hypothesis but then reject the “fat-tail” form of climate damage distribution shown by Weitzman, which is the possibility of a climate systemic risk. Or adopt the climate systemic risk hypothesis and then consider that a price-only mechanism will not be sufficient for preventing the occurrence of uncertain extreme events. Obviously, as demonstrated in the 2008 crisis, systemic events periodically arise in capitalist societies. Moreover, the fat-tailed form of climate damage adopted by Weitzman stems from the best available research on climate change. Therefore, we have to adopt the second choice. This means that the limitation of individual decisions through a set of rules, habits and intermediary institutions is not suboptimal, as it would

be in the world of efficient markets. It is rather a stabilising social force which helps aggregate individual expectations in line with the objectives of the legislator or the regulator. A key vehicle for these coordination mechanisms lies in finance and in the institution of money. Financial fragility to external risks may increase climate fragility through negative externality effects. Conversely, climate fragility incurs new risks that may reinforce financial fragility. Climate policy should then fully integrate the payment system structure into the carbon pricing debate (Aglietta and Espagne 2016).

Getting practical: the necessary transformation of financial and monetary institutions

COP21 was conceived as a large multilevel discussion process which goes beyond the traditional actors of the UNFCCC negotiations. The French presidency has named this attempt to include all social, economic and regional actors in the Paris Alliance. Section V paragraph 133 of the Decision officially recognises the financial institutions as key actors for change. The Governor of the Bank of England, Mark Carney, underlined in his speech in 2015 (Carney 2015) the great danger looming from what he called the tragedy of the horizons: the temporal mismatch between the financial investor's agenda, the financial regulators and the constraining physical climate change process. This seminal speech triggered new policy initiatives for 2016: the Financial Stability Board was tasked by the G20 in Antalya (November 2015) to study methods appraising climate risk included in financial portfolios and to propose a voluntary disclosure process to financial actors; and the G20 in Shanghai (February 2016) gave the Bank of England and the People's Bank of China the mission to investigate the reality of climate change as a financial risk, as highlighted in Mark Carney's speech.

These results, however, fall short of acknowledging the full implications of climate change for societies, the economy and the financial system. Voluntary disclosures cannot mitigate climate risk in a reliable way, in the same way as shared public/private banking stress-tests are never effective in restoring confidence. Furthermore, the joint realisation of three highly correlated risks cannot have less than systemic consequences for the financial system. Climate change constitutes a typical example of a systemic risk for societies as well as the financial system. This disclosure, as well as its policy implications, seems to have been the elephant in the room at both the UNFCCC process and the broader Paris Alliance. Consequently, it is also the main task of climate research in all disciplines to characterise this systemic risk on all levels.

References

Aglietta, M.; Espagne, É. (2016): Climate and Finance Systemic Risks, more than an Analogy? The Climate Fragility Hypothesis. No. 2016–10. Working Paper CEPII. Paris: CEPII.

Espagne, É.; Hourcade, J. C.; Perrissin Fabert, B. (2015): La finance au secours du climat ? La Nature entre prix et valeur. Natures Sciences Sociétés, (Supp. 39),117–121. doi: 10.1051/nss/2015027.

Perrissin Fabert, B.; Pottier, A.; Espagne, E.; Dumas, P.; Nadaud, F. (2014): Why are climate policies of the present decade so crucial for keeping the 2 °C target credible? Climatic Change 126(3–4)337–349. doi: 10.1007/s10584-014-1222-0.

Wagner, G.; Weitzman, M. L. (2015): Climate shock: the economic consequences of a hotter planet. Princeton: Princeton University Press.

Weitzman, M. L. (2009): On Modeling and Interpreting the Economics of Catastrophic Climate Change. Review of Economics and Statistics 91(1)1–19. doi: 10.1162/rest.91.1.1.

Financing urban climate action: is the issue really creditworthiness?

Since around 2008, Climate Investment Funds have highlighted city creditworthiness as a major barrier to more robust municipal investment in sustainable infrastructure and climate mitigation and adaptation. This paper reviews the magnitude of the necessary infrastructure investment, current patterns of capital flows and potential new private investors, finding that current resources amount to less than 10% of annual needs. It discovers that private sector willingness to invest is rising as climate risk disclosure becomes more widespread. Consequently, it concludes that project investment characteristics, as opposed to city creditworthiness, are the main considerations for attracting capital, and that financial instruments and urban infrastructure designs must both be modified if the capital needed is to be available for addressing climate change in cities.

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Introduction

Climate change responses are not limited to actions by the national state or major private sector institutions. Subnational public bodies, especially cities, have a major role to play in both adaptation and mitigation. The infrastructure needs of the world's growing cities over the next 15 years, whether or not they are sustainable and responding appropriately to climate change, will require in excess of USD 6 trillion annually. The current flow of funds, whether from own sources, national governments or international pools of monies, amounts to billions, which falls well short of the necessary amount.

The most common explanation for the lack of finance for urban infrastructure investment is the claim that cities lack creditworthiness and thus cannot raise needed funds. This is a claim made especially with respect to those countries with the most rapidly growing megacities. One recent study found that only 4% of the 500 largest cities in developing countries were creditworthy in international financial markets, with 20% creditworthy in local markets (World Bank 2013). This paper examines this argument about capital access.

We consider both the pre and post COP21 climate finance initiatives in considering what it will actually take to generate the needed capital for both mitigation and adaption by cities. In particular, we question the creditworthiness claim. We review past capital generating efforts and current critiques and conclude that capital markets fail to allocate funds in ways that appropriately incorporate all the risks – and risk avoidance – associated with different investments in an era of ongoing climate change.

Methodology/ongoing activities

We reviewed the major international financing and related initiatives addressed at financing sustainable cities, sustainable infrastructure, and urban climate change mitigation and adaptation. The financing problem becomes immediately obvious when comparing the annual need over the next 15 years to the apparent supply. Needed global infrastructure investment has been estimated to be as much as USD 6.5 trillion annually (Cities Climate Finance Leadership Alliance 2015), but only USD 359 billion was invested internationally in 2012, falling to USD 331 billion in 2013 (Buchner et al. 2014).

Major international initiatives date back to before COP20 in Copenhagen. Examples include:

- UNFCCC launch of the Green Climate Fund (GCF) in 2010, with USD 10 billion of initial pledges from donor countries and a target of USD 100 billion annually for developing countries.
- The World Bank Group's launch of the **Low Carbon, Livable Cities** (LC2) initiative at the Clinton Global Forum in New York in September, 2013.
- The **City Creditworthiness Initiative** – created by LC2, based on the calculation that every USD 1 invested in creditworthiness can leverage over USD 100 in private sector financing.
- UN and partners' longstanding **Compact of Mayors** – a partnership developing tracking and accountability protocols to encourage capital flows to cities, which now builds on the Global Protocol for Community

Scale Greenhouse Gas Emission Inventories (GPC).

- **Inter-American Development Bank's Emerging and Sustainable Cities Program** – reflecting the commitment of one of the multinational banks to working directly with cities. It takes the form of a technical assistance investment in city capacities to develop climate adaptation programmes.

Since 2015, leading up to and emerging from COP21 in Paris, new initiatives now promise substantially higher levels of private sector investment in urban climate change, including:

- The UN's Sustainable Development Goals now specifically emphasise urban action: "Make cities and human settlements inclusive, safe, resilient and sustainable".

- The new UNFCCC-governed mechanism as part of the Paris Agreement enables international transfers of emission reductions while delivering overall global mitigation.

- The NAZCA report that 2364 cities had taken some action on climate change by 2016.

- Publicly-funded Green Investment Banks have begun to prove their value in leveraging private investment and demonstrating that projects are bankable (OECD 2016).

- The Climate Investment Funds, since around 2008, have finally started to vigorously target pension funds and their assets of over USD 35 trillion as potential infrastructure investors.

- Aviva, Aegon and Amlin, insurers with combined assets of more than USD 1.2 trillion and many coverages vulnerable to climate risks, called on the G20 in August 2016 to end their annual fossil fuel subsidies and investments of over USD 550 billion by 2020.

- **Breakthrough Energy Coalition** (Breakthrough Energy Coalition n.d.) involves major corporate CEOs who have decided to 'form a network of private capital committed to building a structure that will allow informed decisions to help accelerate the change to the advanced energy future.'

- **Caring for Climate** (Caring for Climate 2015) was launched for COP21, 'mobilizing business leaders to implement and recommend climate change solutions and policies by advancing practical solutions, sharing experiences, informing public policy and shaping public attitudes.'

At the same time, an increasing number of business and investment institutes/accounting standards are requiring climate risk disclosure as part of investment underwriting. The more this occurs in the private sector, the more investors will see public sector climate mitigation efforts as reducing risk for their other investments. This potential risk mitigation through investment in urban climate change responses is most valuable to long-term investors, pension funds and insurers (who need an assured source of liquidity) – and these entities control the majority of private investment capital.

Results/findings

The investment pattern to date does not yet reflect this new reality. The Asset Owners' Disclosure Project (Asset Owners' Disclosure Project 2016) reports on some USD 38 trillion invested by these long-term investors and found that only 1% of insurers and 6% of pension funds address stranded assets as potential risks, while a mere 8% of insurers assess any climate risks in their investments (although 16% of pension funds do so). In summary, only USD 30 billion of insurance assets are in low carbon investments; pension funds, with even more assets, have invested only USD 63 billion.

In fact, the CCFLA (Cities Climate Finance Leadership Alliance 2015) has identified six major barriers to overcome:

"1. Uncertainty over … policies that affect low-emission, climate-resilient infrastructure;

2. Difficulty in incorporating climate goals into urban infrastructure planning;

3. Lack of city expertise in developing … infrastructure projects that can attract financing;

4. Insufficient city control over infrastructure planning and complex stakeholder coordination;

5. High transaction costs; and

6. Lack of proven funding models at the city level."

Conclusion

Real climate-related risks are being ignored and investment opportunities overlooked at present. *The Global Risk Report 2016* (World Economic Forum 2016) found that:

"The risk rated most likely was large-scale involuntary migration, with last year's top scorer – interstate conflict with regional consequences – giving way to the environmental risks of extreme weather events and the failure of climate change mitigation and adaptation and followed by major natural catastrophes."

The GEF went on to criticise the financial sector, noting that, "despite increasing recognition of the economic risks [of climate change], global financial systems are yet to incorporate them into financial decision-making."

There is clearly an opportunity to attract investment, if cities can limit project risks by redesigning their infrastructure investment processes. To the extent that projects can show co-benefits and address pension fund fiduciary obligations and insurers' liquidity needs, they can tap into vast funds from sectors that have yet to invest directly in climate change mitigation and adaptation.

The issue for international lending institutions may be city creditworthiness, but the issue for the private sources of the majority of investment capital available globally in any year is project risk and return, which can be isolated by design and ownership structures from city finances.

References

Asset Owners Disclosure Project (2016): Insurers lag behind pension funds on tackling climate risk, threatening financial shock. http://aodproject.net/insurers-lag-behind-pension-funds-on-tackling-climate-risk-threatening-financial-shock/

Breakthrough Energy Coalition (n.d.): Breakthrough Energy Coalition. http://www.b-t.energy/coalition/

Buchner, B.; Stadelmann, M.; Wilkinson, J.; Mazza, F.; Rosenberg, A.; Abramskiehn, D. (2014): The Global Landscape of Climate Finance 2014. Climate Policy Initiative. http://climatepolicyinitiative.org/wp-content/uploads/2014/11/The-Global-Landscape-of-Climate-Finance-2014.pdf

Caring for Climate (2015): Caring for Climate Business Forum. http://caringforclimate.org/

Cities Climate Finance Leadership Alliance (2015): The State of City Climate Finance 2015. New York: CCFLA. http://www.citiesclimatefinance.org/wp-content/uploads/2015/12/CCFLA-State-of-City-Climate-Finance-2015.pdf

OECD (2016): Green Investment Banks: Scaling up Private Investment in Low-carbon, Climate-resilient Infrastructure. Green Finance and Investment. Paris: Organisation for Economic Co-operation and Development Publishing. http://www.oecd-ilibrary.org/finance-and-investment/green-investment-banks_9789264245129-en

World Bank (2013): Planning and Financing Low-Carbon, Livable Cities. http://www.worldbank.org/en/news/feature/2013/09/25/planning-financing-low-carbon-cities

World Economic Forum (2016): The Global Risks Report 2016. No. 11. World Economic Forum. http://www3.weforum.org/docs/Media/TheGlobalRisksReport2016.pdf

Climate-related development finance and the Paris Agreement - challenges and opportunities for the work of the OECD Development Assistance Committee

Development finance and co-operation plays a key role in supporting partner countries to act on climate change and deliver commitments under the Paris Agreement. The Organisation for Economic Co-operation and Development (OECD) Development Assistance Committee (DAC) has tracked finance in support of the Rio Conventions since 1998 and promotes the effectiveness of environment-related development co-operation efforts. In response to ongoing international negotiations, the DAC has and continues to review and adjust the methodology used to monitor environment-related development finance in order to remain a key reference for tracking progress and reporting on finance in support of the Rio Conventions. One important area of the DAC's work is to understand how development finance can be used to mobilise the private sector to deliver climate change mitigation and adaptation efforts in developing countries.

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Introduction

Development finance and co-operation play a key role in supporting partner countries to act on climate change and deliver commitments under the Paris Agreement. Bilateral climate-related development finance from DAC members amounted to USD 25 billion on average in 2013-2014, or around 18% of total bilateral overseas development assistance (ODA). This figure has been increasing steadily since 2002. The quality of climate-related development finance, in terms of its impact in delivering mitigation and adaptation in partner countries, is as important as the magnitude of the finance mobilised. In addition, with the increasing recognition of the scale of investment needed for the transition to a low carbon and climate-resilient development pathway, there is the need for climate-related development finance to be applied catalytically in order to leverage other forms of investment from the private sector and philanthropic organisations.

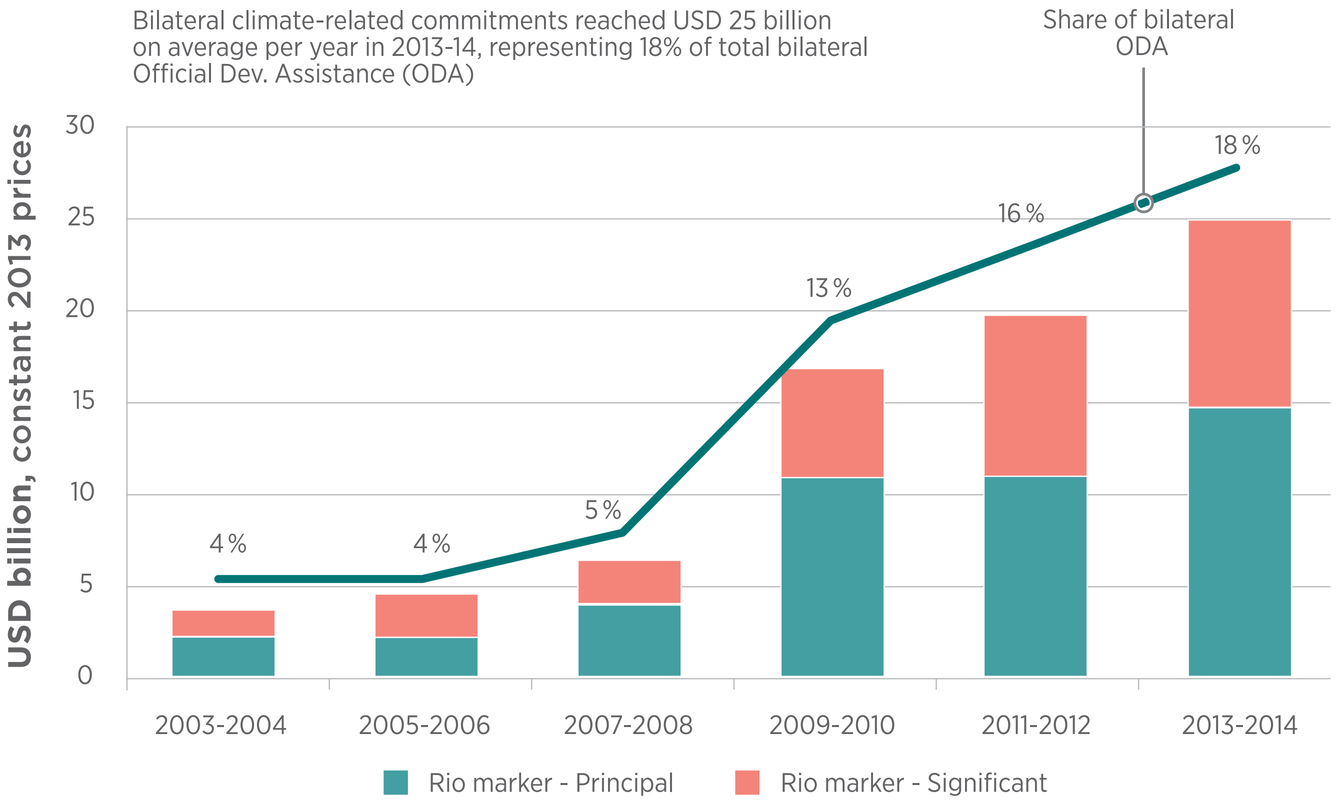

Fig. 1: Bilateral ODA from DAC members and climate-related development finance -
Source: OECD-DAC, 2013-14 average, USD constant 2013 prices

Tracking climate-related development finance

Since 1998, the OECD Development Assistance Committee (DAC) has monitored finance in support of the Rio Conventions on climate change, biodiversity and desertification, using the so-called "Rio markers"[1]. The Rio markers provide an indication of the degree of mainstreaming of environmental considerations into development co-operation portfolios by requesting DAC members to indicate for each activity whether it targets the objectives of the Conventions:

1. As a "principal" objective: the activity would not have been funded but for that objective;
2. As a "significant" objective: the activity has other prime objectives but has been formulated or adjusted to help meet the relevant environmental concerns;
3. Not targeting the objectives.

Over time, and in response to ongoing international negotiations, the demand for data and monitoring has changed, in part to facilitate the tracking of agreed financing targets. In response, the DAC has continued to work on improving transparency, access and use of climate-related development finance to ensure that it remains a key reference for tracking progress and reporting on climate finance commitments. One important development is that the Rio marker data from 2013 onwards now captures an integrated picture of both bilateral and multilateral climate-related development finance.

Ongoing efforts to modernise the DAC statistical system focus on aligning incentives for effective resource mobilisation in support of the 2030 Agenda for Sustainable Development, including on climate. This includes the introduction of grant equivalents as a basis for measuring and reporting ODA; the modernisation of how private sector instruments are measured; and the expansion of the coverage of the statistical system to include the collection of amounts mobilised by official development interventions from the private sector. Work on the last issue is undertaken in close collaboration with the OECD-led Research Collaborative on Tracking Private Climate Finance. The Research Collaborative has explored different methodologies for estimating the mobilisation effect of the range of different and interacting public finance and policy interventions and developed a four-stage framework to structure and guide such efforts (Jachnik et al. 2015). Building on these efforts and DAC expertise, the OECD in collaboration with CPI produced estimates of climate finance in 2013-14 to provide transparency on the progress being made towards the commitment by developed countries under the UNFCCC process to mobilise USD 100 billion a year by 2020 for climate action in developing countries (OECD 2015a).

Promoting the catalytic use of climate-related development finance

There is increased recognition that delivering the Paris Agreement and transitioning to a low carbon, climate-resilient pathway will require significant finance and investment. Public finance plays a critical role in catalysing, leveraging and guiding such investment; however, large-scale private sector engagement and investment will be needed to enable this transition. In recognition of this, an emerging area of DAC's work in the last few years has been to understand how

1 Reporting on climate change mitigation, biodiversity and desertification was introduced in 1998, while a complementary marker for climate change adaptation was adopted in 2009.

development finance can be used to better mobilise private sector engagement for addressing climate change.

Initial findings from DAC's work on this topic highlight that development co-operation providers are increasingly engaging with private sector actors to address climate change. In 2013, for example, up to 20% of climate-related development finance supported activities to engage the private sector, with the majority of the finance being deployed for climate change mitigation and by upper middle income countries (Crishna Morgado et al. forthcoming). Different actors in the development finance landscape play complementary roles in this area:

- Aid agencies and development co-operation providers use technical assistance and provide advisory support to developing country partners to strengthen policies and regulations, improve governance and institutions and improve the financial sector, in order to create the right 'enabling environment' for private sector engagement. They also play an important role in catalysing private investment in countries where the perceived risks of investment are high (e.g. conflict and fragile states, LDCs, SIDs).
- Development finance institutions and development banks use a range of instruments to mitigate the risks associated with green investment in developing countries and attract much needed private investment. One growing area of effort is the 'blending' of concessional public finance with other forms of finance to leverage private investment. For example, the World Economic Forum estimates that funds and facilities supporting blended finance accounted for over USD 25 billion in total assets in a recent survey - just under 6% of these assets targeted clean energy and climate resilience.

DAC's work on private sector engagement for climate change also highlights the challenges and initial lessons learned from member expe rience. Development providers face several challenges in applying private sector engagement (PSE) approaches for green growth and climate change, including a general lack of evidence on the extent to which these efforts have resulted in wide-ranging environmental outcomes (beyond the mobilisation of private investment), the need to better align PSE approaches with national priorities for climate change, and the need to go beyond pilot projects and to scale up successful approaches. Several best practice examples are also emerging, such as the importance of finding common ground and 'speaking the language' of private sector partners, understanding the demand from the private sector for development finance support, and using approaches that integrate support for policy frameworks with project level instruments for infrastructure.

