Transitions Pathways and Risk Analysis for Climate Change Mitigation and Adaptation Strategies

D4.4: Synergies and conflict of different transition pathways: a general summary

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Work Package 4 **Leader Organisation**: BC3

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TRANSRISK

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Preface

Both the models concerning the future climate evolution and its impacts, as well as the models assessing the costs and benefits associated with different mitigation pathways face a high degree of uncertainty. There is an urgent need to not only understand the *costs and benefits* associated with *climate change* but also the *risks, uncertainties and co-effects* related to different *mitigation pathways* as well as *public acceptance* of low-carbon (technology) options (or lack thereof). The main aims and objectives of TRANSrisk therefore are to create a novel assessment framework for analysing costs and benefits of transition pathways that will integrate well-established approaches to modelling the costs of resilient, low-carbon pathways with a wider interdisciplinary approach including risk assessments. In addition *TRANSrisk* aims to design a decision support tool that should help policy makers to better understand uncertainties and risks and enable them to include risk assessments into more robust policy design.

PROJECT PARTNERS

No	Participant name	Short Name	Country code	Partners' logos
1	Science Technology Policy Research, University of Sussex	SPRU	UK	
2	Basque Centre for Climate Change	BC3	ES	
3	Cambridge Econometrics	CE	UK	
4	Energy Research Centre of the Netherlands	ECN	NL	
5	Swiss Federal Institute of Technology (funded by Swiss Gov't)	ETH Zurich	CH	
6	Institute for Structural Research	IBS	PL	
7	Joint Implementation Network	JIN	NL	
8	National Technical University of Athens	NTUA	GR	
9	Stockholm Environment Institute	SEI	SE, KE	
10	University of Graz	UniGraz	AT	
11	University of Piraeus Research Centre	UPRC	GR	
12	Pontifical Catholic University of Chile	CLAPESUC	CL	

1 EC Summary Requirements

1.1 Changes with respect to the DoA

An additional sub-report has been added compared to those listed in the DoA. This paper (D4.4.7) focuses on energy transitions and the resulting jobs implication for the EU. This paper was published prior to this Deliverable in the journal 'Applied Energy', to take advantage of an invitation from the aforementioned journal.

1.2 Dissemination and uptake

Dissemination of this Deliverable and its sub reports will follow the techniques detailed in D8.2 'Communication and Dissemination Plan'. Dissemination pathways will include, but not be limited to, the following:

- Publication of the Deliverable on our public website.
- Production of policy brief(s) based on individual sub reports.
- Publication of online and printed newsletter articles to provide easily digestible summaries of the work.
- Presentations at relevant events and conferences.

A TRANSrisk partners' meeting to be held in Bilbao during July 2017 will be used to further discuss dissemination of this Deliverable, and other Work Package 4 outputs.

Finally, please note that some of the individual sub-reports stem from work on TRANSrisk country case studies. Outputs from these case studies will be disseminated to policy makers and other relevant parties at a country level.

1.3 Evidence of accomplishment

This deliverable.

2 GENERAL SUMMARY

Tremendous transformative action is required to avoid the costly damages from climate change. Such technological and behavioural transformation will not only have an impact on climate change, but will also lead to multiple co-effects. In some cases, these co-effects are in conflict with other global goals, while in other cases there are synergies, for example with Sustainable Development Goals. According to chapter 6.6 of the fifth IPCC assessment report, the overall nature and extent of the co-benefits and risks arising from global transformation pathways largely depends on which mitigation options are implemented and how (Clarke et al. 2014)

These additional benefits and costs arising from such co-benefits and risks associated with climate change mitigation pathways should be taken into account in the consideration of different mitigation strategies. Geographical distribution of co-benefits and risks should also be considered. For example, energy access co-benefits are extremely important in rural parts of Sub-Saharan Africa, whereas air quality co-benefits are much more important in urban areas in India, China and South-America. Water usage has, for example, not the same consequences in Canada as in the Middle East.

