CECILIA 2050

OPTIMAL EU CLIMATE POLICY

Choosing Efficient Combinations of Policy Instruments for Low-carbon development and Innovation to Achieve Europe's 2050 climate targets

Building Blocks for Climate Policy Instrumentation aligned to Governance Story lines and Scenarios

Funded by the European Union

This project has received funding from the European Union's Seventh Programme for Research, Technological Development and Demonstration under Grant Agreement no. 308680.

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With thanks to:

Benjamin Görlach, Ecologic

Project coordination and editing provided by Ecologic Institute.

Manuscript completed in February 2014

This document is available on the Internet at: www.cecilia2050.eu.

Document title	Building blocks for Climate Policy Instrumentation aligned to Governance Story lines and Scenarios
Work Package	WP3: Development of scenarios to 2030 and 2050
Document Type	Deliverable 3.5
Date	7 February 2014
Document Status	Final
Please Cite As	Huppes, Gjalt; Huele, Ruben. 2014. Building Blocks for Climate Policy Instrumentation aligned to Governance Story lines and Scenarios. CECILIA2050 WP3 Deliverable 3.5. Leiden: Institute of Environmental Sciences (CML), Leiden University.

ACKNOWLEDGEMENT & DISCLAIMER

The research leading to these results has received funding from the European Union FP7 ENV.2012.6.1-4: Exploiting the full potential of economic instruments to achieve the EU's key greenhouse gas emissions reductions targets for 2030 and 2050 under the grant agreement n° 308680.

Table of Contents

Executive summary 8

1. Governance scenarios and instrument types for building blocks in climate policy 18

2. Governance story lines and scenarios for climate policy instrumentation 22

3. Governance dimensions for climate instrument scenarios 26

3.1. General considerations 27

3.2. Current IPCC approaches 33

3.3. Scenario family dimensions: supranationality; markets & planning; and administrative capacity 35

3.4. EU governance in a multi-country context 35

3.5. Four directions for EU governance development 37

3.6. Four story lines for EU governance 39

3.6.1. Market Federation 39

3.6.2. Planning Federation 39

3.6.3. Mixed System 40

3.6.4. Re-Nationalized Europe 40

3.7. Exemplary: ETS development in different governance scenarios 42

4. A hierarchy of basic instrument types 44

4.1. From institutional framework to inducing market introduction of innovations 46

4.2. Exemplary filling in of instrument types 47

4.2.1. Institutional Framework 47

4.2.2. Internalization of climate effects through GHG emission pricing 49

4.2.3. Infrastructure for public and private use 51

4.2.4. Basic research and development 52

4.2.5. Technology specifications overruling market behavior 52

4.2.6. Innovation implementation 53

4.3. Building blocks and instrument mixes 54

5. Instrument building blocks for four EU governance story lines 56

5.1. Instrument Building Blocks for the Market Federation 58

5.2. Instrument Building Blocks for the Planning Federation 60

5.3. Instrument Building Blocks for the Mixed System 62

5.4. Instrument Building Blocks for the Re-Nationalized EU 65

5.5. Comparison of building blocks between governance scenarios 66

6. Conclusions 68

References 70

Annex 1 Instrument building blocks for electricity policy in four governance scenarios 75

Governance based institutional development of smart EU electricity markets sketched 75

Introduction 75

Discussion on flexibility in electricity markets in the EU and the US 76

Technical-economic requirements on the electricity system 79

Governance options considered 81

A cost-effective market system 81

Market Federation 82

Planning Federation 84

Mixed Governance and Re-Nationalised EU 86

Summary 86

Annex 2 Instrument building blocks for road transport policy in four governance scenarios 89

Instruments for person car transport: from fleet standards to generic pricing 89

Sectoral Policy on Road Transport: Why and How? 89

Fleet standards and actual use 90

Mechanisms determining road transport emissions 92

Carbon pricing versus fleet standards 93

Costs of regulations with similar effectiveness 97

Instrument building blocks relevant for road transport, per governance scenario 97

Conclusions 102

List of Tables

In Executive Summary: Table 1 Summary table: Survey of Instrument Building Blocks per Governance Scenario 15

Table 5.1 Instrument Building Blocks for the Market Federation 60

Table 5.2 Instrument Building Blocks for the Planning Federation 61

Table 5.3 Instrument Building Blocks for the Mixed System 64

Table 5.4 Instrument Building Blocks for the Re-Nationalized EU 66

Table A2.1 Mechanisms covered by instrument building blocks for person car transport 98