Conclusion

With increasing emphasis on development finance providers to scale up climate action and deliver finance commitments under the Rio Conventions, and to use their contributions catalytically to engage other forms of investment, efforts to bring the development co-operation community together on environment and climate change are crucial. In this context, and in light of the SDGs and the Paris Agreement, the DAC will continue to play an important role in the coming years in promoting more and better aid for the environment.

References

Crishna Morgado, N. et al. (forthcoming): Engaging the private sector for green growth and climate change. OECD Development Co-operation Working Paper. Paris: OECD.

Jachnik, R.; Caruso, R.; Srivastava, A. (2015): Estimating Mobilised Private Climate Finance: Methodological Approaches, Options and Trade-offs. OECD Environment Working Papers. Paris: Organisation for Economic Co-operation and Development. http://www.oecd-ilibrary.org/content/workingpaper/5js4x001rqf8-en

OECD (n.d.a): Amounts mobilised from private sector for development. Organisation for Economic Co-operation and Development. http://www.oecd.org/development/stats/mobilisation.htm

OECD (n.d.b): Research Collaborative: Tracking Private Climate Finance. Organisation for Economic Co-operation and Development. https://www.oecd.org/env/researchcollaborative/

OECD (2015a): Climate finance in 2013-14 and the USD 100 billion goal. A report by the Organisation for Economic Co-operation and Development in collaboration with Climate Policy Initiative. OECD. http://www.oecd.org/environment/cc/OECD-CPI-Climate-Finance-Report.pdf

OECD (2015b): Climate-related development finance in 2013-14. Paris: Organisation for Economic Co-operation and Development. https://www.oecd.org/dac/environment-development/Climate-related-dev-finance-ENG.pdf

OECD (2016): Converged Statistical Reporting Directives for the Creditor Reporting System (CRS) and the Annual DAC Questionnaire. DCD/DAC(2016)3/ADD1/FINAL, DCD/DAC(2016)3/ADD2/FINAL. Organisation for Economic Co-operation and Development. https://www.oecd.org/dac/stats/DCD-DAC(2016)3-ADD1-FINAL-ENG.pdf; https://www.oecd.org/dac/stats/DCD-DAC(2016)3-ADD2-FINAL-ENG.pdf

World Economic Forum (2016): Insights from Blended Finance: Investment Vehicles & Facilities. REF 160715. ReDesigning Development Finance Initiative: A joint initiative of the World Economic Forum and the OECD. Cologny/Geneva. http://www3.weforum.org/docs/WEF_Blended_Finance_Insights_Investments_Vehicles_Facilities_report_2016.pdf

How to motivate to pursue low carbon sustainable develo

cities and pment?

Due to the close relationship between these international goals, it is becoming increasingly evident that the process of designing low carbon transition pathways should be placed firmly within the context of the SDGs. This requires researchers and policymakers concerned with climate change to explicitly consider potential co-benefits as well as negative cross-impacts and solutions to trade-offs at early stages. Cities, as hotspots of future sustainable development, and low carbon societies are important arenas as well as actors for the long-term transitions required.

Visions for post-carbon cities

Due to the fact that a large share of global greenhouse gas emissions originates in urban areas, cities worldwide are key players in carbon reduction strategies. Therefore, in the framework of the EU funded research project POCACITO[1], workshops were organised in different European cities during which vision building and backcasting exercises were conducted to identify a transition process towards post-carbon cities. This contribution presents the outcomes of a set of vision building exercises undertaken with city representatives. The analysis shows that the specific mix of strategies envisaged for each city is influenced by local characteristics. Meanwhile, economic considerations, such as the cities' GDP per capita, seem to be less influential in driving the policy mix.

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Introduction

Urban policies are crucial for global strategies aiming to reduce greenhouse gas emissions. A significant proportion of global greenhouse gas emissions are attributed to urban areas, with figures suggesting they account for as much as 80% of global emissions (Duren and Miller 2012; Satterthwaite 2008). It is, therefore, crucial that cities, which are the centre of economic and social activities, become key players in carbon reduction strategies worldwide. Recognising both their importance, and the potential that urban action can have for global mitigation, many cities have already initiated ambitious strategies for the reduction of carbon emissions in their areas - often independent of national policy frameworks (Carmin et al. 2012; Castán Broto and Bulkeley 2013; Reckien et al. 2014). The most ambitious strategies target the concept of "Post-Carbon Cities", which is conceived as a development based on a rupture in the trajectory of carbon-dependent urban development. The term post-carbon, as defined in the POCACITO Project, emphasises the process of transformation connected to a shift in paradigm, which is necessary for responding to the multiple challenges of climate change, ecosystem degradation, social equity and economic pressures (Ridgway et al. 2014).

Methodology

Given the high levels of inertia of urban ecosystems (Vidalenc and Theys 2013), disruptive urban trajectories need to be conceived and planned on time horizons which stretch well beyond those considered in normal planning processes. Foresight exercises, framed as systematic vision building processes, offer the necessary framework for reflecting on how to enable action leading to such fundamental changes. Future scientific methodologies can be useful for dealing with the long timeframes and the increasing uncertainties these timeframes entail. Of these, scenario building techniques, in particular, can be used for addressing future uncertainties, as they are more flexible in taking into account innovative impacts and changes in trends and are, at the same time, sufficiently formalised for producing outputs which are robust and thus credible for providing policy support. The scenarios can also be sufficiently ambitious to represent the radical policy changes needed for a post-carbon transition which will change the urban shape, urban carbon performance and ultimately urban lifestyles.

Rather than providing reliable predictions of the future, scenarios support the learning process about factors and trends conditioning future developments (Schoemaker 2004). In the literature, it is widely agreed that scenarios represent structured and systematic forms of constructing "possible futures" and can provide useful input for policy processes. Different scenario typologies can be distinguished according to trajectories, for instance, such as "predictive, explorative and normative" (Börjeson et al. 2005). Of these, the normative scenarios are of particular interest for the post-carbon transitions, as they describe how a certain future can be reached rather than exploring which future ob-

1 This project has received funding from the European Union's Seventh Framework Programme for Research, Technological Development and Demonstration under grant agreement no 613286 (www.pocacito.eu)

served trends or policy interventions might evolve.

Part of the normative scenario is the "backcasting" technique, which explores the way "… desirable futures can be attained" (Robinson 1990). It is based on working backwards from a specific desired future end-point (the vision) to the present, to determine the physical feasibility of that future and to identify the policy actions required and their timing to reach that point, while taking into account possible obstacles and opportunities.

Within foresight studies, the participatory element plays a prominent role. The term 'foresight' has been defined as a "systematic, participatory, future-intelligence-gathering and medium-to-long-term vision-building process aimed at enabling present-day decisions and mobilising joint actions" (Gavigan et al. 2001; Van Cutsem 2010). This definition, which is used by the European Foresight Platform, has been adopted in the POCACITO project.

During the workshops organised in the POCACITO case study cities, vision building and backcasting exercises were conducted to identify the transition process towards post-carbon cities. The final aim of the analysis was to provide elements for the definition of a roadmap towards post-carbon urban futures which is suitable for different European urban realities, and thus takes into consideration different needs and policy priorities from which to start a transition process.

In each city, visioning and backcasting workshops followed a common three-step procedure, involving different types of stakeholders considered potentially relevant for the local context. The starting point used in the workshops consisted of the creation of a common view of the baseline and was based on the description of the actual situation of the single city made using the common set of indicators developed in the project (Silva et al. 2014), which aims to assess and monitor the post-carbon city transition process. The discussion with the participating stakeholders of the results from the data collection for this indicator set represented the starting point for the second step, during which the stakeholders designed and discussed elements for a local post-carbon vision. In a third step, the backcasting scenario was built, during which the vision was made tangible by identifying actions, timelines and obstacles to reaching goals.

In the workshops, a creative brainstorming technique was employed to induce stakeholders to first envision the future of their city, then develop qualitative scenarios describing how the transition to their post-carbon vision might be translated into single steps or actions. Obstacles and opportunities expected to be encountered along the way were identified and actions needed to meet future goals were highlighted. The feasibility and robustness of scenarios were tested to consider how the scenarios might work in an alternative socio-economic environment to the business-as-usual scenario.

Common to all workshops, the future vision for the city represented the normative end point, different to the one that could be reached without specific dedicated action. Stakeholders were encouraged to imagine how their city should look in 2050 as a post-carbon city. The backcasting workshop was

based on the visioning process and developed the pathway from the current situation towards the post-carbon vision. Specifically, the aim was to engage stakeholders in identifying the intermediate steps for the future actions, measures and strategies for urban management required to achieve the vision. The qualitative scenario intended to reflect local challenges identified through the initial assessment of the case study city.

The range of case study cities provided coverage of different geographic areas and socio-economic conditions in the EU Member states. The cities involved were Barcelona, Lisbon, Istanbul, Litoměřice (Czech Republic), Malmö, Milan, Rostock (Germany), Turin and Zagreb. All the cities had already introduced some activities to mitigate climate change, so they all had some initial experiences when they attended the POCACITO workshops.

Findings

The urban post-carbon visions developed envisage changes in many different policy sectors, mainly those where urban administrations are responsible or have some autonomy for decision making. In addition to energy policies (where the possibility of change at local level is limited), the sectors considered in the visions encompass many aspects of the urban policies that contribute to shaping future patterns of energy consumption. This includes both the design of urban form and growth, and the energy performance of single buildings and transport, alongside aspects of waste management and consumption.
Furthermore, economic development was considered as a central issue in the visions of several cities, specifically promoting technological change and research activities in the private sector to support innovators and innovative business models, and to increase tourism. Technological change was also seen as a field of action not primarily for creating new technological options for urban infrastructure, but rather as a means of economic development; issues such as tourism and protecting or enhancing biodiversity were seen as direct or indirect means of improving urban quality within existing development paths. Economic innovation was addressed with reference to the "circular economy", mentioning changes in consumption patterns and in waste management. The content of the visions was not restricted to decarbonisation alone, but also encompassed fundamental elements of a sustainability vision, such as social justice or improved governance. The visions for 2050 in the case study cities were described in different ways, yet all shared common themes and overlapping ideas for the future. For comparison, the main points of each vision have been categorised in twelve sectors: transport and mobility, energy, land use and infrastructure, social issues, economy, biodiversity and conservation, technology and innovation, education, tourism, governance, food production, and consumption and waste.

The sectors addressed varied from city to city. For example, Turin concentrated on issues connected to transport, including land use changes and the local economy, also addressing tourism. In contrast, in Litoměřice, nearly all the sectors were addressed.

The coverage of sectors by the visions sheds light on the importance attributed by the cities to certain policy areas which, in turn, gives an initial indication of potential areas to be addressed in a European roadmap. Urban transport and mobility and related adequate land use planning, as well as economic changes and energy-related issues, were prominent issues addressed by all the cities.

Social issues were included in the visions of seven of the cities, and consumption and waste were included in six. Technology and innovation and governance were discussed by five of the cities. Half of the cities covered education, tourism and food production. The importance of biodiversity was seen, at least in this context, as less crucial: only three cities addressed biodiversity and conservation in their visions.

Results from the eight case study cities show similar elements in the actions proposed by local stakeholders. All the cities paid great attention to the transport and

energy sectors, where many of the envisaged actions are concentrated. The actions largely focus on non-fossil energy generation, new energy efficiency at building level, increasing the quality of public transport, decarbonising private transport and increasing the share of non-motorised movement (e.g. walking and cycling).

Further to these “carbon focused” urban issues in the transition to post-carbon cities, as defined by the objectives of the POCACITO project, some actions contain, to a greater or lesser extent, goals relating to local economic development and social inclusion. An interesting fact is the importance attributed to urban governance. The role of public policies for achieving goals described in the post-carbon visions is considered crucial by many stakeholders and in most cities; in some cases it coincides with significant opportunities for participation and social inclusion. In connection to this, the call for “education” was mainly understood as a tool for awareness-raising for the promotion of more conscious behaviour by citizens as a first step toward active involvement in post-carbon strategies. Interestingly for a study on European cities, some strategies also addressed education as an issue related to social justice, proposing actions that promote access to all forms of education for all.

Some of the cities, particularly those with relatively low GDP, emphasised the promotion of their urban economies and articulated the desire to become more competitive in attracting investment. For example, measures to directly promote economic development were prominent in the actions suggested in the workshop in Istanbul. They also envisioned indirect measures, such as improvements to the quality of urban spaces and the creation of new attractions etc., as these contribute to increasing the cities’ ability to attract new investment. Similar activities were also foreseen in other cities with a relatively low or decreasing level of GDP, such as Lisbon, Turin and the two post-communist cities, Zagreb and Litoměřice. The orientation towards the need to attract new economic development is less pronounced in the other cities but, nevertheless, this area was included in all the visions. A specific role is reserved for urban tourism in this context, as high quality urban spaces can attract tourism, thereby translating urban quality directly into a precondition for urban economic development. Further to this relationship between urban quality and economic development, there was very little awareness of the potential synergy between decarbonisation strategies and economic development. The high priority attributed to economic activities, compared to those directly connected to decarbonisation, could be interpreted as an indication that economic wealth is considered as a prerequisite for activating new strategies related to decarbonisation. The potential impact of increasing economic activities and, in turn, increasing energy demand and carbon emissions, is reflected in some of the visions targeting the transition of the urban economy into a sustainable low carbon economy. In the visions for Barcelona and Milan, this aspect is not explicitly noted; only increased competitiveness or increasing the use of smart technologies is envisaged as a goal.

Some importance is also given to technological innovation, seen mainly as a means of enhancing the competitiveness of urban areas. Interestingly, the decarbonisation of industrial production, or in the services sector, was not addressed at all, except to be implicitly included in the consideration of the decarbonisation of the heating and cooling of buildings (in relation to the services sector). Technological innovation as an instrument for new energy generation was not addressed as an important priority; the actions pointed to existing technologies (e.g. smart technologies, electric and hybrid cars etc.).

Aspects relating to the quality of the urban environment were addressed either as part of sector-oriented strategies (e.g. increasing mobility on foot and by bike; conserving and enhancing biodiversity) or as an instrument for economic growth (e.g. a more attractive urban environment could have the value of increasing tourism and bringing economic benefits).

Conclusion

The analysis shows that the specific mix of strategies envisaged for each city was influenced by local characteristics such as geographical location and city size. There were also different points of departure with regards to emission reductions (greater or smaller achievements in terms of CO_2 intensity). In contrast, economic considerations, such as the level of GDP per capita, seem to be less influential in driving the policy mix.

The relative homogeneity of the results and the high rate of correspondence of issues considered in the international debate on post-carbon transitions could be interpreted as a bottom-up endorsement of these arguments.

However, it could also be seen as the result of a relatively high level of uniformity in the composition of stakeholder groups across the local case study workshops, raising the question of how visions and scenarios might be developed in a forum not composed mainly of "educated middle-class representatives".

References

Börjeson, L.; Höjer, M.; Dreborg, K.-H.; Ekvall, T.; Finnveden, G. (2005): Towards a user's guide to scenarios: A report on scenario types and scenario techniques. http://www.diva-portal.org/smash/record.jsf?pid=diva2:497896

Carmin, J.; Nadkarni, N.; Rhie, C. (2012): Progress and Challenges in Urban Climate Adaptation Planning: Results of a Global Survey. Cambridge, USA: Massachusetts Institute of Technology.

Castán Broto, V.; Bulkeley, H. (2013): A survey of urban climate change experiments in 100 cities. Global Environmental Change 23(1)92–102.

Duren, R. M.; Miller, C. E. (2012): Measuring the carbon emissions of megacities. Nature Climate Change 2(8)560–562.

Gavigan, J. P.; Scapolo, F.; Keenan, M.; Miles, I.; Farhi, F.; Lecoq, D.; Capriati, M.; Di Bartolomeo, T. (2001): FOREN Guide: Foresight for Regional Development Network: A Practical Guide to Regional Foresight. Brussels, Belgium: European Commission.

Reckien, D.; Flacke, J.; De Gregorio Hurtado, S.; Salvia, M.; Heidrich, O.; Dawson, R. J.; et al. (2014): Urban climate change response and the impact of climate networks in Europe. In R. J. Dawson, A. Wykmans, O. Heidrich, J. Köhler, S. Dobson, and E. Feliú (Eds.), In: Understanding Cities: Advances in integrated assessment of urban sustainability. Newcastle upon Tyne, UK: Centre for Earth Systems Engineering Research (CESER), Newcastle University.

Ridgway, M.; Knoblauch, D.; Eriksson, E.; Ljungkvist, H.; Harris, S.; Breil, M.; Baloue, S.; Weingartner, K. (2014): Common Approach Framework Document. Deliverable for the POCACITO project. http://pocacito.eu/sites/default/files/D1_2_Common_Approach_Framework_Document_0.pdf

Robinson, J. B. (1990): Futures Under Glass: A Recipe for People Who Hate to Predict. Futures 22(8)820–842. doi: 10.1016/0016-3287(90)90018-D.

Satterthwaite, D. (2008): Cities' contribution to global warming: notes on the allocation of greenhouse gas emissions. Environment and urbanization 20(2)539–549.

Schoemaker, P. J. H. (2004): Forecasting and Scenario Planning: The Challenges of Uncertainty and Complexity. In D. J. Koehler and N. Harvey (Eds.), In: Blackwell Handbook of Judgment and Decision Making. Malden, MA, USA: Blackwell Publishing Ltd. http://doi.wiley.com/10.1002/9780470752937.ch14

Silva, C.; Selada, C.; Mendes, G.; Marques, I. (2014): Report on Key Performance Indicators. Project Report D1.2. Berlin, Germany: Ecologic Institute.

Van Cutsem, M. (2010): Cities of tomorrow - Challenges, visions, dys-visions as seen by cities. Bruxelles: Institut Destree and European Commission (DG Regio). http://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/citiesoftomorrow/citiesoftomorrow_foresight.pdf

Vidalenc, E.; Theys, J. (2013): Towards post carbon cities: Why? How? eceee 2013 Summer Study. Toulon/Hyères, France. http://proceedings.eceee.org/papers/proceedings2013/3-310-13_Vidalenc.pdf

The triple dividend of urban resilience transition

Integrated urban resilience strategies and actions can generate multiple co-benefits by tackling climate change mitigation and adaptation, sustainable development and local urban challenges in a systemic manner.

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Introduction

Over 50% of the world's population resides in urban areas where over 75% of the natural resources are consumed and approximately 75% of global carbon emissions produced; these urbanisation trends are rapidly increasing in terms of urban population and intensity of the consumption of resources and production of negative externalities (UNEP-DTIE 2013; UN-Habitat 2016).

Urbanisation trends and dynamics are exacerbating existing and emerging urban development challenges, including the provision of urban services and infrastructure, urban sprawl, growing informal settlements, inequality and exclusion, security, health, fair access to resources, internal and international migration and relocation phenomena.

In addition, cities, due to their high concentration of human life and activities, are responsible for the current climate change trends and dynamics. At the same time, human settlements are vulnerable to the increasingly negative impacts of climate change, including slow and rapid on-set disaster risks, which have a multiplying effect on these urban challenges, increasing the vulnerability of cities in a systematic and unprecedented way.

In order to foster urban resilience transition, a radical re-think of the way in which cities are planned, managed and lived in is indispensable, specifically integrating approaches to simultaneously address climate change, sustainable development and specific urban challenges (Tollin 2015).

Urban resilience transition momentum

There is a momentum for urban resilience, which includes a number of international initiatives and policies.

Initiatives:

- **UNHABITAT's Cities Resilience Profiling Programs (CRPP)**: a global programme aimed at providing local and national governments with tools to measure and increase resilience, with a focus on stakeholder collaboration.
- **Rockefeller Foundation's 100 Resilient Cities**: a network of over 100 cities worldwide, jointly working to increase urban resilience against major social, physical and economic challenges, including those related to climate change.
- **RESURBE International Program on Urban Resilience**: a multi-stakeholder platform with a focus on research, capacity-building and urban development projects on urban resilience, combining climate change risk, adaptation and mitigation.
- **City Climate Leadership Group (C40)**: a network of world megacities which aims to develop actions to mitigate climate change by reducing emissions, and to adapt to its inevitable effects and impacts.
- **Mayors Adapt**: launched by the European Union under the framework of Mayor Adapt: a programme with the aim of strengthening the resilience of cities to the impact of climate change.
- **Medellin Collaboration for Urban Resilience**: aimed at strengthening the resilience of all cities and human settlements around the world. Collectively, the collaboration supports 4,000 cities globally and commits towards advancing resilient urban development.

Policies:

- **UN 2030 Agenda for Sustainable Development and Sustainable Development Goals (UN 2014, 2015a)**
The 2030 Agenda highlights: "We are determined to take the bold and transformative steps which are urgently needed to shift the world onto a sustainable and resilient path". Goal 11 on Cities focuses on urban resilience: to make cities and human settlements

inclusive, safe, resilient and sustainable. Mentions of other aspects of resilience are present in Goal 13 on Climate Change, Goal 1 on Poverty Reduction and Goal 9 on Infrastructure.

- **UNISDR International Strategy for Disaster Reduction and Sendai Framework for Disaster Risk Reduction (UN 2015b)**
  The framework states: “Prevent new and reduce existing disaster risk through the implementation of integrated and inclusive economic, structural, legal, social, health, cultural, educational, environmental, technological, political and institutional measures that prevent and reduce hazard exposure and vulnerability to disaster for response and recovery, and thus strengthen resilience.” It includes a specific priority on investing in disaster risk reduction for resilience.

- **UN-Habitat HABITAT III and the New Urban Agenda (UN 2016)**
  The Agenda states: “We anchor our vision in the concept of cities for all, referring to the equal use and enjoyment of cities, towns, and villages, seeking to promote inclusivity and ensure that all inhabitants, of present and future generations, without discrimination of any kind, are able to inhabit and produce just, safe, healthy, accessible, resilient, and sustainable cities and human settlements, as a common good that essentially contributes to prosperity and quality of life.” Moreover, one specific strategy is dedicated to environmentally sustainable and resilient urban development.