Based upon the co-benefits and risks identified in chapter 6.6 of the fifth IPCC assessment report (Clarke et al. 2014), the studies carried out for this Work Package 4 Deliverable investigate these co-effects of climate change mitigation pathways in different regions, depending on the relevance of the effect. In several cases, the geographical focus of the studies on co-effects for this task overlap with the country and regional case studies in Work Package 3. The eight reports within this task primarily concentrate on specific environmental, social and economic co-effects of climate change mitigation pathways in a variety of regions and countries of the world:

- Human health (D4.4.1 - Global)
- Socioeconomic impacts of pollution (D4.4.2 - Chile)
- Energy access through modelling (D4.4.3 - Africa)
- Energy access through descriptive analysis (D4.4.4 – Kenya, Ethiopia & Rwanda)
- The energy-water nexus (D4.4.5 - Ethiopia)
- Land use (D4.4.6 – European Union, India, Japan & South-Korea)
- Macro-economic impacts in terms of employment (D4.4.7 – European Union)
- Macro-economic impacts in terms other indicators, such as welfare and competitiveness (D4.4.8 - Austria)

Exploring the range of co-effects across different parts of the globe will help to address common problems that needs to be further addressed, and to identify synergies supporting mitigation action that are unique to a country or region.

Figure 1 provides a geographical overview of the studies within this task and the overlap with the country case studies done within TRANSrisk.

A brief summary on the specific co-effects and outcomes of the different studies within this task follows in the following sections. Except for the studies in D4.4.2 and D4.4.4, these outcomes are based on outputs from a variety of models. However, model outputs on their own are insufficient for decision making without assessing the local dimension or environmental dimensions that are not covered by the model. Therefore, it is recommended for decision makers to reach out for more evaluation tools to complement these model outcomes.