Table A2.2 Instrument Building Blocks Road Transport for the Market Federation summarized 100

Table A2.3 Instrument Building Blocks Road Transport for the Planning Federation summarized 101

Table A2.4 Instrument Building Blocks Road Transport for the Mixed System summarized 102

Table A2.5 Instrument Building Blocks Road Transport for the Re-Nationalized EU summarized 103

List of Figures

Figure 2.1 Expanding the IPCC scenarios framework with an instrument box 25

Figure 3.1 Two dimensions and four basic story lines in IPCC socio-economic scenarios 34

Figure 3.2 Four directions for EU governance development 38

Figure 3.3 The World Governance situation now 39

Figure 5.1 Importance of different instrument types in four climate governance scenarios 68

Figure A1.1 Market clearance in the European electricity market 82

Figure A2.1 Actual and norm emission data for the German car fleet, 2001 to 2010 93

Figure A2.2 Actual emissions with equalized fleet relative to norm emissions of that fleet 93

Figure A2.3. Decision tree on instrument building blocks for direct person car emissions 97

LIST OF ABBREVIATIONS

AR5	5^{th} Assessment Report, IPCC
CCS	Carbon Capture and Storage (also: Sequestration)
DARPA	Defence Advanced Research Projects Agency, USA
ETS	European Trading System (of emission permits)
ETSI	European Telecommunications Standards Institute
GATT	General Agreement on Tariffs and Trade
GDP	Gross Domestic Product
GHG	Green House Gas
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
KET	Key Enabling Technologies, EU
NGO	Non-Governmental Organisation
OECD	Organisation for Economic Cooperation and Development
OSGP	Open Smart Grid Protocol
R&D	Research & Development
RCP2.6	Relevant Concentration Pathway, with climate forcing limited to 2.6^{o}C in 2100
SRES	Special Report on Emissions Scenarios, IPCC
SSP	Shared Socio-economic Pathway
UNCTAD	United Nations Conference on Trade And Development
WP	Work Package
WTO	World Trade Organization

Executive summary

Climate policy instrumentation in a governance scenario context

Climate policy is at a cross road, in the EU, in member states, and more broadly in the world. Diverging tendencies and options indicate different directions for instrument development and technology development. Such issues are not just administrative and technical but link to the basic fabric of society, its governance structure. When considering climate policy instrumentation, we need story lines in which to place different scenarios for instrument development. Focusing on generic market development with climate internalization leads to different choices as when focusing on the instruments to bring specific technologies in the market. Story lines lead to scenario families and next to governance scenarios filled in with climate policy instruments. Such scenarios are not predictive. They must be broadly feasible however. They are not technical scenarios either, focusing on key technology paths. Nor are they result scenarios, establishing a future level of emissions and climate change, as in the RCPs with levels of climate forcing in 2100. However, each of the story lines and the scenarios developed in them should in principle be able to help reach the 2-degrees goal, as an RCP2.6. If that is the case depends on development of full mixes of instruments, their quantification, and then: a substantial amount of uncertainty. We don't know yet how technologies will develop, how socio-economic developments will be, and surely we don't know the deviations from the normal, be it disasters or pleasant surprises like unexpected technology breakthroughs and deep cultural changes.

Governance story lines guiding climate policy instrumentation

The general structure of story lines, scenario families, scenarios, and filled in scenarios, with models, has been developed in and around the IPCC and has been used extensively in modelling also for the UNFCCC. However, these IPCC socio-economic scenarios are mainly policy-free, with lately some policy elements introduced as part of their socio-economic scenarios. The policy element there is more in terms of success of policy than linked to governance directions with their specific instrumentations. To create an explicit link between story lines and climate policy implementation using instruments, governance story lines are required, giving a background for reasoned choices on how climate instrumentation may develop. The baseline for all story lines and scenario development here is that in principle each scenario could reach the 2-degrees target of climate stabilization, in IPCC terms, the story lines should link to RCP2.6. Filled in at the instrument building block level, they are not yet quantified instrument mixes and hence cannot yet predict emissions and concomitant climate change. Therefore, the link is soft in answering the question: could this scenario help reach the 2-degrees goal? The governance scenarios don't depict tomorrow's policies, substantially determined by current policies. They can guide the path from now towards more long term developments to 2050 and beyond, indicating smaller steps in these different scenario directions in the short term already.