- **UNFCCC COP21 and the Paris Agreement (UNFCCC 2015)**
  The concept of resilience is overreaching adaptation and mitigation; Paragraph 40 of the Decision highlights the objective of enhancing linkages and creating synergy between mitigation, adaptation, finance, technology transfer and capacity-building. Within Article 6 of the Agreement, the Parties recognise the role of non-state actors (including cities) in pursuing voluntary cooperation in the implementation of the (I)NDCs to allow for greater ambition in their mitigation and adaptation actions and to promote sustainable development and environmental integrity. Furthermore, it is fundamental to remember that the Paris Agreement is legally binding.

The triple dividend of urban resilience

In this sense, urban resilience transition goes beyond the ability to recover from natural and made-made disasters; it is the ability to systemically plan, design, construct and manage urban systems that are less vulnerable and able to dynamically adapt and develop in a sustainable manner. The triple dividend of urban resilience stems from the ability to adopt an integrated urban resilience approach that can generate co-benefits for addressing specific local challenges, promoting development in a sustainable manner and addressing climate change challenging coupling mitigation and adaptation (including slow and rapid on-set disasters).

Some key knowledge gaps/challenges will require specific efforts to foster the urban resilience transition:

- **Urban planning and design** theory and practice require a new formulation to become more adaptive and capable of addressing systemic uncertainties.

- **Evaluation of urban resilience** is still under development, particularly for assessing the impact of policies, strategies and action and for guaranteeing financial investment.

- **Interdisciplinarity of resilience:** despite over 40 years of research on resilience in biology, sociology, psychology, engineering, etc., research on urban resilience is still new and cannot be limited to the sum of knowledge from other

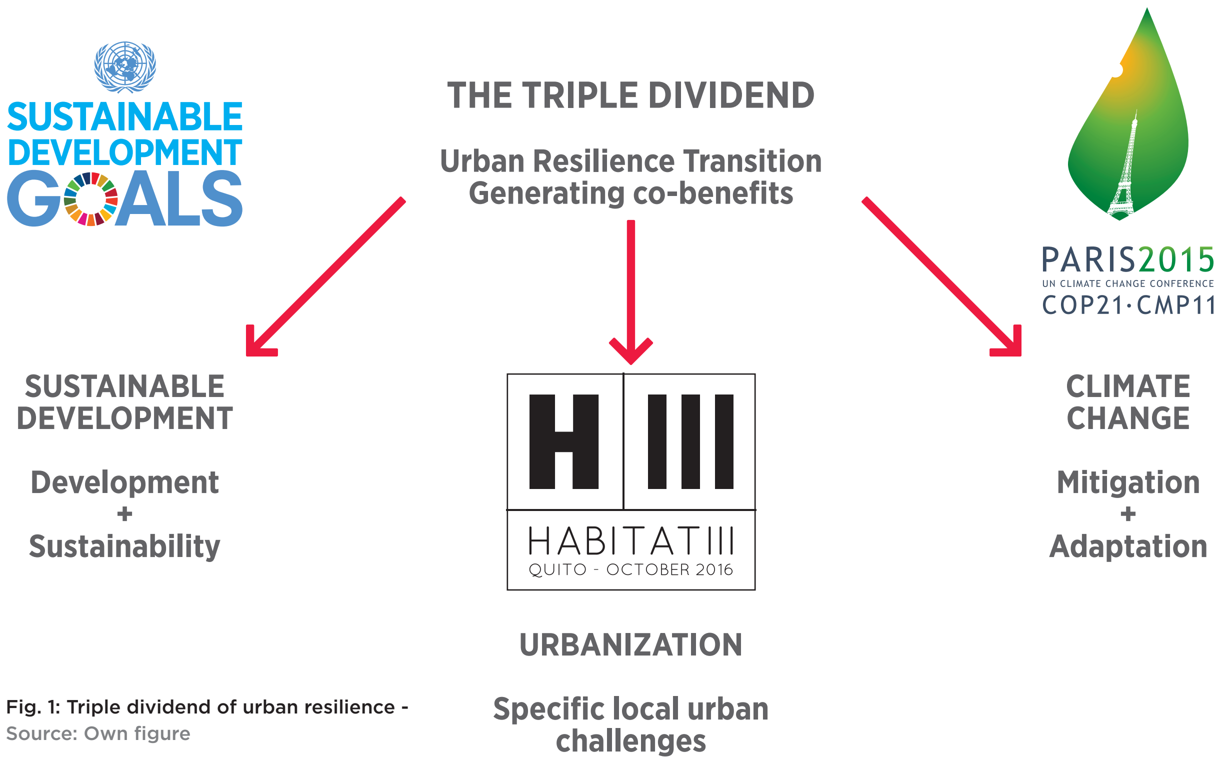

Fig. 1: Triple dividend of urban resilience -
Source: Own figure

disciplines. It requires a new, integrated and systemic understanding.

- **Research-practice divide:** there is limited interaction between research and practice related to urban resilience, requiring extra effort to support informed and evidence-based policy and decision making.

- **National strategies and local actions harmonisation:** increased effort to harmonise international/national strategies and policies (i.e. Nationally Determined Contributions) with local actions is fundamental.

Conclusion: a process design approach for urban resilience transition

In order to facilitate the urban resilience transition, it is fundamental to re-think the planning practice in a systemic and self-adaptive manner though a process design methodology capable of addressing uncertainty through coupling different future scenario methodologies and linking this directly to physical planning and implementation. Such process design relies on integrated evaluation systems that can support evidence-based decision making, as well as on the principles of participatory knowledge brokerage among multi-stakeholders throughout all the phases of the process, and through planners adopting the role of facilitators.

Fig. 2: Process design methodology for urban resilience -
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References

Tollin, N. (2015): The role of cities and local authorities following COP21 and the Paris Agreement. Sostenible (16)43–51.

UN (2014): Open Working Group proposal for Sustainable Development Goals. New York: United Nations. https://sustainabledevelopment.un.org/content/documents/1579SDGs%20Proposal.pdf

UN (2015a): Transforming our world: the 2030 Agenda for Sustainable Development. Resolution adopted by the General Assembly on 25 September 2015. A/RES/70/1. New York: United Nations. https://sustainabledevelopment.un.org/post2015/transformingourworld

UN (2015b): General Assembly Resolution 69/283. Sendai Framework for Disaster Risk Reduction 2015–2030. A/RES/69/283. New York: United Nations. http://www.preventionweb.net/files/resolutions/N1516716.pdf

UN (2016): New Urban Agenda: Quito Declaration on Sustainable Cities and Human Settlements for All: Draft outcome document of the United Nations Conference on Housing and Sustainable Urban Development (Habitat III). Adoption of the final outcome of the Conference. A/CONF.226/4. New York: United Nations. https://www2.habitat3.org/file/537303/view/591155

UNEP-DTIE (2013): Cities and Buildings. Paris: United Nations Environment Programm - Economy Division. http://www.unep.org/SBCI/pdfs/Cities_and_Buildings-UNEP_DTIE_Initiatives_and_projects_hd.pdf

UNFCCC (2015): Adoption of the Paris Agreement. FCCC/CP/2015/L.9/Rev.1. Paris: United Nations Framework Convention on Climate Change. http://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf

UN-Habitat (2016): World Cities Report 2016. Urbanization and Development: Emerging Futures. Nairobi, Kenya: United Nations Human Settlements Programme. http://wcr.unhabitat.org/

InnovationCity Ruhr as an example of a transformative approach[1]

After a multi-stage selection process by an independent jury, in 2010 a district of the German city of Bottrop was nominated to be the InnovationCity Ruhr, a pilot district for the strategic development and implementation of a low carbon strategy. An accompanying research project aims to: **(1)** support the transformation process scientifically; **(2)** ensure the target-orientation of the implemented strategies and measures; and **(3)** use the experiences from the pilot district for replication in other cities. Analyses focusing on framework conditions of the project provided evidence of a successful learning process between the different actors, as well as good communication and strong commitment. However, as the InnovationCity project is based on specific circumstances, the question for the roll-out is how similar results can be achieved elsewhere under less optimal conditions.

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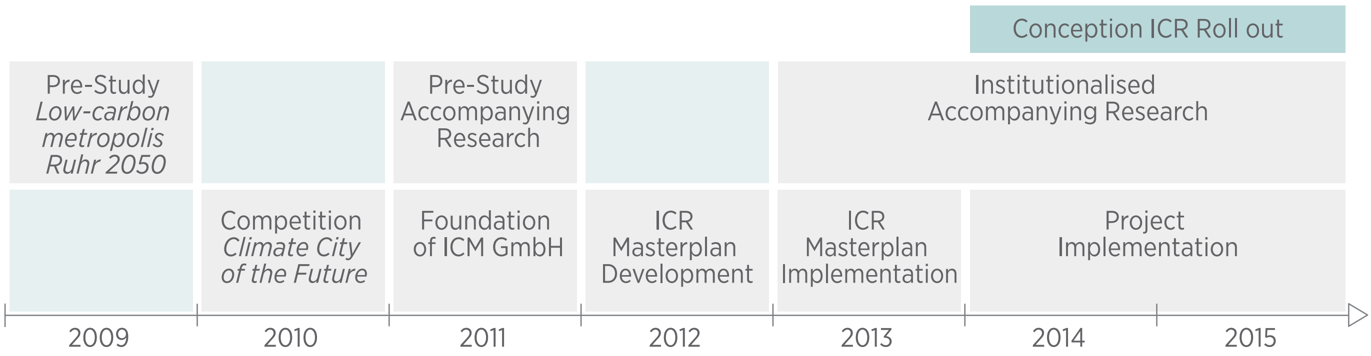
Background

In 2010 the Initiativkreis Ruhr (Ruhr Initiative Group (IR)), a private sector association in North Rhine-Westphalia, launched the competition “Klimastadt der Zukunft” (climate city of the future). Municipalities from the Ruhr area were invited to propose pilot districts for the strategic development and implementation of a low carbon strategy – targeting a 50% reduction in CO_2 by 2020 within the specific district.

After a multi-stage selection process by an independent jury, Bottrop was nominated as the InnovationCity Ruhr. The jury was convinced, among other things, that the selected pilot area included several typical regional characteristics (in terms of social structure, building stock and the energy supply system). This was taken as an indicator that the pilot project should be easily replicated elsewhere in the region. In addition, it was promising that Bottrop had a good network of people in the business, administration and political sectors who co-operated well together (including the highly motivated mayor). The jury was also impressed that the local people were actively involved during the application phase. Finally, the jury was persuaded by the holistic approach of Bottrop’s’ application, targeting a broad range of fields of application and implementation rather than simply focusing on individual projects (lighthouse projects).

1 Results of a SWOT analysis carried out in the context of the project’s mid-point evaluation in 2015 by Manfred Fischedick (Wuppertal Institute), Johannes Venjakob (Wuppertal Institute), Georg Unger (EnergieAgentur.NRW), Nicola Werbeck (RUFIS), Rainer Danielzyk (University of Hannover) and Dieter Rehfeld (IAT)



Some of the milestones in terms of how the project has been established and implemented in the pilot district within the city of Bottrop are particularly significant.

The InnovationCity Management Company (ICM), founded in 2011, controls the entire process of the project and has about 25 employees. Some are delegated members of the city administration to ensure direct communication between the ICM, which is mainly financed by private sector companies, and the administration. The ICM can be described as an institutional innovation. The establishment of this institution has meant that the process management is not tied to the conventional municipal structures, resulting in a higher degree of independence, goal orientation and flexibility. The ICM's strong institutional network of actors from the private sector, politics, administration, science and civil society has played a decisive role in the success of the project.

Another crucial element of the overall process is the elaboration of a **master plan:** a comprehensive potential analysis resulted in the derivation of an appropriate project catalogue. The master plan forms the basis of many of the implementation projects in the pilot area. The city council approved the master plan at its meeting on 8 April 2014 and the plan now functions as the basis for the overall urban development in the pilot area. These two basic elements (and particularly their combination) go beyond usual climate mitigation concepts and represent a unique feature of the InnovationCity.

Establishment of institutionalised accompanying research

An accompanying institutionalised research project has been established to support the challenging implementation process and a number of research studies have been initiated. The research project is funded by the Ministry of Innovation, Science and Research of the State of North Rhine-Westphalia.

This research provides the opportunity to systematically evaluate the experiences of the implementation process and to transfer this to other cities/districts. Research on the meta-level (for example, analysis of the success factors of the transformation process) as well as specific empirical analyses (for example, of constraints to the energetic refurbishment of the building stock) are both components

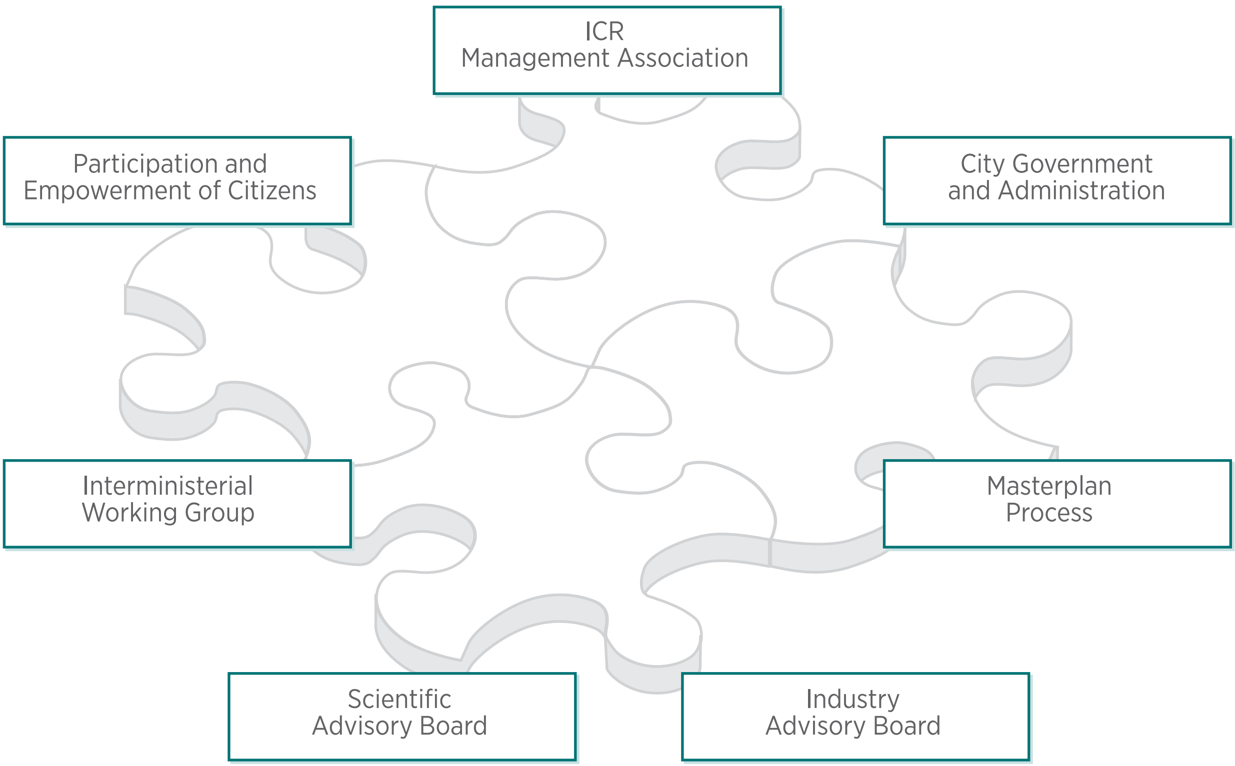


Fig. 2: Institutional elements of the InnovationCity project - Source: Own figure

Fig. 1: Milestones of the project's establishment and implementation - Source: Own figure

of the accompanying research. Therefore, in addition to the levels of planning (master plan) and implementation (ICM), a scientific level has been established. The main objectives at this level are: (1) to support the transformation process scientifically (transformative knowledge); (2) to ensure the target-orientation of the implemented strategies and measures; and (3) to use the experiences from the pilot district for other cities.

SWOT analysis at the project mid-point in 2015

Within its first five years, the InnovationCity project recorded some impressive successes. A reduction in CO_2 emissions by 2020 of almost 38% had already been ensured, leaving a further reduction of only 12% to be made by introducing new projects over the following five years. An important pillar of the project's success is the consultation regarding energetic refurbishment issues for all Bottrop homeowners, which is offered free of charge. Nearly 2,000 of these consultations had been provided by the mid-point of the project. 56% of the participants had carried out refurbishment/modernisation measures, improving the energy performance of their buildings.

The InnovationCity scientific advisory board conducted analyses focusing on the framework conditions of the project. Some key findings are presented below.

Strengths

Together with four other shareholders, the private sector association IR is responsible for the project and was the driving force in the development of the project design. This commitment increases the reliability and the incentive for the association's member companies to carry out innovative projects in the InnovationCity. High levels of engagement by the state government in terms of support for the acquisition of funding and the monitoring of the project by an inter-ministerial working group send an important political signal. The strong backing of the project by the Bottrop city administration, already evident in the competition phase and underlined in the master plan process by the acceptance of the InnovationCity master plan as a basis for Bottrop's urban development plan, is a very important strength of the project. The support of the project is also reflected in the delegation of municipal employees to the InnovationCity management company. Another success factor is the wide diversity of projects in terms of their thematic scope, following the holistic approach of the pilot project (housing, work, energy, mobility, city, empowerment) and the project's financial volume. This variety allows for many different actors to be involved with the project. Over 250 individual projects have already been implemented within the pilot.

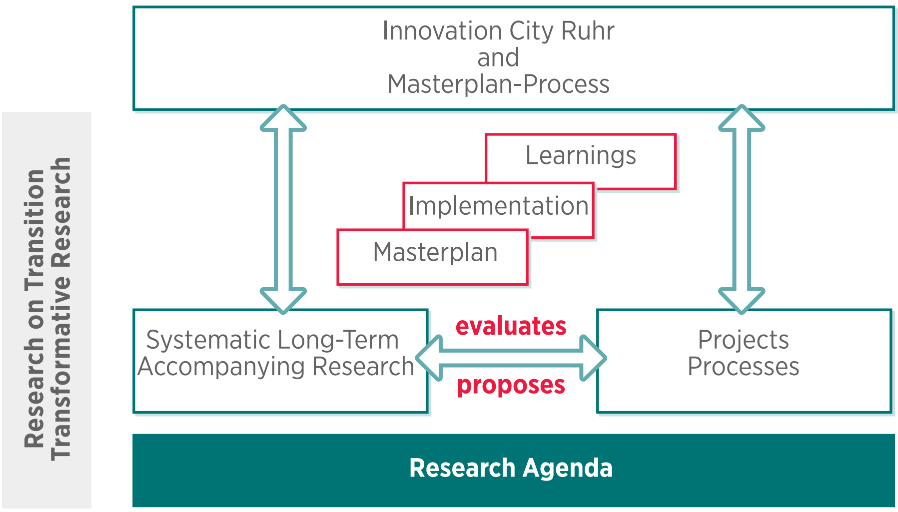


Fig. 3: InnovationCity Ruhr – Accompanying research - Source: Own figure

Weaknesses

The management process of the InnovationCity is relatively demanding on staff resources. The way in which the project is implemented in Bottrop could not be fully replicated in other cities/model districts. An adapted project design has been developed for the InnovationCity roll-out to other cities within the Ruhr area, which started in March 2016. An important pillar is the energy consultation, aimed primarily at homeowners. It has not yet been possible to carry out the consultation for all the many tenants, especially those in low-income households. From a business perspective, small and medium-sized enterprises based in the pilot area have not yet been integrated sufficiently. The ICM has made extensive efforts to develop joint projects. However, local companies are not yet convinced of the benefits and are generally pursuing their own energy strategies. The master

plan represents the fundamental basis for the work in the pilot district. This kind of profound and detailed analysis of the status quo and the proposal of specific implementation measures (the master plan runs to 1,500 pages) cannot be considered as a standard when transferring the project concept to other areas. An adapted concept has been developed for this purpose. However, numerous approaches and project ideas could certainly be applied to comparable urban structures. The success of the project continues to depend, to a large extent, on external funding from industry and/or the public sector.

Opportunities

The innovative institutional management concept (ICM) and the interaction between the different stakeholders can serve as a basis when transferring the concept to other areas. The structural characteristics of the Bottrop pilot district, which are typical of the Ruhr area, make replication in other districts within the Ruhr area promising. Beyond that, the Bottrop case could function as a blueprint for other old industrialised regions in Germany and Europe.

Threats

The success of InnovationCity depends on the on-going implementation of projects in the pilot district. More than 250 projects have already been implemented. If funders/companies retreat or projects face insurmountable obstacles, the project as a whole will be at risk. In addition to the financial conditions, support from the municipal administration is crucial for the project's success. Separating the project management from the urban development policy gives the actors flexibility and independence. At the same time, closely coordinated strategies are required to avoid mutual hindrances. Communication and transparency play an important role when dealing with the expectations of the inhabitants of the pilot area. In this context, it is very important to communicate widely the benefits of the InnovationCity project - for individual citizens and for the entire city.

Outlook

There is evidence of a successful learning process, which was necessary for the effective collaboration between the different actors involved in the project. No single instrument is crucial for the project, but the fundamental principles are communication and co-operation. This includes the strong commitment of all the participants involved in the project, as well as effective networking. InnovationCity is based on specific starting conditions, both in terms of the people involved and the available financial resources, and these particular circumstances cannot be wholly replicated elsewhere. For the wider roll-out, the question is how similar results can be achieved under less optimal conditions. A more sophisticated evaluation of the project should, therefore, focus on the learning processes of all stakeholders. These learning processes do not only affect those stakeholders directly involved in the project, but also lead to spill-over effects (e.g. the activation of passive actors, adaptation of ineffective political programmes and benchmarking of other activities).