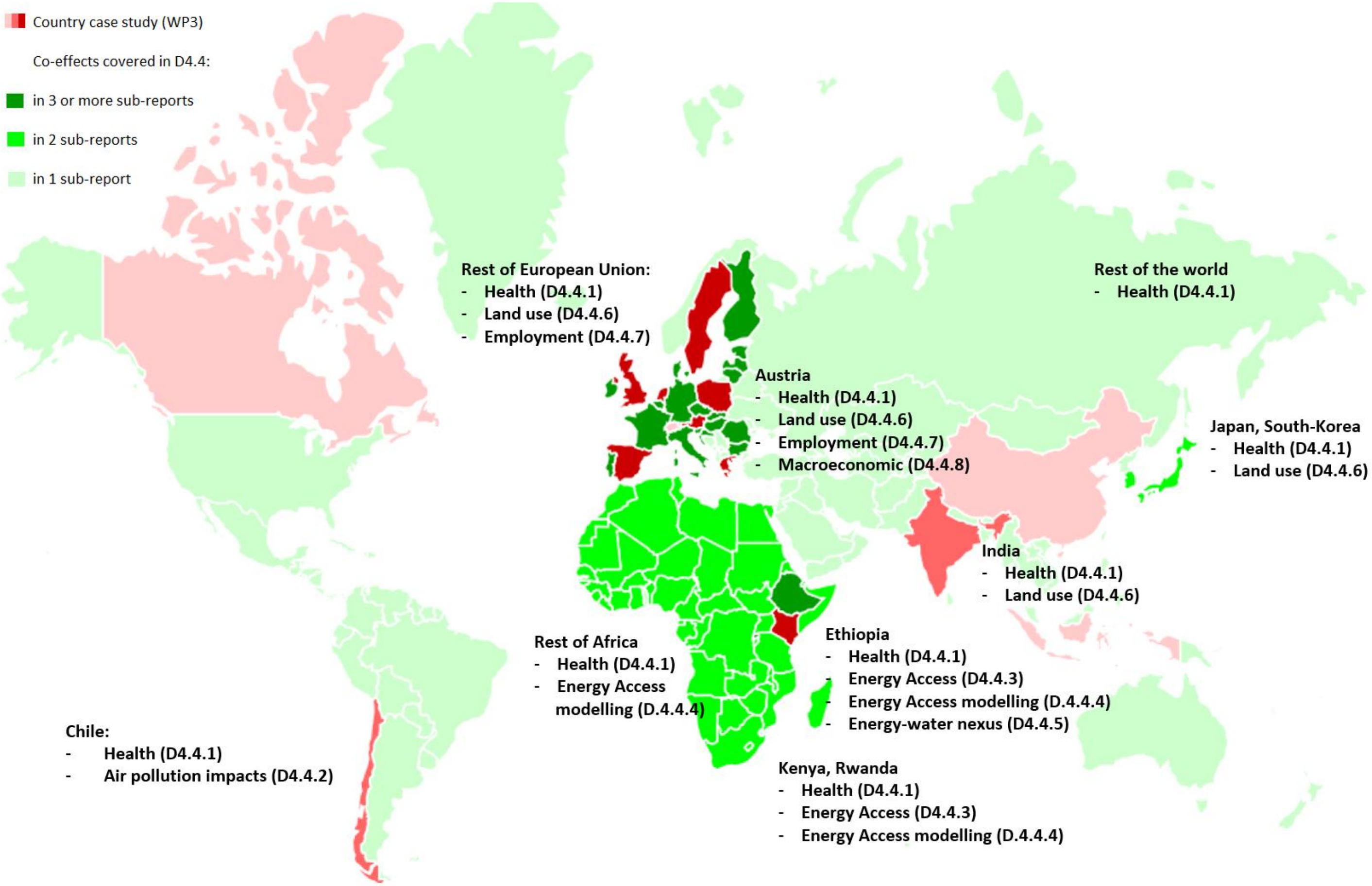

Figure 1: Geographical overview of studies within this task and overlap with country case studies (Work package 3)

2.1 Air pollution and health

Greenhouse gas and air pollutant emissions typically share common sources, such as power plants, factories, cars and livestock. Therefore, climate change mitigation scenarios that focus on limiting greenhouse gas emissions usually also limit air pollutants in the same effort (Markandya et al. 2009). By linking an integrated assessment model with an air-quality source-receptor model, Deliverable 4.4.1 reports on the health co-benefits of various mitigation pathways. In a 2ºC scenario (with all the technologies available) premature deaths are likely to be reduced globally by 15% in 2050, from 4 Million to 2.85 Million. This report also shows that if an economic value is assigned to those premature deaths (based on the value of statistical life) the health co-benefits are higher that the mitigation policy costs by a proportion ranging from 1.3 to 2, depending on the pathway. In other words, the global costs of limiting climate change to 2 degree Celsius will be more than offset by the global health benefits from these benefits. This means policies can often be justified on health grounds alone, even before the climate change mitigation impacts are taken into account. However, the geographical dispersion of these costs and benefits are significant: while the health benefits outweigh the costs of mitigation in Europe and most of Asia, predominantly India (by 5 times) and China (by 2.8 times), in the rest of the world the mitigation costs are significantly higher than the health benefits.

This geographical dispersion is largely a factor of population density. The more people living in a concentrated area, the higher the health damage impact of pollutant emissions in that area. Following that logic, deliverable 4.4.2 looks in detail at health impacts in the urban region of Santiago de Chile, which was one of the most polluted cities in Latin America at the beginning of the 1990s. The report concludes that the benefits of the Chilean Government's plan to reduce air pollutants in the Metropolitan Region of Santiago ("Santiago Respira") will greatly outweigh the costs of the plan. Almost all measures in this plan will also mitigate greenhouse emissions. This shows that the logic and results obtained in deliverable 4.4.1 (i.e. climate mitigation policies leading to health co-benefits) will in many actual cases work the other way around (i.e. health policies leading to mitigation co-benefits).

2.2 Energy access

While emissions from energy consumption are currently the main cause of climate change, many people in the poorest regions of this world have still no access to modern forms of energy (González-Eguino 2015). Energy access is a fundamental development goal, as expressed in Sustainable Development Goal number 7. The relationship between climate change mitigation and energy access is not entirely understood (Chakravarty & Tavoni 2013). On the one hand, if mitigation policies increase energy prices for the world's poor there is a risk that they could potentially impair the transition to universal energy access by making energy less affordable. On the other hand, mitigation policies could offer 'leapfrogging' opportunities for developing countries by allowing them to move straight to sustainable forms of energy. Deliverable 4.4.3 looks at these opportunities on the African continent using an Integrated Assessment Model, and reports evidence for the feasibility of leapfrogging from an energy-system cost minimisation perspective. Its analysis of multiple scenarios reveals that it is optimal to preclude the use of CO_2-emitting technologies in Africa, and massively deploy renewable options instead. However, the report also argues that target of the Africa Renewable Energy Initiative (AREI) of an additional 300 GW of renewable power is probably unrealistic.