References

Innovation City Management (n.d.): InnovationCity Ruhr. InnovationCity Ruhr. http://www.icruhr.de/index.php?id=3&L=1

Improving land use to make cities low carbon and climate-resilient: the Silang-Sta. Rosa subwatershed, the Philippines

The Silang-Sta. Rosa subwatershed has undergone massive land use changes in the past two decades, brought about by rapid urbanisation and industrialisation. Since it is ideally strategically located for economic development, further conversion of forest and agricultural land for industrial, residential and commercial activities is planned in the area by 2025. This study was conducted with the aim of making the cities in the Silang-Sta. Rosa subwatershed low carbon and climate-resilient. This research suggests that runoff-neutral development to lower the intensity of floods associated with the proposed land conversion will reduce the number of affected people by about 20% by 2025.

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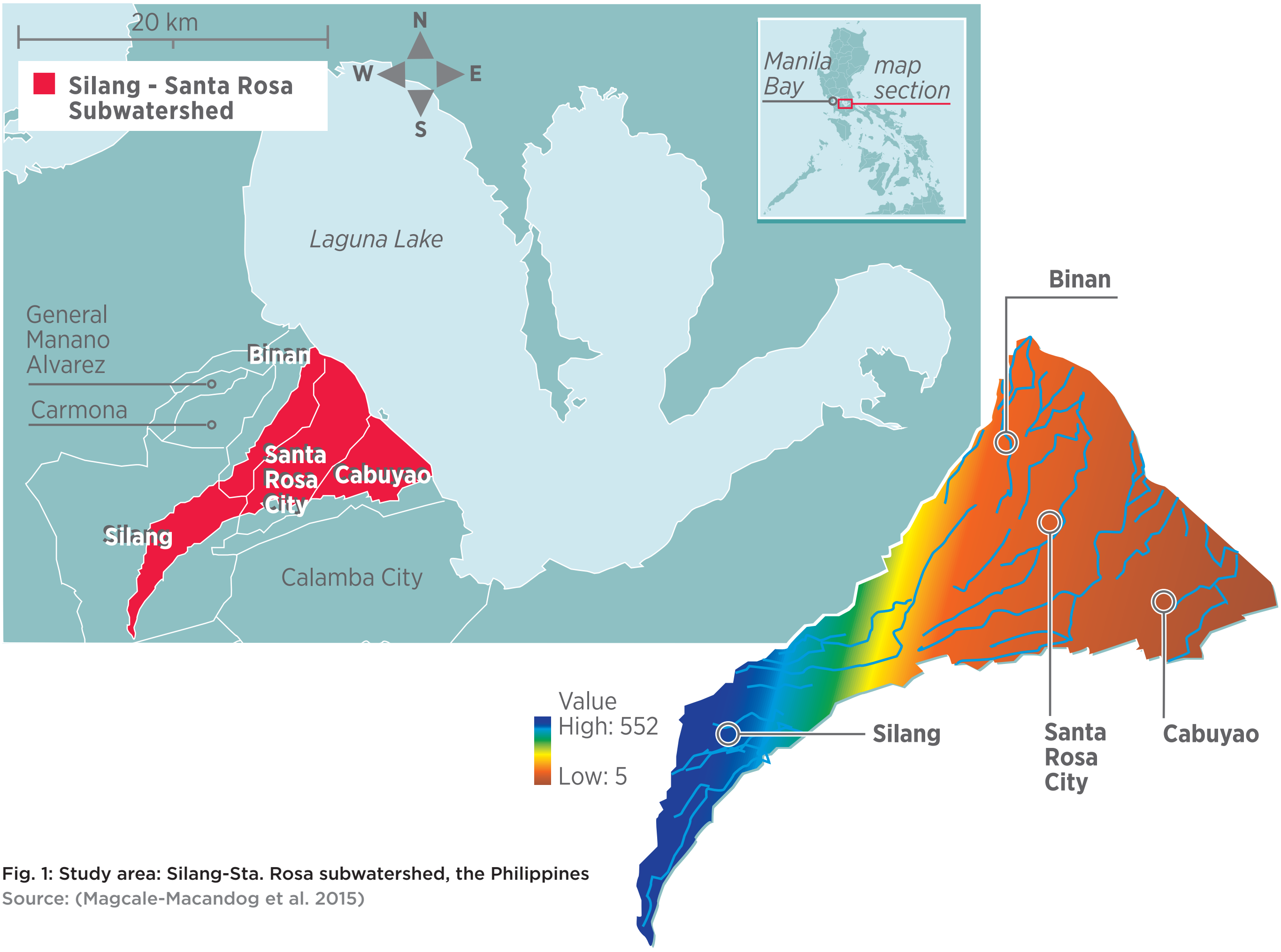


Fig. 1: Study area: Silang-Sta. Rosa subwatershed, the Philippines
Source: (Magcale-Macandog et al. 2015)

Introduction

The Silang-Sta. Rosa subwatershed is located on the western side of the Laguna Lake Basin at 14o 13' 44" N latitude and 121o 01' 05" E longitude. It is administratively located in the cities of Sta. Rosa, Biñan and Cabuyao in the province of Laguna, and in the municipality of Silang in the province of Cavite (**Figure 1**).

The total area of the subwatershed is 4,156 hectares. It has a mean slope of 6.2%. The lowland area of the subwatershed is characterised by level to nearly level land with slopes ranging from 0%-3%, which is most suitable for irrigation and lowland rice production. The areas with gently sloping to undulating land (3%-8%) and rolling to moderately steep land (18%-30%) in the midstream and upstream of the subwatershed are suitable for upland crop production (Sta. Rosa LEAP 2005).

The subwatershed is principally drained by the Silang-Sta. Rosa River, which flows from the mountainous area of Silang, Cavite, towards Laguna Lake. The Silang-Sta. Rosa River subwatershed consists of two major landforms, the uplands and the lowlands. The uplands of Silang and the mid slope of Sta. Rosa provide the recharge of water for the subwatershed, which contributes to the groundwater recharge of the urban areas of the subwatershed.

The Silang-Sta. Rosa subwatershed has undergone massive land use changes in the past two decades, brought about by rapid urbanisation and industrialisation (Lasco and Espaldon 2005). It is in an ideal strategic location for economic development, 40 km south of Metro Manila (Sta. Rosa CLUDP 2000). As an industrial enclave, Sta. Rosa has attracted a number of local and foreign investors into the town's premier industrial estates, which has provided local employment, general export earnings, increased municipal revenues, as well as serving as a vehicle for the transfer of technology with forward and backward linkages to the local economy. Silang-Sta. Rosa subwatershed is an urban ecosystem with high demand for land and water resources from the residential, commercial and industrial sectors. This study was conducted with the aim of making the cities in the Silang-Sta. Rosa subwatershed low carbon and climate-resilient.

Methodology

A basin-scale participatory land use management approach was conducted in the Silang-Sta. Rosa subwatershed (Endo et al. 2016). This approach aims to support decision making by taking four steps, including risk analysis based on plausible future scenarios (**Figure 2**). In the scenario analysis, local government officials from the various departments (engineering and planning, environment, disaster and agriculture) were invited to participate in the mapping of future land use developments. A current land use map of the subwatershed was prepared and the participating local government officials were asked to delineate future developments and land use over the next decade by overlaying tracing paper. Risk assessment was carried out using GIS-based hydrological models (HEC-RAS and HEC-HMS) to simulate future flooding scenarios. Consultation meetings with the local government units were conducted

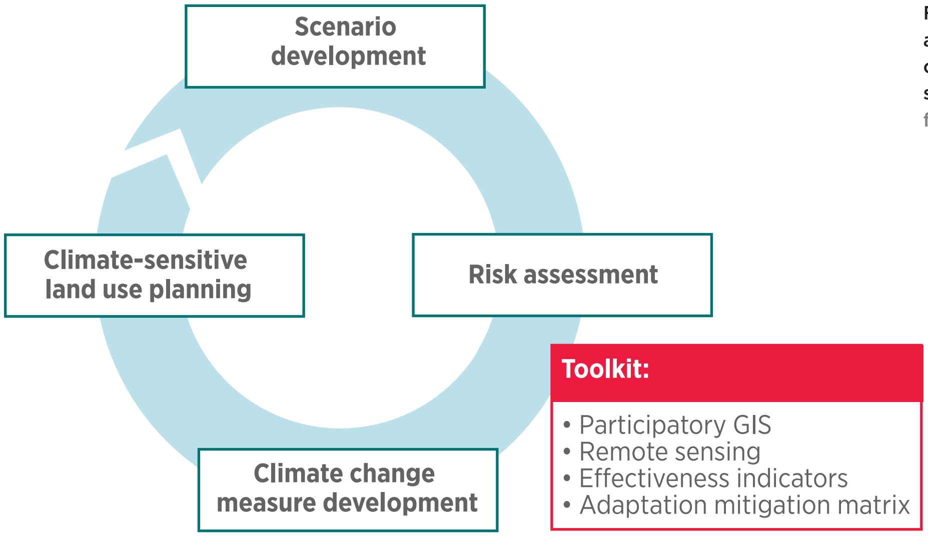


Fig. 2: Participatory land use management at the watershed level consisting of four components with a set of analytical tools such as participatory GIS - Source: Own figure

to present the results of the hydrological modelling and identify climate change countermeasures. It is mandatory for all local government units to update their Comprehensive Land Use Plan (CLUP) every 5 years and, during the consultation meetings, various strategies for the mainstream inclusion of these climate change adaptation measures in the updated CLUPs were discussed.

Results and discussion

The conversion of a vast area of forest and agricultural land for industrial, residential and commercial activities is planned by 2025 (**Figure 3**). In the municipality of Silang, all the agricultural, agroforest and remaining forested areas will be converted into residential areas during the next decade. The midstream area of the watershed will be converted for industrial use, while the downstream area will be converted for residential use. Only the city of Cabuyao plans to allocate 20% of its land area for forest in the midstream area and for agriculture in the downstream areas. Due to this land use conversion, a greater area of the subwatershed will have an impermeable surface. As a result, it is anticipated that the flood risk area will increase from 970 hectares to 1,180 hectares

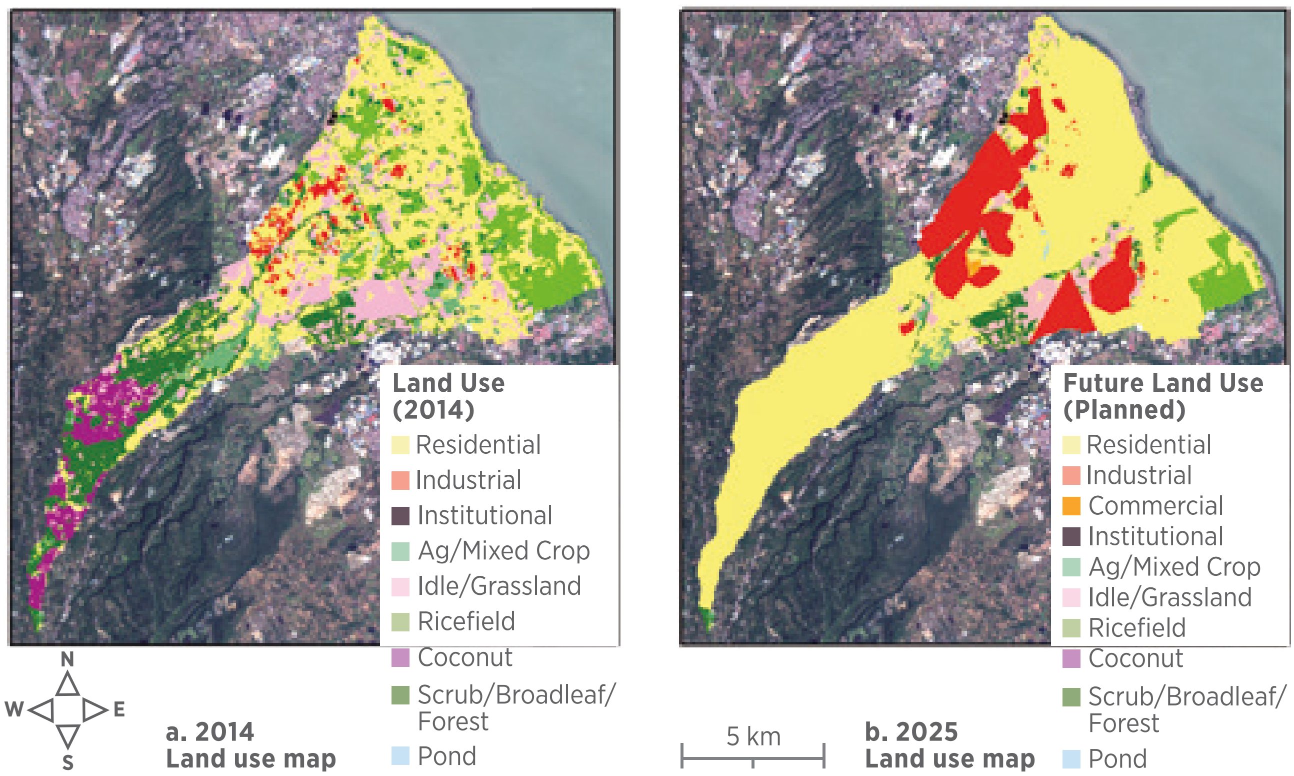


Fig. 3: a) Current land use map based on 2014 Satellite image. b) Future land use map based on the results of a participatory land use mapping session with representatives from the four local government units of the Silang-Sta. Rosa subwatershed - Source: (Endo et al. 2015)

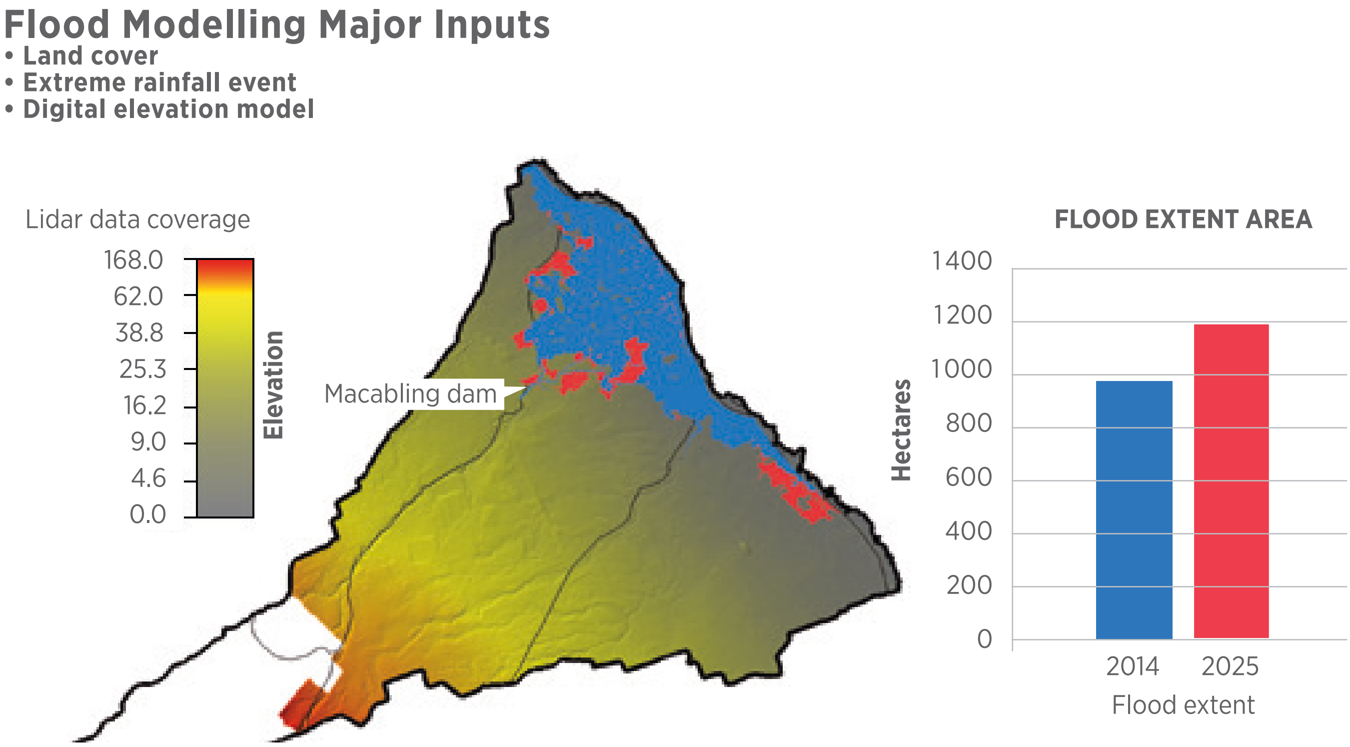


Fig. 4: Flood areas in Silang-Sta. Rosa subwatershed, the Philippines - Source: (Bragais et al. 2015)

(**Figure 4**) (Bragais et al. 2015). Further, it is envisioned that the extent of flood damage will be aggravated due to increased runoff, and projected climate change is likely to worsen the situation. Under current land use, it was reported that more than 130,000 people have been affected by flooding in the subwatershed (Endo et al. 2016).

The possible measures for climate change adaptation and mitigation identified by the LGU officers included development control in high risk areas, maintaining green space and urban greening, strengthening building codes particularly in high risk areas, green building, afforestation, riverbank rehabilitation, river clean-up and dredging, and the harmonisation of the Comprehensive Land Use Plans for integrated watershed management. To put these efforts in motion, a Memorandum of Agreement among the Mayors of the four local government units and the General Manager of the Laguna Lake Development Authority (LLDA) was signed to establish the Council for Integrated Watershed Management.

This research suggests that runoff-neutral development to lower the intensity of floods associated with the proposed land conversion will reduce the number of affected people by about 20% by 2025 (Endo et al. 2016). Preserving existing vegetation would also avoid more than 528,000 tonnes of CO_2 emissions (Endo et al. 2016). It is crucial to coordinate and harmonise the land use plans of the various local governments in this subwatershed to achieve effective management at the basin level. The case presented in this paper provides a model for integrating climate change into local development planning.

References

Bragais, M.; Johnson, B. A.; Magcale-Macandog, D. B.; Endo, I. (2015): Land cover conversion and flood extent in Silang-Sta. Rosa sub-watershed. Los Baños, Philippines.

Endo, I.; Johnson, B.; Kojima, S.; Chiba, Y.; Nakata, M.; Bragais, M.; Magcale-Macandog, D. B.; Macandog, P. B. (2015): Making land-use climate-sensitive: A pilot to integrate climate change adaptation and mitigation. https://pub.iges.or.jp/system/files/publication_documents/pub/issue/4465/IGES_A4_4p_e_0312-3.pdf

Endo, I.; Magcale-Macandog, D. B.; Kojima, S.; Johnson, B. A.; Bragais, M.; Macandog, P. B. (2015): Integrating CCA&M strategies in the Comprehensive Land Use Plan: A pilot case in Silang-Sta. Rosa subwatershed, the Philippines. Paper presented at the International Workshop on Climate Change Vulnerability and Adaptation in River Basins of Asia: Challenges and Prospects, IPB International Convention Centre, Bogor, Indonesia.

Endo, I.; Magcale-Macandog, D. B.; Kojima, S.; Johnson, B. A.; Bragais, M.; Macandog, P. B.; Scheyvens, H. (2016): Participatory land-use approach for integrating climate change adaptation and mitigation into basin-scale local planning. Submitted to Sustainable Cities and Society.

Johnson, B.; Bragais, M.; Endo, I.; Magcale-Macandog, D.; Macandog, P. (2015): Image Segmentation Parameter Optimization Considering Within- and Between-Segment Heterogeneity at Multiple Scale Levels: Test Case for Mapping Residential Areas Using Landsat Imagery. ISPRS International Journal of Geo-Information 4(4)2292–2305. doi: 10.3390/ijgi4042292.

Magcale-Macandog, D. B.; Endo, I.; Johnson, B. A.; Bragais, M.; Carrasco-Creencia, E. (2016): Participatory Watershed Land-use Management: An approach for integrated climate change actions. Presented at the Workshop for capacity building on climate change impact assessments and adaptation planning in the Asia-Pacific region: Technical review of background assessment for Climate Change adaptation. 27-28 January, 2016, Manila, Philippines.

Magcale-Macandog, D. B.; Endo, I.; Johnson, B. A.; Bragais, M.; Carrasco-Creencia, E. (2016): Participatory Watershed Land-use Management: An approach for integrated climate change actions. Presented at the Workshop for Urban resilience to climate change and green growth in critical watersheds of the Philippines, ADB, Manila, Philippines.

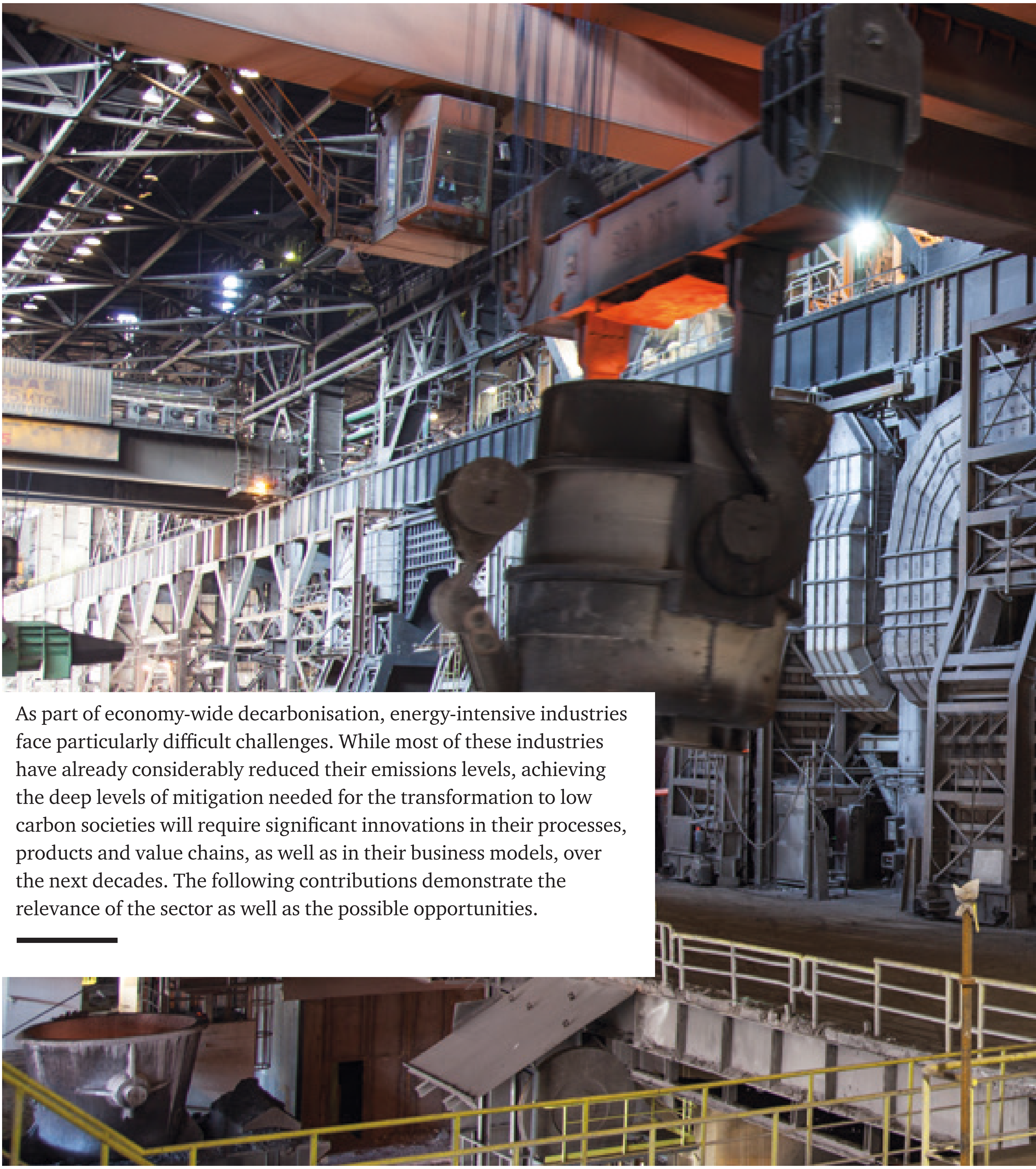
Magcale-Macandog, D. B.; Endo, I.; Kojima, S.; Johnson, B.; Bragais, M. A.; Magcale-Macandog, P. B. (2015): Integrating CCA&M strategies in the Comprehensive Land Use Plan: A pilot case in Silang-Sta. Rosa subwatershed, the Philippines. Manuscript submitted for publication.

Magcale-Macandog, D. B.; Kojima, S.; Johnson, B. A.; Bragais, M.; Macandog, P. B.; Onishi, A.; Scheyvens, H. (2015a): Evaluation of the resiliency of the Silang-Sta. Rosa subwatershed, Laguna Philippines. Presented at the Paper presented during the Low Carbon Asia Research Network (LoCARNet) 4th Annual Meeting, International Conference of Low Carbon Asia: Stabilising climate through Low carbon actions in Asia - Road to COP21 and beyond, Johor Bahru, Malaysia.

Magcale-Macandog, D. B.; Kojima, S.; Johnson, B. A.; Bragais, M.; Macandog, P. B.; Onishi, A.; Scheyvens, H. (2015b): Designing low carbon and climate resilient watershed management through a multi-stakeholder process: Study case in the Philippines. Presented at the Paper presented during the Low Carbon Asia Research Network (LoCARNet) 4th Annual Meeting, International Conference of Low Carbon Asia: Stabilising climate through Low carbon actions in Asia - Road to COP21 and beyond, Johor Bahru, Malaysia.

Zafarella, M. T.; Magcale-Macandog, D. B.; Lachica, G. C.; Luna, D. A.; Miel, J. C.; Sumilang, M. I. V. (2012): Ecological Profile of the Silang - Santa Rosa River and a Program for the Restoration/Rehabilitation of its Degraded Streams. Final Report.

Deep decarbonisation
the role of industries



As part of economy-wide decarbonisation, energy-intensive industries face particularly difficult challenges. While most of these industries have already considerably reduced their emissions levels, achieving the deep levels of mitigation needed for the transformation to low carbon societies will require significant innovations in their processes, products and value chains, as well as in their business models, over the next decades. The following contributions demonstrate the relevance of the sector as well as the possible opportunities.

Industries and companies as non-state actors?

This article aims to answer the questions of who the non-state actors are and how global governance can involve them in the context of the Paris Agreement. Based on the different roles of companies and their potential contributions to climate action, there are at least three possible routes for their participation. One is the portal established under the climate change convention, which allows companies and investors to register their commitments alongside other non-state actors such as cities. Another is a platform for engaging non-state actors in high-level discussions organised in conjunction with an annual climate change conference. The third is a mechanism for contributing to mitigation and supporting sustainable development which explicitly allows for the participation of private entities. The Paris Agreement and the Decision signal potential future paths for enhancing business engagement.

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Introduction

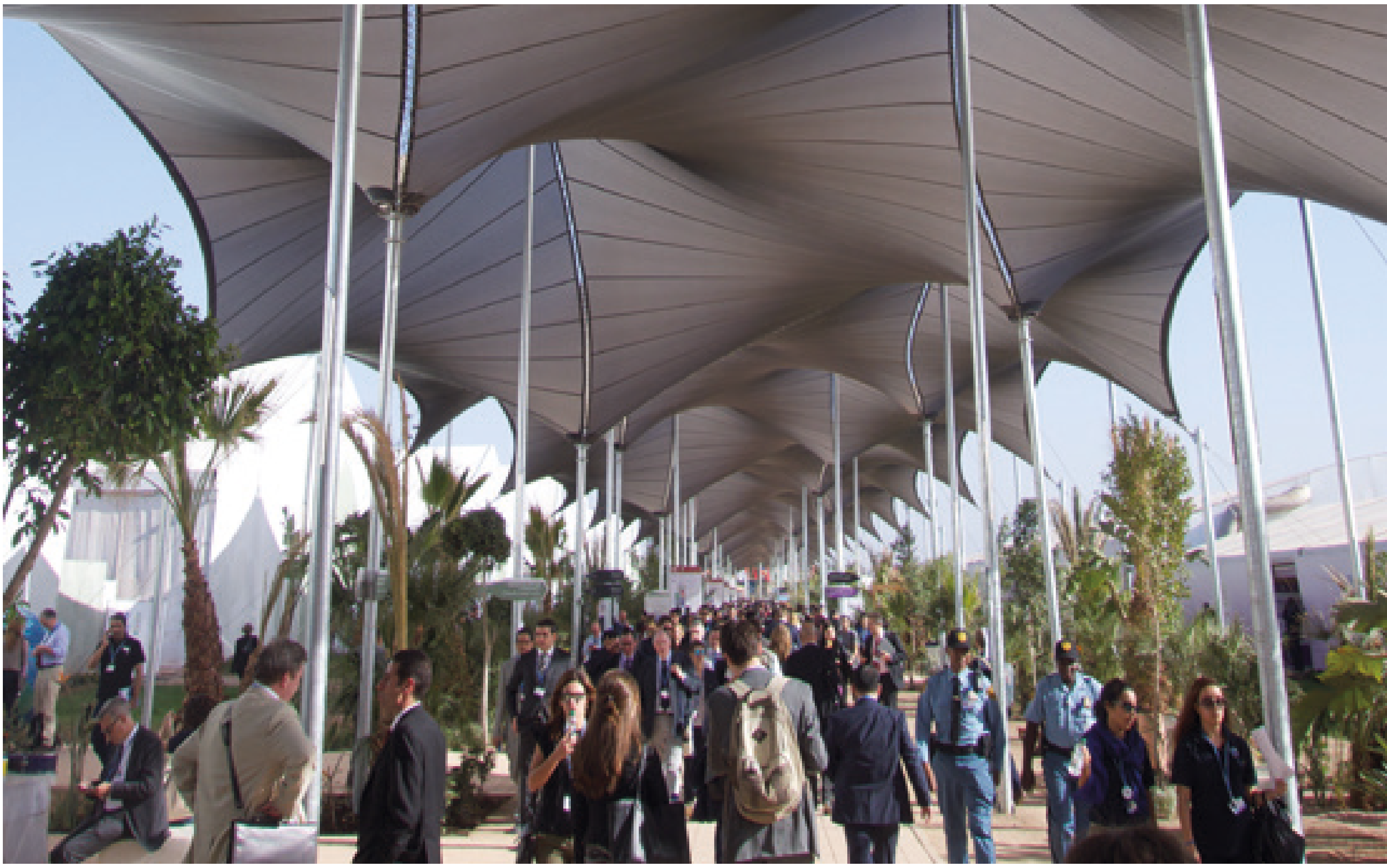
Are industries and companies non-state actors? How can global governance better involve them? The Paris Agreement and an associated Decision (Decision 1/CP.21) adopted by the Conference of Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC) make a strong case. It is significant that these official documents contain explicit references to the potential roles of private entities and non-Party stakeholders, which is a departure from Party-oriented agreements, such as the UNFCCC and the Kyoto Protocol. Neither agreement includes references to non-state actors or non-Party stakeholders. The Kyoto Protocol makes only a few references to the private sector and private entities: an enabling environment for the private sector in international cooperation on finance and technology transfer (Art 10(c)) and involvement of private entities in the Clean Development Mechanism (CDM) (Art 12.9). There was a turning point in the Lima Paris Action Agenda, which prompted Parties to recognise the roles of non-state actors by creating an online space for them to register their commitments and initiatives ('The Non-State Actor Zone for Climate Action (NAZCA)', see Decision 1/CP.21, 134). The creation of NAZCA paved the foundation for the official recognition of the role of non-state actors in the Paris Agreement and ensured the continuity and transition of the current pre-2020 framework to the new framework envisioned in the Paris Agreement from 2021.

This article attempts to develop the two research questions identified by the LCS-RNet and respond to them by way of a literature review including the two key documents, the Paris Agreement and Decision 1/CP.21. The preliminary findings presented at the annual conference (Wuppertal, 6-7 September 2016) were updated for this article after incorporating the conference participants' feedback.

Who are non-state actors?

There is no explicit reference to non-state actors in the Paris Agreement or the associated Decision. The Decision defines non-Party stakeholders as comprising civil society, the private sector, financial institutions, cities and other subnational authorities (Decision 1/CP.21, 133). According to this definition, it seems reasonable to include industries and companies in the category of non-state actors. Some entities, however, are not so clear-cut. One example is State-Owned Enterprises (SOEs), which are common in sectors with high GHG emissions, such as energy and transport. To what extent SOEs speak for governments or to what extent they can speak in their own voice requires careful treatment.

Business and industry can provide inputs to the UNFCCC in different ways. At an international level they could consolidate their position via BINGO (Business and Industry NGOs) (e.g. Nasiritousi et al. 2016), for which the International Chamber of Commerce serves as a focal point with the UNFCCC secretariat. In the run up to COP21, business and industry could also participate in the development of the Intended Nationally Determined Contribution at a national level (UNEP 2015) and continue doing so for the implementation of the



Nationally Determined Contribution (NDC) from 2021.

Different types of inputs are driven by different motives. There are three major motives: to achieve mitigation actions in cost-effective ways (e.g. electricity and heat production and other energy industries, which account for 35% and 21% respectively of global greenhouse (GHG) emissions ((IPCC 2014) based on global emissions from 2010)); to reduce climate impacts and risks on assets as part of adaptation actions (e.g. insurance and real estate sectors); and to demonstrate corporate social responsibility. These three major motives would underline four possible roles of business in climate action: to implement mitigation actions; to develop and provide technologies or technical solutions; to invest in more climate-friendly technologies and/or divest from fossil fuels in their portfolios (Grossmann 2016); and to inform consumers about the impacts of products.

Businesses could make potential contributions to mitigation through direct emission reductions and/or the disclosure of data and information. For the latter, recent major initiatives include i) the UNEP Climate Initiatives Platform, which aims at the exchange of good practice; ii) the CDP, a global disclosure system for companies, cities, states and regions to measure and manage impacts on the climate (UNEP 2015); iii) Science-Based Targets, which request companies to set targets compatible with the 2°C goal (UNEP 2015); and iv) We Mean Business, which provides a broader framework for business commitments, resulting in 912 commitments made by 374 companies and 183 investors (Moss 2015; We Mean Business Coalition 2016).

What is the Paris Agreement framework for business contribution to climate action?

There are at least three possible routes for business participation in the new framework: NAZCA, high-level events, and the mitigation mechanism or sustainable development mechanism.

The first route is the UNFCCC portal, NAZCA, which allows companies and investors to register their commitments and cooperative actions alongside cities, regions and civil society organisations. The emphasis is placed on the effects of scaling up their efforts and supporting mitigation and adaptation actions (Decision 1/CP.21, 117 and 134). The second is a high-level event to be convened by high-level champions in conjunction with COP during the period 2016-2020. The event aims to provide representatives of the Parties, international organisations, international cooperative initiatives and non-Party stakeholders with meaningful and regular opportunities for high-level discussion (Decision 1/CP.21, 120(d), also see 121(b)). The third is a mechanism for contributing to the mitigation of GHG emissions and supporting sustainable development (thereafter called Mitigation Mechanism (MM) or Sustainable Development Mechanism (SDM)), by delivering an emissions reduction against a reference level in the NDC (Art 6.4, PA; see also (IETA 2016; Marcu 2016). The Agreement explicitly allows for the participation of private entities in the implementation of NDCs (Art 6.4(b) and 6.8(b)). These references imply that private entities are expected to engage in the MM or SDM upon their Parties' authorisation in a similar manner to their participation in the CDM, taking into consideration their access to data and information which are essential to set reference scenarios in the NDCs.

Conclusion

These three possible routes for business participation could have positive implications for an emerging framework for non-state actors. Chan et al. (2015) propose the following design principles for the framework to galvanise the groundswell of climate actions. They argue that the framework should be comprehensive, bringing together existing sources of information and building upon existing registries of non-state climate actions and commitments such as NAZCA. They also argue that the framework should be evaluative, incorporating benchmarking, review and follow-up procedures for the accountability of non-state initiatives. The need for follow-up procedures would be a major challenge for the existing initiatives, which have so far emphasised the registration of commitments (see also (Stavins et al. 2014)). Their final claim is that the framework should be catalytic, helping concerned actors identify gaps and fill them by scaling up existing initiatives. The high-level involvement of champions could lend powerful convening authority to catalyse new initiatives in under-served areas (Chan et al. 2015).

While the NAZCA has been in operation under the Lima-Paris Action Agenda, the other two options, i.e. high-level events 2016-20 and the MM/SDM 2021-30, require further specification in terms of modalities and procedures. Nevertheless, the Paris Agreement and the Decision signal potential ways forward for enhancing business engagement.

References

Chan, S.; van Asselt, H.; Hale, T.; Abbott, K. W.; Beisheim, M.; Hoffmann, M.; et al. (2015): Reinvigorating International Climate Policy: A Comprehensive Framework for Effective Nonstate Action. Global Policy 6(4)466–473. doi: 10.1111/1758-5899.12294.

Grossmann, C. (2016): We have an agreement in Paris: So, what's next for the private sector? Development in a Changing Climate: Making our future sustainable. https://blogs.worldbank.org/climatechange/we-have-agreement-paris-so-what-s-next-private-sector

IETA (2016): A Vision for the Market Provisions of the Paris Agreement. Genève, Switzerland: IETA. http://www.ieta.org/resources/Resources/Position_Papers/2016/IETA_Article_6_Implementation_Paper_May2016.pdf

Marcu, A. (2016): Carbon Market Provisions in the Paris Agreement (Article 6). No. 128. CEPS Special Report. Centre for European Policy Studies. https://www.ceps.eu/system/files/SR%20No%20128%20ACM%20Post%20COP21%20Analysis%20of%20Article%206.pdf

Moss, K. (2015): Business Helped Make the Paris Agreement Possible. World Resources Institute Blog. http://www.wri.org/blog/2015/12/business-helped-make-paris-agreement-possible

Nasiritousi, N.; Hjerpe, M.; Linnér, B.-O. (2016): The roles of non-state actors in climate change governance: understanding agency through governance profiles. International Environmental Agreements: Politics, Law and Economics 16(1)109–126. doi: 10.1007/s10784-014-9243-8.

Stavins, R.; Zou, J.; Brewer, T.; Conte Grand, M.; den Elzen, M.; Finus, M.; et al. (2014): International Cooperation: Agreements & Instruments. In: Climate Change 2014: Mitigation of Climate Change. Working Group III Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK and New York, NY, USA. http://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_chapter13.pdf

We Mean Business Coalition (2016): The Paris Agreement: What It Means for Business. z-card. http://www.wemeanbusinesscoalition.org/sites/default/files/The-Paris-Agreement_Z-Card_0.pdf

UNEP (2015): The Emissions Gap Report 2015. Nairobi, Kenya: United Nations Environment Programme. http://uneplive.unep.org/media/docs/theme/13/EGR_2015_301115_lores.pdf

Decarbonising Europe's energy-intensive industries

As part of economy-wide decarbonisation, Europe's energy-intensive industries must reduce their emissions by more than 80% by 2050 compared to 1990 levels. While most of these industries have already reduced their emissions levels significantly, achieving this deep level of mitigation will require the consistent combination of process, product and business model innovations (sometimes radical) over the next decades.

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Introduction

In 2015, the Paris Agreement adopted at the United Nations Framework Convention on Climate Change (UNFCCC) committed 195 countries to reach net zero greenhouse gas emissions in the second half of the 21st century. In the European Union (EU) this will entail, in all likelihood, an economy-wide reduction target in excess of the current target of 80% - 95% of emissions by 2050 (European Commission 2011). It also means essentially full decarbonisation for all energy-intensive industries over the next 35 years. This paper examines the building blocks of a strategy that will allow sectors such as steel, cement and chemical production to radically reduce their greenhouse gas emissions but also, through this transformation, protect or enhance their economic competitiveness.

Between 1990 and 2013, EU industry contributed significantly to the economy-wide emission reductions in the EU. Since 1990, the chemical sector's greenhouse gas emissions have decreased by almost 60% - from more than 300 million tonnes CO_2-eq in 1990 to less than 150 million tonnes in 2013 (European Environmental Agency 2016). This was achieved through the almost total elimination of emissions of non-CO_2 greenhouse gases and by significantly improving the efficiency of processes. In 2013, total EU emissions from steelmaking were 166 MT CO_2-eq (European Environmental Agency 2016). This represents a greenhouse gas emissions decrease of 39% between 1990-2013. However, most of these reductions are related to the significant reduction in primary steel production capacity in the EU. The EU cement industry's greenhouse gas emissions decreased by almost 40% between 1990 and 2013 - from 164 million tonnes CO_2-eq in 1990 to almost 103 million tonnes in 2013 (WBCSD 2015). The reductions occurred mainly due to lower production levels (-28% in 2013 compared to 1990) following the economic crisis in 2008, particularly in Southern European countries.

While the above-mentioned greenhouse gas reductions are impressive, tapping

into the reduction potential required for almost full decarbonisation will not be easy, as most of the low-hanging fruits have already been picked. Furthermore, most, if not all, of the energy-intensive industries face major challenges regardless of future mitigation commitments. These include production and capacity surpluses, as well as increased competition with other regions around the world that have competitive advantages through lower cost fuels or larger domestic markets. These elements could hamper the potential for reducing emissions in the future. They could, on the other hand, also present an opportunity to focus on the climate-friendly solutions that come with co-benefits, which would increase the economic performance and competitiveness of these industries.

Building blocks of a low carbon industrial transformation

To access the low carbon transformation, Europe's energy-intensive industries must use a combination of three types of innovations that address processes, products and business models. Due to the capital and risk-intensive nature of these transformations and the relatively short timescale within which they must be accomplished, the public sector will have play a catalysing role.

Industrial process innovations

Most industrial sectors are researching low carbon process breakthrough technologies. The petrochemical industry could, in theory, replace its fossil fuel feedstock with biomass waste and hence reduce emissions dramatically. There is likely to be sufficient biomass waste available in the EU to replace the fossil fuel based feedstock (European Chemical Industry Council 2013). However, the availability would still be limited and restrictions on the use of biomass waste for power production would be needed. Ammonia production could be electrified through solid state synthesis and therefore reduce the process emissions almost completely (Amar et al. 2011). The cement industry could have a unique opportunity to use a specific type of CCS technology (calcium looping), which comes with important co-benefits (Global CCS Institute 2015). Higher use of existing cement clinker substitutes could further reduce cement production emissions by 30%, while giving the same properties to cement as the commonly used Portland cement (Li et al. 2007). In the steel sector a new type of blast furnace that would negate the need for coking and sintering in hot iron production is currently being tested. This technology would be less costly to build and operate compared to conventional technologies. It could also reduce emissions by 20% and up to 80% with the availability of CCS (Croezen and Korteland 2010; ULCOS n.d.). Most sectors are also exploring the use of CO or CO_2 waste gases as input material for new products.