Deliverable 4.4.4 provides a detailed description of the energy access problem in Sub-Saharan Africa with a focus on Ethiopia, Kenya and Rwanda. With electrification rates of 25%, 20% and 27% respectively in these countries (and 35% for Sub-Saharan Africa as a whole), this region faces a huge challenge in terms of energy access over coming decades. Ethiopia, Kenya and Rwanda are among those countries that have linked their overall development goals to renewable energy targets, as a way of growing their economies more sustainably and improve energy access without compromising climate goals. The analysis in this Deliverable looks at the climate change mitigation goals of Ethiopia, Kenya and Rwanda in the Nationally Determined Contributions of the Paris Agreement, and considers whether there are synergies or conflicts between mitigations and energy access goals. Interestingly, most mitigation goals are synergetic with energy access goals due to the significant renewable energy endowments in these countries and the reduced land use emissions that are achievable when switching away from traditional biomass (charcoal and fuelwood). There is evidence from Ethiopia that households are willing to pay more for cleaner cooking fuels (Takama et al. 2012). The report also discusses climate adaptation, which is closely related to the heavy dependence on traditional biomass and rain-fed agriculture. Linkages in the African context across the three issues—energy access, mitigation and adaptation—are identified and discussed.

2.3 Energy-water nexus

Recent decades have seen the world’s freshwater resources come under increasing pressure. Water demand from the energy industry is expected to grow significantly until 2050 (Clarke et al. 2014). While some renewable energy technologies such as wind and PV reduce freshwater demand, other energy technologies based on Carbon Capture and Storage (CCS) and biomass actually increase its demand. Hydropower displaces the supply of freshwater locations, which can have severe consequences if the supply is displaced from areas where freshwater is already scarce. Using an Integrated Assessment Model and a hydrological model based on the river basins in Ethiopia, Deliverable 4.4.5 looks at the energy-water nexus related to the ambitious hydropower development plan in Ethiopia. The study concludes that the high projections of future hydropower generation in Ethiopia are not in conflict with the increasing domestic and agricultural demand for freshwater, neither will it be endangered by the effects of climate change.

Chapter 7.1 in Deliverable 4.4.4 also looks at the energy-water nexus by estimating the water impacts of different climate change mitigation technologies, and conclude that its impacts on the availability of clean water are in most cases positive.

2.4 Land use

While fossil fuels represent concentrated deposits of energy, renewable technologies are characterised by power densities several orders of magnitude lower. This means that to deliver the same output, renewable energies are substantially more land-intensive and, therefore, could have significant impacts on land-use systems and food security (Wise et al. 2009). While technologies such as wind power can be easily combined with other land uses, technologies like biomass and solar power occupy significant amount of land per unit of energy outputted (Capellán-Pérez et al. 2017). In Deliverable 4.4.6, an Integrated Assessment Model is used to estimate the consequences of increasing land competition as a result of the renewable energy deployment expected by current policy projections. The report focuses on three regions where land is relatively scarce: the European Union, India and Japan & South-Korea. The study suggests that if renewable energy provision is left to the market, the carbon released due to the direct or indirect replacement of dense vegetation by solar and biomass energy could add up to 9% and 40% respectively of the emissions from gas-fired electricity. Apart from that, such a large-scale conversion of agricultural land for energy purposes also has an impact on agricultural self-sufficiency in the region (although, on the other hand, energy self-sufficiency increases significantly), whereas a conversion of undeveloped land for energy purposes (or agricultural purposes, in an indirect way) can have severe impacts for biodiversity.

Additionally, Chapter 7.2 in Deliverable 4.4.4 looks at the potential impacts of agro-forestry systems. It shows how they readily bundle both mitigation and adaptation strategies and provide several pathways to securing food and energy security for poor households, whilst at the same time contributing to climate change mitigation.