Product innovations for a low carbon society

In addition to these breakthrough process technologies, innovative products will also have to play a key role in the industrial low carbon transition. In the chemical sector, the development of new high-performing chemical compounds that can be easily assembled from bio-based feedstock will be essential (Werpy and Petersen 2004). The new products would facilitate the transition from a petrochemical to biochemical industry. For the cement sector, the most important low carbon product innovations will be in the design of new types of concrete. It is, in theory, possible to produce high quality concrete that only requires half of the amount of Portland cement as a binding agent. This would lead to an emissions reduction of 50% (Garcia 2008), at current production levels. Advanced material science leading to high performance and lightweight steel could open up a high value-added market for steel producers, which would target downstream consumers in need of this type of steel for the low carbon performance of their products.

Business model transitions and synergies with economy-wide decarbonisation

Finally, business model transitions will be essential for enabling both economic and environmental benefits. Ammonia and fertiliser production could move from pure manufacturing into the direction of agricultural services, by benefiting from the use of emerging biotechnologies. The cement and steel (Schuler et al. 2014) industries will have to address the current (and possibly structural) overcapacity through rationalisation, modernisation and increased overall added value at lower sales volumes (Allwood and Cullen 2012).

These industrial transitions cannot be considered in isolation; they must instead be aligned with other major shifts that are expected in the EU economy over the next decades. The growth of renewable electricity can become an asset for industrial transformation. The electrification of ammonia and steel production opens up the opportunity for these processes to act as batteries, consuming more electricity when plenty of renewables feed into the grid and reducing consumption at times of high demand and low renewable energy generation. These new services would, of course, need to be rewarded in future EU power markets[1]. A paradigm shift towards higher levels of resource efficiency and a circular economy in the EU would also complement the industrial transitions mentioned in this report. The steel and

1 See http://www.bloomberg.com/news/articles/2014-11-27/molten-aluminum-lakes-offer-power-storage-for-german-wind-farms; (Hestin et al. 2015)

chemical sectors both have ample potential to increase the re-use and recycling of products (Bureau of International Recycling 2015). For the steel industry, this would complement the move towards higher levels of electric arc steel and away from blast furnace production. Finally, the anticipated electric vehicle revolution would have an impact on the availability of fossil fuel based feedstock for the chemical sector, through the closures of refining capacity over the next decades (Bloomberg New Energy Finance 2016).

The role of the public sector

The investments in new process technologies are capital-intensive and entail technological risk. Product and business model changes also bear a certain risk, especially for mature and established industries. The required transitions in energy-intensive industries will not, therefore, take place without the development of smart and committed public policies.

Firstly, governments will have to assist these industries through modernisation and rationalisation. Governments could also help to create markets for new low carbon products through public procurement. Avoiding regulatory misalignment is a third element that requires evaluation in order to avoid punishing industries that move towards low carbon processes or business models.

One of the more challenging areas of the industrial low carbon transformation will be to commercialise promising low carbon process technologies. These new process technologies will need to be market-ready by 2030 to allow for deployment across the EU by 2050. Again, these investments will be capital-intensive but also, due to their pioneering nature, risk-intensive. The proposed EU Emissions Trading System (EU ETS) Innovation Fund for the period 2020-2030 could become an important tool for enabling the timely commercialisation of these process technologies. Industrial demonstration process technologies that are eligible should also demonstrate economic (or other) co-benefits. This could enhance the success of future implementation and commercialisation. A milestone-based reward system could reduce the risk for both the public and private sectors in the implementation of projects. Financing these projects will require a toolbox of instruments that match the needs of specific industries. Member States could consider new forms of co-financing, such as the use of public procurement. Finally, timely implementation of Innovation Fund projects will depend on streamlined State Aid guidelines that allow fast-track approval of co-financing by Member States.

Conclusion

There is no single silver bullet to break through the final frontier for deep emission reductions in energy-intensive industries. An economically attractive low carbon transition will require the combination of three pillars. These are the process, product and business model transformations. Thanks to technological process and product innovations that are already taking place within the energy-intensive industries, achieving deep emission reductions is possible over the next decades. Greater awareness within the public sector of the fact that realising deep emission reductions will require a helping hand is essential (e.g. through the EU ETS innovation fund).

A full transition can only be guaranteed if there is a sustained effort by both the public and private sectors to fully integrate the decarbonisation challenges within industrial policy, hence making this both an economic and a low carbon success.

References

Amar, I. A.; Lan, R.; Petit, C. T. G.; Tao, S. (2011): Solid-state electrochemical synthesis of ammonia: a review. Journal of Solid State Electrochemistry 15(9)1845–1860. doi: 10.1007/s10008-011-1376-x.

Bio-based Industries Consortium (2012): Accelerating innovation and market uptake of biobased products. http://biconsortium.eu/sites/biconsortium.eu/files/publications/BIC_Vision_web_0.pdf

Bloomberg New Energy Finance (2016): Electric vehicles to be 35% of global new car sales by 2040. https://about.bnef.com/blog/electric-vehicles-to-be-35-of-global-new-car-sales-by-2040/

Bureau of International Recycling (2015): World Steel Recycling In Figures 2010-2014. http://www.bir.org/assets/Documents/publications/brochures/Ferrous-report-2015-FIN-WEB2.pdf

Croezen, H.; Korteland, M. (2010): Technological developments in Europe: A long-term view of CO_2 efficient manufacturing in the European region. Delft, The Netherlands: CE Delft. http://www.cedelft.eu/publicatie/technological_developments_in_europe%3Cbr%3Ea_long-term_view_of_co2_efficient_manufacturing_in_the_european_region/1098

European Chemical Industry Council (2013): European chemistry for growth: Unlocking a competitive, low carbon and energy efficient future. CEFIC supported by ECOFYS. Brussels, Belgium: CEFIC. http://www.cefic.org/Documents/RESOURCES/Reports-and-Brochure/Energy-Roadmap-The%20Report-European-chemistry-for-growth.pdf

European Commission (2011): Impact assessment accompanying document to: A Roadmap for moving to a competitive low carbon economy in 2050. SEC(2011) 288 final. Brussels, Belgium. lex.europa.eu/LexUriServ/LexUriServ.do?uri=SEC:2011:0288:FIN:EN:PDF

European Environmental Agency (2016): EEA greenhouse gas - data viewer. EEA greenhouse gas - data viewer. http://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer

Garcia, E. (2008): Demande de brevet Europeen. Saint-Didier-de-la-Tour.

Global CCS Institute (2015): ITRI Calcium Looping Pilot. https://www.globalccsinstitute.com/projects/itri-calcium-looping-pilot

Hestin, M.; Faninger, T.; Milios, L. (2015): Increased EU Plastics Recycling Targets: Environmental, Economic and Social Impact Assessment. Final Report. Plastic Recyclers Europe. http://www.plasticsrecyclers.eu/sites/default/files/BIO_Deloitte_PRE_Plastics%20Recycling%20Impact_Assesment_Final%20Report.pdf

Li, G. S.; Walenta, G.; Gartner, E. M. (2007): Formation and hydration of low-CO_2 cements based on belite, calcium sulfoaluminate and calcium aluminoferrite. Proceedings of the 12th ICCC. Presented at the 12th International Congress on the Chemistry of Cement, Montreal, Canada. https://www.researchgate.net/publication/260422274_Formation_and_hydration_of_low-CO2_cements_based_on_belite_calcium_sulfoaluminate_and_calcium_aluminoferrite

nova-Institute (2013): Production Capacities for Bio-based Polymers in Europe: Status Quo and Trends towards 2020.

Randall, T. (2016): Here's How Electric Cars Will Cause the Next Oil Crisis. http://www.bloomberg.com/features/2016-ev-oil-crisis/

Schuler, F.; Veraszto, T.; Voigt, N.; Schubert, M.; Mergelkamp, I.; Singh, T. (2014): Coping with Overcapacity: Navigating Steel's Capacity Conundrum. https://www.bcgperspectives.com/content/articles/metals_mining_lean_manufacturing_pricing_coping_with_overcapacity/

ULCOS (n.d.): HIsarna smelter technology. http://www.ulcos.org/en/research/isarna.php

WBCSD (2015): GNR: Totals & Averages: Light Report 2013. World Business Council for Sustainable Development: Cement Sustainability Initiative.

Werpy, T.; Petersen, G. (2004): Top Value Added Chemicals from Biomass: Volume I - Results of Screening for Potential Candidates from Sugars and Synthesis Gas. DOE/GO-102004-1992. National Renewable Energy Lab., Golden, CO (US). https://www.osti.gov/scitech/biblio/15008859%5d

Wyns, T.; Axelson, M. (2016): Decarbonising Europe's Energy Intensive Industries: The Final Frontier. Brussels, Belgium: Institute for European Studies, Vrije Universiteit Brussel. http://carbonmarketwatch.org/wp-content/uploads/2016/04/Final-Frontier-Innovation-Report-Web-Version.pdf

Rethinking basic materials production[1]

Energy-intensive processing industries (EPIs) that produce steel, aluminum, plastics, cement, glass and paper are responsible for a large share of global greenhouse gas emissions. These basic materials are essential for society as well as for climate mitigation across all other sectors; for example, through better insulation for buildings, steel for wind turbines or silicon for solar cells. Whereas the prospects for decarbonising the transport, building and energy sectors have significantly improved over the past 10 to 20 years, options for zero emissions from basic materials production have received less attention in R&D, innovation and climate policy. Zero emissions are possible from a resource and technological point of view, but industry and market structures present considerable policy and governance challenges to making low carbon transition in the EPIs.

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Introduction

Globally, industry is responsible for over 30% of all greenhouse gas emissions, of which the majority is emitted by EPIs (Fischedick et al. 2014). Over the past decades, these industries have made significant resource and energy efficiency improvements. However, meeting the EU 2050 emission reductions target of 80% to 95% compared to 1990 levels requires further and extensive low carbon innovation, often of a radical nature. The "well below 2°C" target, recently adopted in Paris, requires emissions to decrease to zero.

Emissions from EPIs arise from the combustion of fuels for energy and from production processes; for example, the calcination of limestone to clinker, the reduction of iron ore to iron and the depletion of carbon cathodes in aluminum production. Industries also cause indirect emissions in the electricity sector (from the combustion of fuels) and in the waste sector; for example, when plastic waste is incinerated. Improvements in material, energy and end-use efficiencies can lead to considerable reductions in demand for materials and thus lower emissions (Allwood and Cullen 2012). The recycling of materials is a powerful strategy as the energy needs and emissions of recycled materials are typically much lower than of virgin materials. Nevertheless, it is also necessary to decarbonise the processing of virgin or recycled feedstocks such as biomass, iron ore, bauxite, limestone, ethylene, scrap metal or recycled paper and plastics into basic materials.

There are three basic technical options: replacing fossil fuels and feedstock with biomass; electrification of the process; and the use of carbon capture and storage (CCS) (Åhman et al. 2012; Lechtenböhmer et al. 2016). All these entail fundamental technical changes and innovation, including the development and introduction of new core production processes and new associated infrastructures. The technologies are still

1 The author would like to thank several colleagues involved in projects and publications which this short paper draws on, including Max Åhman, Alexandra Nikoleris, Ellen Palm, Stefan Lechtenböhmer, Clemens Schneider, Joeri Wesseling, Karin Ericsson, Bengt Johansson, Oscar Svensson, Lars Coenen, Ernst Worrell and Teis Hansen.

relatively unexplored, and they exist only in small demonstration and pilot projects, on the laboratory scale, or as more or less proven ideas. In the case of petrochemicals, the main option is to replace the fossil feedstock with biomass and/or hydrocarbons produced in processes based on renewable electricity (e.g. methane from power-to-gas conversion). For steel production, the options for producing virgin steel without process-related emissions imply either the introduction of new concepts such as process-integrated CCS, electrification (electrowinning) or biomethane/hydrogen direct reduction (DRI). Each sub-sector within the EPIs faces its own specific technical challenges to producing basic materials with zero emissions. However, what all the zero emission solutions for EPIs have in common is that they can be regarded as systemic (i.e. require system-wide changes) and will result in substantially higher production costs, but essentially no co-benefits or advantages.

Electrification of basic materials production

Biomass is a scarce resource and hence its potential use for energy and feedstock in the EPIs is limited. CCS has larger potential but is not a sustainable solution in the long term. New renewable energy (notably solar and wind) comes mainly in the form of electricity and its production is not, for practical purposes, constrained by resource limitations. Electricity is also a versatile energy carrier. This motivates the exploration of electricity as the main future source of energy and feedstock for the EPIs.

A scenario for the EU in which the EPIs are electrified, and electricity is used to produce feedstock for plastics production, shows that about 1700 TWh of extra renewable electricity would be needed (see **Figure 1**, (Lechtenböhmer et al. 2016)). This can be compared to the current total electricity use in the EU of 2780 TWh (the industry share is about 1000 TWh). The potentially large increase in electricity demand raises the question of availability. However, the potential for renewable electricity production is much greater than the potential increase in demand.

In a circular economy with increased focus on material efficiency and the concurrent development of bio-based materials, electricity demand could be much lower than suggested in the above scenario. A potentially more challenging problem than energy in a renewables-based circular economy is the closing of the loop on carbon and CO_2, particularly when it comes to plastics (Palm et al. 2016). Assuming the CO_2 use per tonne of feedstock monomers is equal for all plastics (i.e. about 3 tonnes of CO_2/tonne), the total annual CO_2 demand for EU plastic production can be estimated to be between 180 and 190 Mton.

The potential sources of CO_2 can be both fossil and non-fossil. Although air capture removes the scarcity argument, it would be convenient to capture CO_2 in more concentrated streams. In a circular economy, concentrated non-fossil sources of CO_2 may come from, for example, the combustion or pyrolysis of biomass and municipal waste (including end-of-life plastics), or from the production of ethanol and upgrading of biogas.

Governing transitions to fossil-free basic materials production

The fossil-free production of basic materials is technically possible but it will, for the foreseeable future, incur

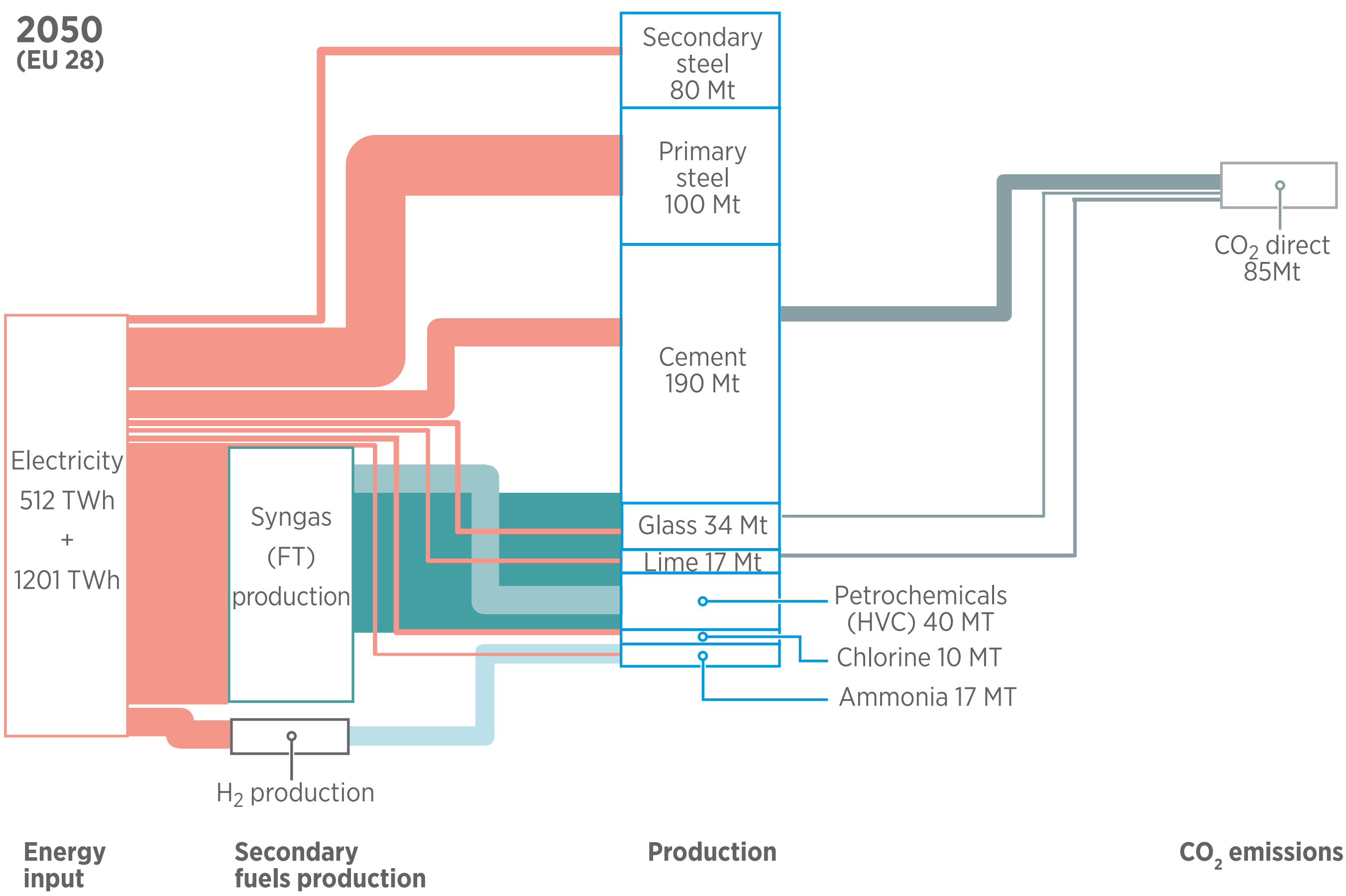

Fig. 1: EU scenario for 2050 with electrified EPIs - Source: (Lechtenböhmer et al. 2016)

substantially higher production costs with no tangible co-benefits. This is a serious problem from an implementation point of view. Most of these industries compete on international markets where cost increases reduce competitiveness, which in turn may lead to geographical relocation and carbon leakage. It is not, however, a problem from the wider economic development point of view. Basic materials generally represent a small share of GDP and also a very small share of the final price of finished products.

The EPI characteristics and innovation systems also present a challenge (Wesseling et al. 2016). EPIs are typically capital-intensive, have long investment cycles and strong economies of scale. Innovation is mainly in incremental process improvements and in product development. Profit margins are often small or cyclical in these bulk commodity markets. Public policy thus far has focused on reducing local environmental impacts and on making efficiency improvements, and it has generally sheltered EPIs from policy impacts that increase costs (for example, through tax exemptions or the free allocation of emission permits).

Based on insights from other sectors, as well as the particular situation of the EPIs, it is possible to identify a number of key elements needed for a low carbon transition. One such element is the need for direction. Stakeholder-oriented, low carbon scenario visioning and pathway processes are important tools for coordinating, directing, legitimising and learning about transitions. Another element is understanding system innovation. A transition is not only about replacing single technologies and processes. It can have system-wide implications on value chains, require institutional innovations and have considerable implications for energy systems and the circular economy as a whole. Deployment requires risk sharing between the EPIs and governments to facilitate stable investment conditions, perhaps similar to those provided for renewable energy technologies through feed-in-tariffs and quota-based systems. Governing a transition also requires institutional capacity and expertise within responsible government agencies. Finally, decarbonising the EPIs requires international coordination and new approaches in international climate and trade policy, as protected spaces for technology development, deployment and upscaling are necessary (Åhman et al. 2016).

Conclusions

Zero emissions is a liberating, albeit challenging, concept. To achieve zero emissions we now must work on fundamental technology shifts in the energy-intensive processing industries. Strategies are needed and steps must be taken to facilitate pilot plants, demonstrations, up-scaling and co-evolution with energy systems over the next 30 to 50 years. With the abundance of renewable energy, the reasonable availability of minerals and feedstock, and the scope for improved materials efficiency and circularity, there appears to be no fundamental resource or technological restrictions to the fossil-free and sustainable production of basic materials. It does, however, require the development of technologies, systems and markets through policy and governance strategies.

References

Allwood, J. M.; Cullen, J. M. (2012): Sustainable Materials - With Both Eyes Open. Cambridge, UK: UIT Cambridge Ltd.

Åhman, M.; Nikoleris, A.; Nilsson, L. J. (2012): Decarbonising industry in Sweden: an assessment of possibilities and policy needs. No. 77. Environment and Energy System Studies. Lund, Sweden: Lund University. https://www.naturvardsverket.se/upload/miljoarbete-i-samhallet/miljoarbete-i-sverige/klimat/fardplan-2050/decarbonising-industry-sweden-lunds-univ.pdf

Åhman, M.; Nilsson, L. J.; Johansson, B. (2016): Global climate policy and deep decarbonization of energy-intensive industries. Climate Policy 0(0)1–16. doi: 10.1080/14693062.2016.1167009.

Fischedick, M.; Roy, J.; Abdel-Aziz, A.; Acquaye, A.; Allwood, J. M.; Ceron, J.-P.; et al. (2014): Industry. In: Climate Change 2014: Mitigation of Climate Change. Working Group III Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK and New York, NY, USA. http://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_chapter13.pdf

Lechtenböhmer, S.; Nilsson, L. J.; Åhman, M.; Schneider, C. (2016): Decarbonising the energy intensive basic materials industry through electrification – Implications for future EU electricity demand. Energy 115, Part 3,1623–1631. doi: 10.1016/j.energy.2016.07.110.

Palm, E.; Nilsson, L. J.; Åhman, M. (2016): Electricity-based plastics and their potential demand for electricity and carbon dioxide. Journal of Cleaner Production 129,548–555. doi: 10.1016/j.jclepro.2016.03.158.

Wesseling, J.; Lechtenböhmer, S.; Åhman, M.; Nilsson, L. J.; Worrell, E.; Coenen, L. (2016): The characteristics of energy intensive processing industries towards deep decarbonization: implications for transitions research. Manuscript.

Enabling CO_2 reuse value chains: the importance of geographical conditions

Strategies for capturing CO_2 from existing industrial processes are considered important in the transition to low carbon economies. CO_2 reuse offers the possibility of making different contributions to the mitigation of overall emissions. To enable re-use at different scales, knowledge on the practical logistics of capture, treatment and transport is essential before establishing whether a final conversion process would be viable. In addition to knowledge about the individual stages of the value chain, the implications of each stage must be adapted to the processes of subsequent and preceding stages in the local context. This understanding helps stakeholders to search for partners and explore business cases according to the composition and scale of the source, feasible distances and final application requirements.

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Introduction

Carbon capture and utilisation (CCU) is an attractive option for abating CO_2 and displacing primary hydrocarbon use. CO_2 is already used as feedstock in some processes and is produced in high purity by others. Previous research has focused on the individual stages of a CCU value chain. This work examines the pre-conditions for joining the stages. It systematises the technical choices for discrete CO_2 emitters and receivers. Sources are classified to enable consolidation and the factors and thresholds for the choice of transport mode are laid out. The Value Chain Analysis project of the EnCO$_2$re programme[1] provides a framework to support the preparation of CCU business cases.

Evaluating CCU value chains

Ideally, large mass flow and high concentration are sought as requisites for considering a CCU scheme. These two parameters, as well as the impurities present in the flow, influence the cost of capture and treatment. Impurities are the least tractable parameter. They can vary widely due to, amongst others, variations in reaction ratios and feedstock quality. The resulting range of possibilities and implications complicates their categorisation.

The classification of sources starts with the mass flow. Sources that emit more than 0.1 MtCO_2 per year (Mtpa) are considered "large scale" (IPCC 2005); it is estimated that sources emitting less than 0.1 Mtpa together account for less than 1% of the emissions from all stationary sources. Our stakeholder engagement revealed four sensible scale categories:

- Micro: 0.035-0.075 Mtpa
- Small: 0.075-0.1 Mtpa
- Moderate: 0.1-0.5 Mtpa
- Large: ≥0.5 Mtpa

The concentration of CO_2 in the effluent depends largely on whether or not the source involves combustion. In processes such as hydrogen or ammonia production, the levels of concentration are higher, mostly reaching over 95% (Element Energy et al. 2014). Sources have been classified in four bins by (Jin et al. 2012), based on the impact of the CO_2 concentration on the energy required for separating the CO_2. Our stakeholder engagement resulted in a practical classification of three bins based on the number of sources in each category and the technologies suitable for treating them:

- High Level: >90%
- Moderate Level: 20-90%
- Low Level: <20%

Capture and treatment technologies have been reviewed extensively by (Styring et al. 2011) and (Global CCS Institute 2011). The work in EnCO$_2$re synthesises the most applicable combinations for promising value chains. Three categories of capture technologies, i.e. (i) post-combustion capture, (ii) pre-combustion capture, and (iii) oxy-fuel combustion, were analysed in combination with the sources for which they are suitable. Based on their technology readiness level (TRL), companies interested in providing or receiving CO_2 can select options for further cost analysis. Cost curves were generated for promising technical combinations reflecting the influence of scale. This allows individual nearby sources to estimate the cost of reaching a particular level of purity and scale by consolidation. The participants of a new CCU scheme could assess the collective cost of offering a large, uniform CO_2 stream.

Potential CO_2 providers need to estimate the radius in which they can search for CO_2 receivers. The choice of transport means and the maximum suitable distance depend on: (i) the purity of the CO_2 stream, (ii) the scale of the flow, (iii) terrain morphology, and (iv) existing infrastructure. Although configurations with the lowest number of steps, such as storage, uploading and unloading, are preferred, the main pre-condition is to find demand points with matching purity

1 http://enco2re.climate-kic.org/

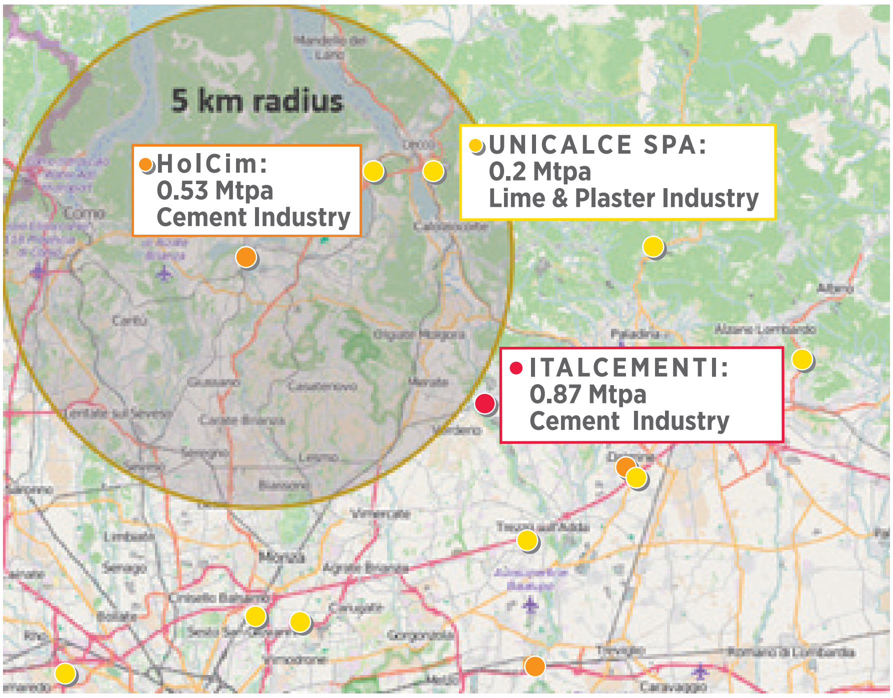

Fig. 1: Viable range for seeking CO_2 receiving processes -
Source: Own figure based on openstreetmap.org

requirements, mass flow uptake capacity and willingness to pay for the captured CO_2. Calculations including assumed values, for example for the sale of emission permits and CO_2 market prices, illustrate cost trends for various CO_2 streams using all transport means across a range of distances. CO_2 providers can visualise the geographical areas they could serve, as shown in **Figure 1.**

Conclusions

To explore the full CCU potential of a region it is necessary to coordinate the specifications of the different value chains. Understanding how to consolidate sources and the requirements, location, scale and TRL of the sinks, can constructively inform the choice of capture, treatment and transport technologies. The EnCO_2re programme can help stakeholders to define a CCU scheme by performing the calculations presented in this Value Chain Analysis framework using their local requirements. The ability to find the right partners is unlocked by the ability to identify the right technologies at the right scales.

References

Element Energy; Carbon Counts; Process Systems Enterprise; Imperial College London; University of Sheffield (2014): Demonstrating CO_2 capture in the UK cement, chemicals, iron, steel and oil refining sectors by 2025: A Techno-economic Study. Final Report for DECC and BIS. Cambridge, UK. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/311482/Element_Energy_DECC_BIS_Industrial_CCS_and_CCU_final_report_14052014.pdf

Global CCS Institute (2011): The global status of CCS: 2011. Canberra, Australia: Global CCS Institute. https://hub.globalccsinstitute.com/sites/default/files/publications/22562/global-status-ccs-2011.pdf

IPCC (2005): IPCC special report on carbon dioxide capture and storage. Prepared by Working Group III of the Intergovernmental Panel on Climate Change. Cambridge, UK and New York, USA: Cambridge University Press.

Jin, H.; Gao, L.; Li, S.; van Sambeek, E.; Porter, R.; Mikunda, T.; et al. (2012): Supporting early Carbon Capture Utilisation and Storage development in non-power industrial sectors. No. 12. Shaanxi Province, China: The Centre for Low Carbon Futures.

Styring, P.; Jansen, D.; de Coninck, H.; Reith, H.; Armstrong, K. (2011): Carbon Capture and Utilisation in the green economy: Using CO_2 to manufacture fuel, chemicals and materials. No. 501. The Centre for Low Carbon Futures 2011 and CO_2Chem Publishing 2012.

Deep decarbonisation in industries: what does it mean for India?

Energy-intensive industries in India have successfully increased their output while simultaneously lowering their energy-intensity. Over time, as technological solutions have been increasingly adopted at a cost, producers have responded in textbook fashion to rises in the price of energy and substitutes and to top down policy measures etc. to maintain their competitiveness in the market place. Our analysis shows the Enhanced Energy Efficiency measures outlined in the National Action Plan on Climate Change are not compatible with the global 2°C goal. However, if non energy-intensive industries are brought into the policy fold, an increasing shift to the use of electricity in production processes is encouraged, and the underlying potential of decarbonising the electricity sector is targeted, Indian industries can deliver the global 2°C target despite activity growth in the coming decades and through to the middle of the 21st century.

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Introduction

India has been following an energy efficient pathway for many years. While market price initially influenced the energy end users' decisions, policy-induced incentives and the adoption of new technology became drivers for rapid change. However, an important question remains: where is the new potential for decoupling activity growth and carbon emissions?

Methodology and ongoing activities

We used micro level producer behaviour models using long time series, as well as panel data from the Annual Survey of Industries' detailed data sets, to estimate parameters using translog production function models to reflect the changing behaviour of the Indian industries. We also used India-specific parameters and detailed data to expand and run the GCAM model for the Indian region using detailed data for Indian industries in collaboration with the Joint Global Change Research Institute, Maryland, USA. The goal was to assess the need for actions in the Indian industry sector given the global 2°C temperature goal and assumed global carbon price regime. We also used the decomposition method and conducted primary interviews at company level to substantiate our findings.

Factors	1973-74 to 2011-12	1973-74 to 1988-89	1989-90 to 1997-98	1997-98 to 2011-12
Capital - Labour	Substitute	Substitute	Complement	Substitute
Capital - Material	Substitute	Substitute	Substitute	Substitute
Capital - Energy	Complement	Complement	Substitute	Complement
Labour - Material	Substitute	Substitute	Substitute	Substitute
Labour - Energy	Substitute	Substitute	Substitute	Substitute
Material - Energy	Substitute	Substitute	Substitute	Substitute
Own price elasticity of energy	-1.16	-0.43	-0.95	-0.53

Table 1: Responsiveness of Indian energy-intensive industries - Source: Own figure based on (Government of India (various years a)) and (Dasgupta and Roy 2015)

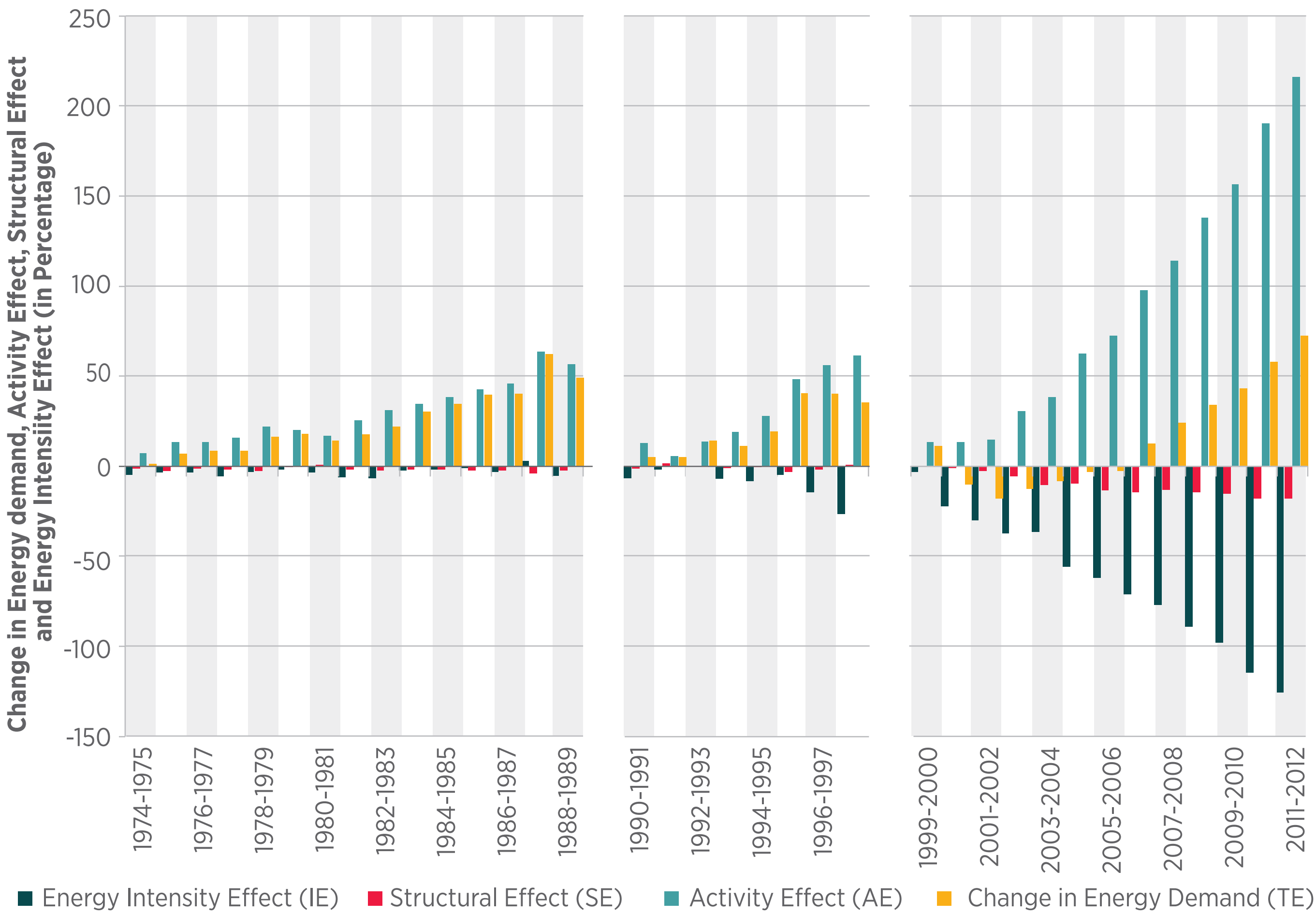


Fig. 1: Breakdown of energy use in Indian energy-intensive industries -
Source: Own figure based on (Government of India (various years a)) and (Dasgupta and Roy (forthcoming))

Findings

It is interesting to note how energy-intensity growth has been instrumental in decoupling the activity growth of Indian industries from energy use growth - a trend which started in 1992 but has played a significant role since 2000 (see **Figure 1**).

This has been made possible by increasing the substitution of energy inputs through technological process change, input change and fuel change (see **Table 1**). This is a significant finding in the context of the ongoing debate on carbon tax/ carbon price. The conclusion of earlier studies, which argued against carbon price/tax due to the possible negative impact on productivity growth (Roy et al. 1999), is no longer valid as behav-ioural responses have evolved over time. All industries are spending money to

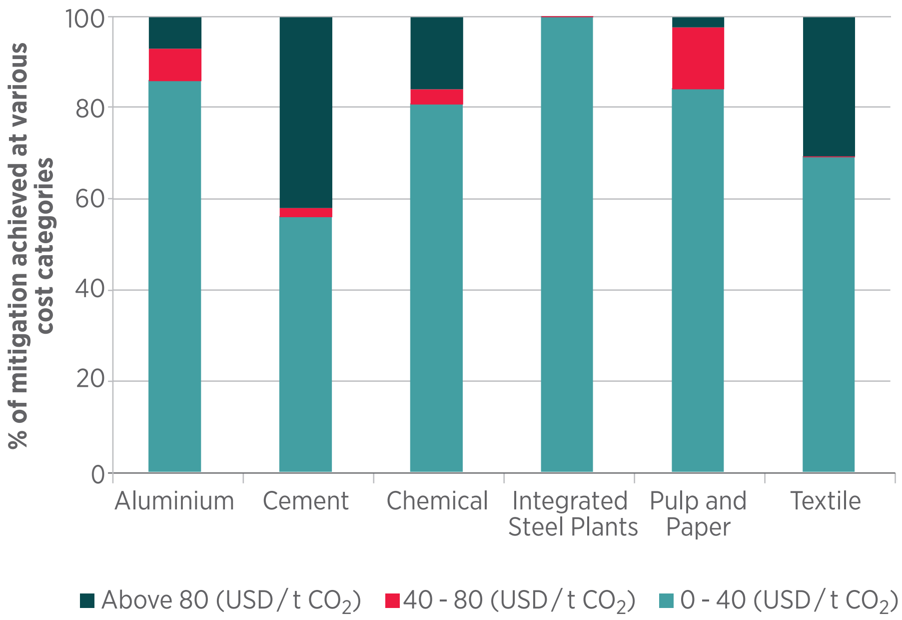
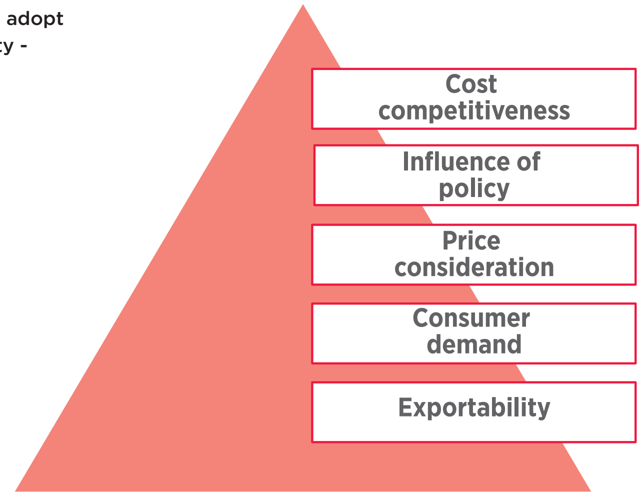


Fig. 2: Mitigation costs incurred by energy-intensive industries in India -
Source: Own estimation based on (Government of India (various years b))

Fig. 3: Driving factors for industry to adopt actions compatible with sustainability - Source: Own figure based on (Chakraborty and Roy 2012)



change their production energy and reduce their emissions (see **Figure 2**). All the low-cost options have been implemented across the sectors. The interviews with the companies revealed that the most important driver for their behavioural change has been cost competitiveness in the market place (see **Figure 3**). However, the GCAM runs show that the future potential for achieving the global 2°C target under the current global price regime lies mainly with the non energy-intensive industries (see **Figure 4**) and the strategic decarbonisation of the electricity sector (see **Figure 5**).

Conclusion

The Indian industry sector has responded actively to various market signals and policy regimes and has been successful in achieving higher energy efficiency over time. However, non energy-intensive industries can also play a role in delivering efficiency through policy intervention which is compatible with global goals and policy regimes for deep decarbonisation. Future potential also lies in increasing the electrification of production processes and the decarbonisation of the electricity production sector.

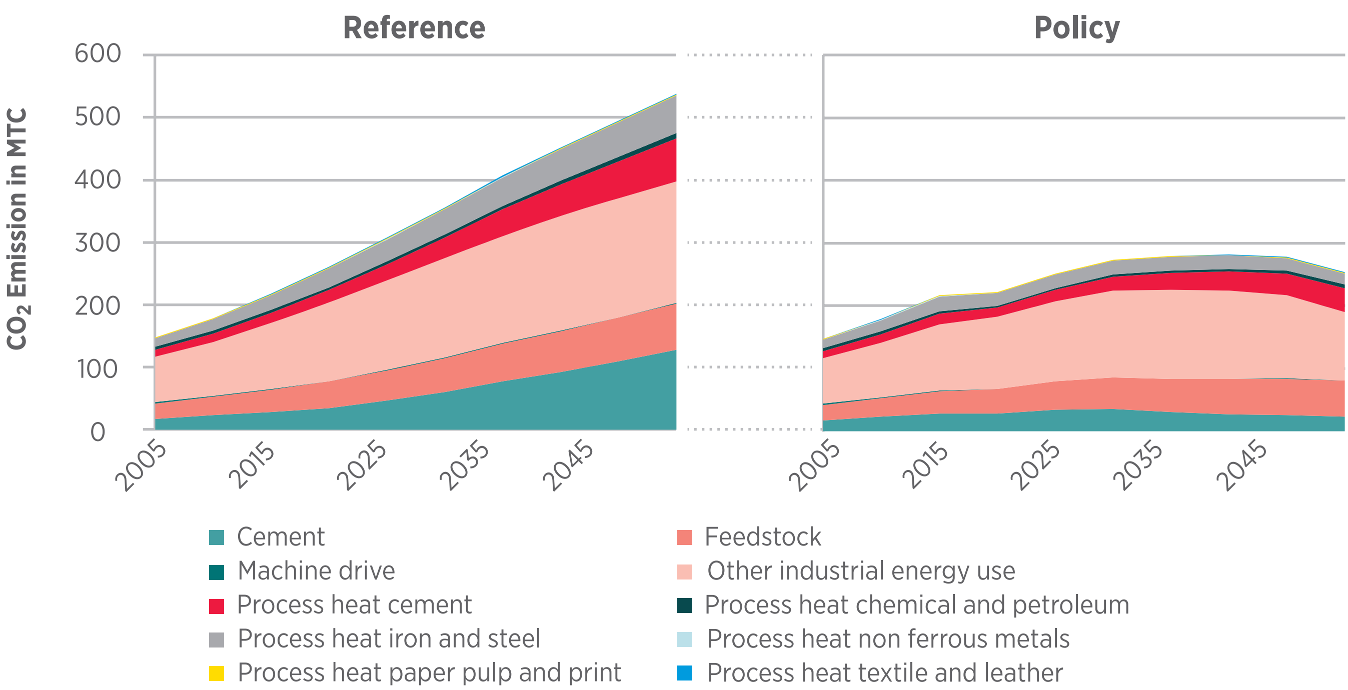


Fig. 4: GCAM results for Indian industries under the global 2°C goal and carbon price - Source: Own estimates

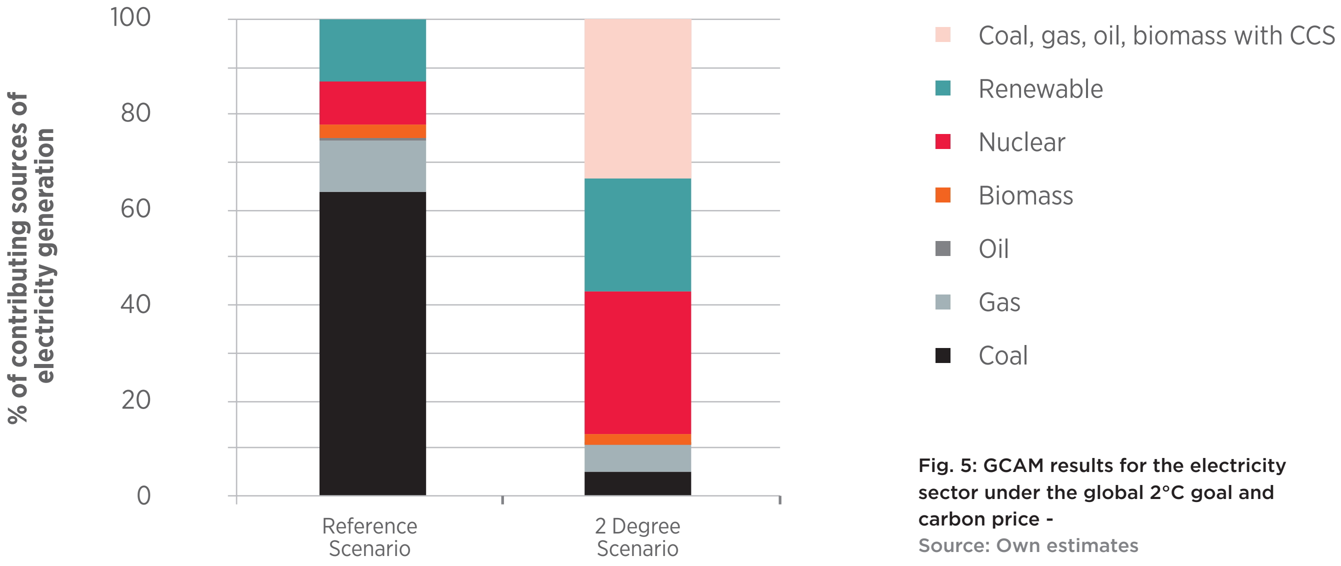


Fig. 5: GCAM results for the electricity sector under the global 2°C goal and carbon price -
Source: Own estimates

References

Chakraborty, D.; Roy, J. (2012): Climate Change Adaptation and Mitigation Strategies: Responses from Select Indian Energy Intensive Industrial Units. Full paper in the Seminar Proceedings of the International Conference on Public Policy and Governance. Bangalore/India: Dept. of Management, IISC Bangalore and Dept. of Public Affairs Centre.