2.5 Macroeconomic indicators

The potential consequences of climate policies on macroeconomic indicators such as employment, welfare and competitiveness is of high importance for policy makers, and affects decisions on whether climate policies are realised or not. One strand in the relevant literature is to measure the ‘net’ direct and indirect impacts on job creation from the deployment of specific low-carbon technologies, and job destruction from the removal of high-carbon technologies. Deliverable 4.4.7 provide *ex post* (actual) measures of the direct and indirect employment effects of the transformation of the energy sector in the European Union between 1995 and 2009 using an input-output model. The study concludes that this structural change in the energy sector has increased employment in the EU by 0.24% and has created new 530,000 jobs in this period, of which one third is due to trans-boundary or spill-over effects within the EU (i.e. employment generated in one country due to the changes in another). Although employment in most member states has gained from the transition (especially in Poland, Germany, Hungary, Italy and Spain) employment slightly decreased in four member states (Ireland, Lithuania, France and Czech Republic).

Another strand in literature explores the overall macroeconomic impacts, taking other factors such as welfare and competitiveness into account as well. This requires more complex models to estimate the full effects. Comparing the results from a General Equilibrium Model with those from an energy-environmental-economy macro-economic model, Deliverable 4.4.8 reports on the macro-economic *ex ante* (forecast) implications of the low-carbon transition within a GHG-intensive sector, in this case the Austrian iron and steel sector. The iron and steel sector is deeply interwoven into current economic structures, since its output is used as intermediate input in many other industries (e.g. automotive, building construction etc.), it demands relatively large amounts of intermediate inputs from other sectors (e.g. energy, extraction etc.) and also generates significant income. Moreover, the iron and steel sector is included in the list of Energy-intensive and trade-exposed (EITE) industries that, according to the European Commission, may suffer from competitive disadvantage with respect to producers of similar goods in countries without CO_2 regulations and that have special protection (Böhringer et al. 2017). Hence, the needed radical transformations within the iron and steel sector might have strong economy-wide implications.

Although the results between both models differ, they both agree that the price of iron and steel products will rise significantly due to more expensive low-carbon production technologies. While both models show that this price increase will have a negative impact on GDP in the long term, the magnitude differs from around 1% in the General Equilibrium Model to only around 0.25% for the energy-environmental-economy macro-economic model.

2.6 Conclusions

A large part of the literature on the mitigation cost of climate change has been focused on direct market effects of greenhouse gas reduction, but they have not taken other co-benefits or adverse side-effects of mitigation actions into account. This Deliverable has described the important region or country-specific implications of capturing these co-effects which are also essential for further achievement of sustainability.

3 REFERENCES

Böhringer, C. et al., 2017. The efficiency cost of protective measures in climate policy. *Energy Policy*, 104, pp.446–454.

Capellán-Pérez, I., de Castro, C. & Arto, I., 2017. Assessing vulnerabilities and limits in the transition to renewable energies: Land requirements under 100% solar energy scenarios. *Renewable and Sustainable Energy Reviews*, 77, pp.760–782. Available at: http://www.sciencedirect.com/science/article/pii/S1364032117304720 [Accessed May 22, 2017].

Chakravarty, S. & Tavoni, M., 2013. Energy poverty alleviation and climate change mitigation: Is there a trade off? *Energy Economics*, 40, Supplement 1, pp.S67–S73.

Clarke, L. et al., 2014. Assessing Transformation Pathways. In *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. pp. 413–510.

González-Eguino, M., 2015. Energy poverty: An overview. *Renewable and Sustainable Energy Reviews*, 47, pp.377–385.

Markandya, A. et al., 2009. Public health benefits of strategies to reduce greenhouse-gas emissions: low-carbon electricity generation. *The Lancet*, 374(9706), pp.2006–2015.

Takama, T., Tsephel, S. & Johnson, F.X., 2012. Evaluating the relative strength of product-specific factors in fuel switching and stove choice decisions in Ethiopia. A discrete choice model of household preferences for clean cooking alternatives. *Energy Economics*, 34(6), pp.1763–1773. Available at: http://www.sciencedirect.com/science/article/pii/S0140988312001375 [Accessed May 29, 2017].

Wise, M. et al., 2009. Implications of Limiting CO2 Concentrations for Land Use and Energy. *Science*, 324(5931), pp.1183–1186.