Government of India (various years a): Annual Survey of Industries. Ministry of Statistics and Programme Implementation, Central Statistics Office. Kolkata. http://www.csoisw.gov.in/CMS/cms/Home.aspx

Government of India (various years b): National Awards on Energy Conservation. Ministry of Power.

Dasgupta, S.; Roy, J. (2015): Understanding technological progress and input price as drivers of energy demand in manufacturing industries in India. Energy Policy 83(C)1–13.

Dasgupta, S.; Roy, J. (forthcoming): Analysing energy intensity trends and decoupling of growth from energy use in Indian manufacturing industries during 1973–1974 to 2011–2012. Energy Efficiency. Article in Press. doi: 10.1007/s12053-016-9497-9.

Dasgupta, S.; van der Salm, F.; Roy, J. (2015): Designing PAT as a Climate Policy in India: Issues Learnt from EU-ETS. In N. Ghosh, P. Mukhopadhyay, A. Shah, and M. Panda (Eds.), Nature, Economy and Society: Understanding the Linkages. New Delhi: Springer India.

Roy, J.; Sathaye, J.; Sanstad, A.; Mongia, P.; Schumacher, K. (1999): Productivity Trends in India's Energy Intensive Industries. The Energy Journal, 20(3)33–61.

Science in the context and climate policy afte

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To help achieve the SDGs and climate objectives, there are calls for science to evolve from its current role. Science might have to develop from a conventional paradigm to one that is transformative and transboundary. As a result, the organisation within specialised departments and disciplines would be modified to create a new scientific approach – one that is interdisciplinary, transdisciplinary and multi-stakeholder based. This would include continuous interaction and dialogue between scientists and other stakeholders in society, including policymakers, non-governmental agencies, citizens and business.

Science, technology and innovation as means of attaining the Sustainable Development Goals

In September 2015, the Sustainable Development Goals were agreed by the UN General Assembly, delivering an integrated vison of sustainable development. In December 2015, the Paris Accord set the framework for a new climate regime to reach the 1.5°C-2°C target. The importance of science, technology and innovation was recognised as one of the main means of attaining the SDG targets when the Addis Ababa Action Agenda called for the establishment of a Technology Facilitation Mechanism. A technology mechanism has also been established in the UNFCCC context, following a decision made at the Conference of the Parties in Cancun in 2010.

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Introduction

In September 2015, the Sustainable Development Goals were agreed, delivering an integrated vision of sustainable development. More specifically, in the area of social sustainability, targets for poverty and hunger eradication, healthy living, clean water and sanitation, quality education and gender equality attainment were set; in the area of environmental protection, specific targets were set for climate protection, protection of life below water and on land; in the area of economic development, targets for affordable and clean energy, decent work and economic growth, industry, innovation and infrastructure were set. At the same time, the importance of science, technology and innovation was recognised as one of the main means of attaining the SDGs; paragraph 123 of the Addis Ababa Action Agenda and paragraph 70 of the Post 2015 Development Agenda Outcome Document called for the establishment of a Technology Facilitation Mechanism. The mechanism will comprise a UN interagency task team on STI for SDGs, a collaborative annual multi-stakeholder forum on Science, Technology and Innovation (STI) for SDGs, and an online platform as a gateway for information on existing STI initiatives, mechanisms and programmes. A technology mechanism was also established in the UNFCCC context, following a decision made at the Conference of the Parties in Cancun in 2010.

The Technology Mechanism under UNFCCC

A Technology Mechanism was established in 2010 by UNFCCC Conference of the Parties (COP) to enhance technology development and transfer and to support action on mitigation and adaptation in order to achieve the full implementation of the Convention on Climate Change. Furthermore, the COP decided to accelerate actions at different stages of the technology cycle, including research and development, demonstration, deployment, diffusion and transfer of technology in support of action on mitigation and adaptation. The technology mechanism consists of two bodies, the Technology Executive Committee (TEC), for providing the strategy of the technology transfer, and the Climate Technology Centre and Network (CTCN), whose task it is to implement technology transfer projects in developing countries.

The CTCN mission is “stimulating technology cooperation and enhance the development and transfer of technologies to developing country Parties at their request”. The services provided by CTCN include:

1. Technical assistance to developing countries;
2. Knowledge sharing and training;
3. Fostering collaboration on climate technologies (including linking climate technology projects with financing opportunities).

CTCN is hosted by UNEP in collaboration with UNIDO and supported by 11 partner institutions with expertise in climate technologies.

The technical assistance CTCN provides covers the areas of mitigation and adaptation. In terms of mitigation, the sectors involved are energy, transport and waste management; for adaptation, the sectors are water, agriculture and ecosystem protection and monitoring.

The types of technical assistance requested by developing countries for a

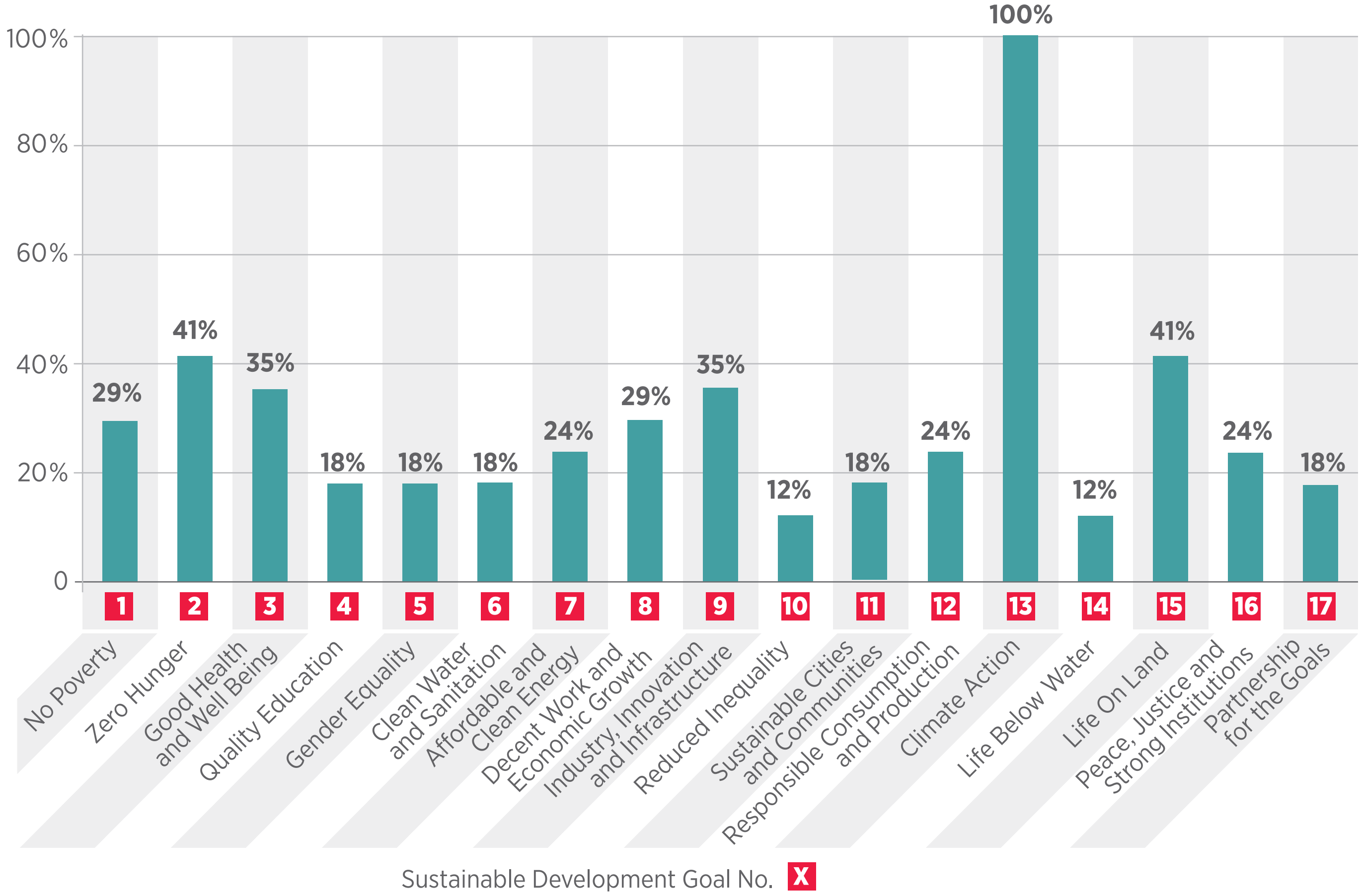

Fig. 1: CTCN analysis on the impact of implemented technology transfer projects on SDG areas -
Source: (Climate Technology Centre and Network 2016)

specific mitigation and/or adaptation technology include requests for strengthening research and development of new climate technologies, requests for conducting feasibility studies for specific known climate technology options, increasing diffusion of known technologies in local conditions, enhancing law, policy and regulatory reform recommendations, designing sector specific roadmap or strategy, enhancing finance facilitation and market creation, and identifying and prioritising technologies.

CTCN has put forward an analysis of the impact of the implemented projects on the SDGs. The result of this analysis has been synthesised in **Figure 1**, showing that climate protection projects impact on all the other areas of the SDGs.

This kind of analysis, due to the high research and innovation content of the implemented projects, demonstrates the significant impact of STI in achieving the SDGs.

This raises the issue of why it is so difficult for specific STI projects to attract both public and private investment. One of the reasons is the risk of failure of the research activities in attaining the expected results; another reason is the time lag, typically a decade, between the initial research activity and the moment when

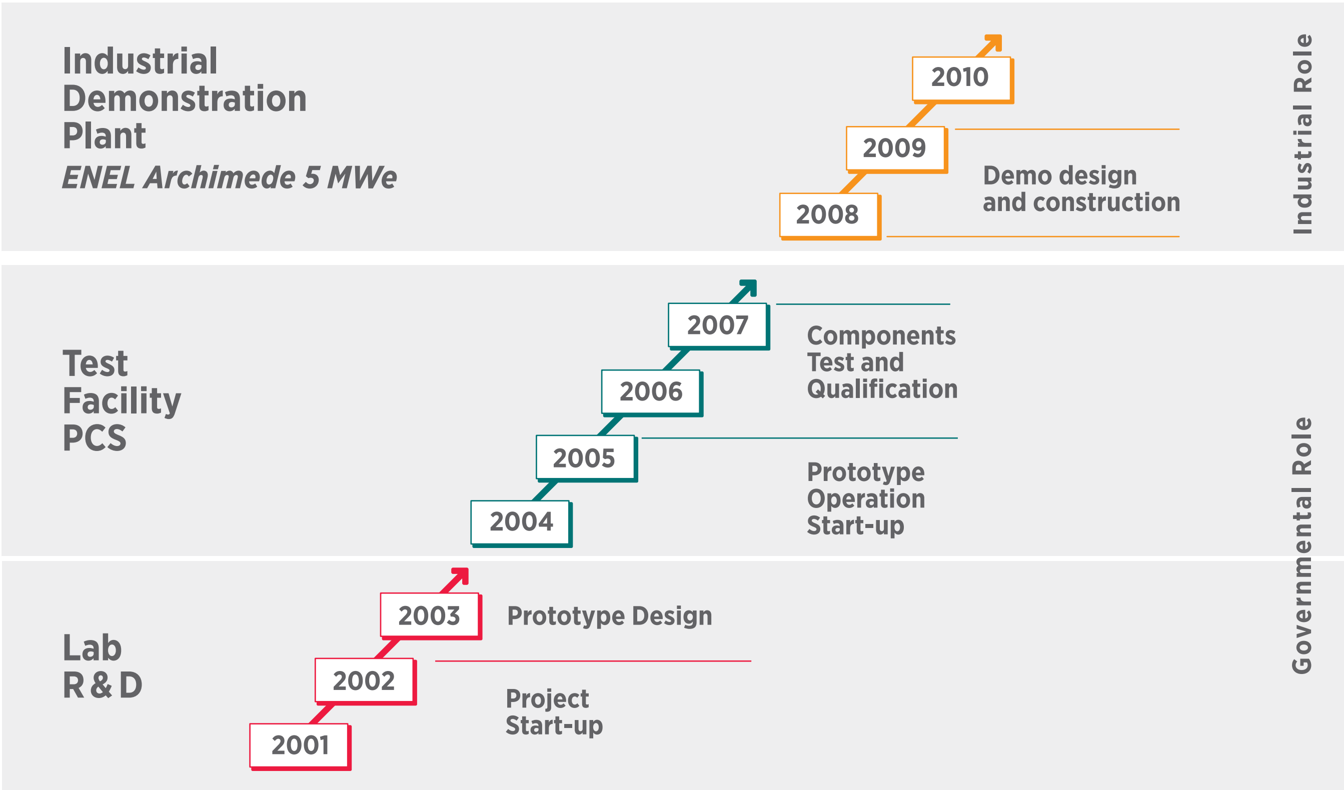

Fig. 2: High temperature solar plant - time lag between research activity and market availability of the product - Source: Own figure

the impact of the research becomes visible in the market. An example of this is shown in **Figure 2**, illustrating the case of a high temperature solar plant.

Conclusions

The Paris Accord is largely a science-based set of decisions; there is no need to restate the role of science in tackling climate change and, more generally, in achieving the SDGs.

The Technology Mechanism could be a mean of fostering science, technology and innovation (STI), but it is not a silver bullet. Research requires more focused financing for the training of researchers and the setting up and maintaining of laboratories. This requires an adequate and predictable level of financing.

The STI involvement required includes a multitude of disciplines and their integration - physics, chemistry, biology, medicine and pharmaceutics, economy, statistics, social and political science, as well as some transdisciplinary science such as transitional science.

A worldwide action plan on STI, adequately financed and evaluated, should be set. The UN interagency task team on STI for the SDGs could help in drafting a programme that tries to match demand with offers of research.

References

Climate Technology Centre and Network (2016): 8th CTCN Advisory Board Meeting: Meeting Documents: 7.1 Technical Assistance and Impacts in a Snapshot.
https://www.ctc-n.org/sites/www.ctc-n.org/files/ab20168_7.1_ta_snapshot_and_impacts_v2.pdf

IRENA (2015): Renewable Energy and Jobs: Annual Review 2015. Abu Dhabi, United Arab Emirates: International Renewable Energy Agency.
http://www.irena.org/DocumentDownloads/Publications/IRENA_RE_Jobs_Annual_Review_2015.pdf

UN (2015): Transforming our world: the 2030 Agenda for Sustainable Development. Resolution adopted by the General Assembly on 25 September 2015. A/RES/70/1. New York: United Nations.
https://sustainabledevelopment.un.org/post2015/transformingourworld

UNFCCC (2010): Report of the Conference of the Parties on its sixteenth session, held in Cancun from 29 November to 10 December 2010: Decisions adopted by the Conference of the Parties. FCCC/CP/2010/7/Add.1. Cancun: United Nations Framework Convention on Climate Change.
http://unfccc.int/resource/docs/2010/cop16/eng/07a01.pdf#page=19

The role of the IPCC in achieving the climate targets and the Sustainable Development Goals

Following the Paris Agreement, the greater global ambition on climate change goes hand in hand with higher expectations about the role the IPCC will play in relationship to the convention process. Regarding the IPCC's move towards a more solutions-based approach, the current Co-Chairs of the IPCC's Working Group III (WGIII) expect mitigation to play a more prominent role – even more prominent perhaps than in the Fifth Assessment Cycle. They would particularly like to foster three aspects of the practical steps that need to be taken: the greater integration of top-down and bottom-up approaches, the participation of a wider range of disciplines and the better linking of climate change mitigation with other agreed international policy goals, especially the SDGs.

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Since the Paris Agreement the global ambition on climate change has increased and there are also higher expectations about the role of the IPCC in relationship to the convention process. We are clearly tasked with producing the report on 1.5°C, due by September 2018, and the scoping meeting for that has just taken place. There are also high expectations about the IPCC's contribution to the global stock take, which will start in 2018, and in May we attended the SBSTA (Subsidiary Body for Scientific and Technological Advice) meeting in Bonn to start the dialogue about the role that the IPCC will play in that process.

Regarding the IPCC's move towards the more solutions-based approach that the Chair of the IPCC, Hoesung Lee, would like to pursue, this presents us with two main issues. Firstly, it places much greater emphasis on the work of WGIII than has perhaps been the case in the past. As a result, we anticipate that mitigation will play an even more prominent role than in the Fifth Assessment Cycle. The other aspect of the solutions agenda is that much greater attention must be paid to the practical steps necessary if we are to succeed in advancing the mitigation agenda. In this cycle, we aim to make headway in three main areas.

The first area is to achieve better synthesis between the high level top-down approaches that dominated the Fifth Assessment Cycle, including the substantial use of integrated assessment

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models, and bottom-up approaches that give real insights into what technology should be deployed, when it should be deployed and what other non-technical measures could be taken to advance the mitigation agenda. Consequently, we will see the considerable use of integrated assessment models in the Sixth Assessment Cycle but these will be employed alongside other approaches, such as national and/or regional modelling or research methodologies that do not involve modelling - case studies for example. The greater integration of top-down and bottom-up approaches and the development of a language so the two communities can communicate will be an essential element of the Sixth Assessment Cycle.

The second area concerns the need to make much greater use of a wider range of disciplines. Specifically, this means drawing on other social sciences in addition to economics to inform the agenda, particularly around issues such as lifestyle, consumption and behaviour, which we believe can be dealt with better within the Sixth Assessment Cycle.

The third area of the agenda is to better link climate change mitigation to other agreed international policy goals, specifically the Sustainable Development Goals. The issue is how to relate climate change to wider sustainable development objectives. This does not mean focusing on sustainable development, as the IPCC is primarily concerned with climate change, but it means putting climate change firmly in the context of the Sustainable Development Goals. An important point to note is that we are continually asked by policymakers not only about the impacts of climate change itself, but also about the impacts of some of the more ambitious climate change mitigation options. For example, if we move below the 2°C target towards 1.5°C, this could involve the much greater deployment of negative emission technologies which have their own sustainability consequences in terms of land use etc. As WGIII will be taking the technical lead on the Special Report on land use during the cycle, this topic will be of great interest to us. The role that technologies such as bioenergy with carbon capture and storage could play will be given serious consideration.

Finally, a word about LCS-RNet. We were initially attracted to LCS-RNet and became closely involved with the network due to the fact that it not only focused on high level modelling activity, but was also concerned with a wider range of objectives. It put climate change into its wider societal context. Consequently, we hope to draw increasingly on LCS-RNet and its outputs to build a wider perspective on climate change which includes not only technical fixes such as BECCS (bio-energy with carbon capture and storage), but also considers broader changes including new patterns of economic development and more innovative ways of addressing the climate change mitigation agenda.

References:

IPCC (n.d.):
IPCC - Intergovernmental Panel on Climate Change.
https://www.ipcc.ch/

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