Governance story lines for the EU

Governance in the EU is not fixed forever. There are conflicting tendencies, as in renationalization of policies against a further centralization towards a more federal structure. Climate policy in Germany, UK and Denmark shows such a decentralizing tendency. Not only are these tendencies there, they also link to views on what the direction should be. Repairs to the ETS price level show the other direction. Other types of options are there as well, with different directions for development in a more political governance sense. One may see, or prefer, a more administrative-planning direction developing or one may see or prefer a more liberal market direction developing with generic internalization of climate effects, as involving generic green taxes. Such choices do not just relate to climate policy, but climate policy is part of such more generic developments and choices in governance.

Four feasible story lines have been developed showing directions for the development of governance for climate policy implementation. They lead to core options for policy instrumentation, as instrument Building Blocks. Two of them assume some level of further federalization, one leaves the mixed or hybrid nature of the EU more or less as it is, and one investigates the more decentralized option. All four of them are deep options, in principle allowing for effective EU wide climate policy with the potential to reach RCP2.6.

The two more federal options differentiate in terms of societal governance direction. One has the technology specific focus, with instruments stimulating or forcing specific technologies and products into the market. It is the ***Planning Federation***. The other leaves technologies more open, with stronger generic incentives built into a market structure, by encompassing emission pricing. It is the ***Liberal Market Federation***. The third option accepts the different levels of policy and instrumentation, with some market and some planning elements at the central level, major initiatives at the member state level, and a core coordinating role for the EU, to align the national policies within an overall EU framework. It is the ***Mixed System*** we are mainly in now. The fourth option sees the key role for development of encompassing climate policy at the national level, with extreme successes as in the German Energiewende as a main guide. The role of the EU then becomes a more coordinating one, also avoiding the breakdown of the open market structure. This is the ***Re-Nationalized EU***.

It seems not feasible to develop a fully market based system in the current Mixed System EU, and surely this in not feasible in the Re-Nationalized EU. Markets will be more fragmented and partial, following more specific technology goals and product specific goals mostly related to member state views. The pure market direction therefore is lacking there. These two options each follow a technology-specific planning approach, differing from the federal planning approach in the more prominent role of member states in planning.

EU ETS development in different governance scenarios

The EU ETS may develop very differently in these four governance scenarios. In the current Mixed System EU, repairs of the ETS are based on the mixed governance structure. Some price stabilization through volume adjustments will be realized, but always with a delay and therefore with substantial medium term price fluctuations remaining. Expanding the domain of application is difficult as national agreements are required and implementation becomes a heavier burden for national administrations. In the Re-Nationalized EU repairs to the ETS are difficult and also superfluous. Developments like the UK floor tax and the German feed-in tariffs make a weak ETS irrelevant. National taxes and subsidies, and other measures, take over. In the Planning Federation, problems in the ETS are resolved through adapting the amount of allowances in the market to a predetermined rising price level with an agreed bandwidth. The domain of application is expanded so as to also cover fossil fuels in all transport. In the Market Federation, the domain of application is expanded so as to cover all fossil carbon activities. This requires a major administrative revision, as the number of firms and households brought under the system then rises to roughly a hundred million. The solution to that administrative problem is to apply the ETS at EU system boundary: at primary production in the EU and at import of fossils and derivatives, and at CCS in the EU and at exports. At full price stabilization for the full EU, however, trade becomes superfluous as all decision makers already are pressed towards the same long term and to the same short term marginal costs. This last option for ETS development might be seen as a technical option we could just follow now to improve the ETS. This seems highly improbable however given the discussion. Essentially, this line of development for the ETS would mean to change the ETS volume system into a full pricing system, as a carbon tax. It would be part of filling in the Market Federation, as a clear governance choice, different from choices in the Planning Federation and the Mixed System, while in the Re-Nationalized EU the ETS would ultimately collapse, because repair efforts are blocked.

This example shows how long term governance scenarios can work now already.

A hierarchy of policy instruments

Instruments for climate policy differ in their generality of application. Less general instruments are more technology and behavioral specific. With more specific instruments, more instruments are required to arrive at a certain climate goal, like RCP2.6. Sparseness in instrumentation is an independent factor in instrument scenario development, for two reasons. Administrative capacity is limited both in terms of volume and quality, not just for climate policy. Also, more detailed instrumentation entails higher transaction costs, also privately, thus increasing costs and reducing competitiveness. The general strategy in all story lines and instrument scenarios is to first develop the most generic ones, and then fill the gaps far enough to be able to ultimately reach the climate target. In the hierarchy of technological generality six levels are distinguished: **Institutional Framework; Generic Emission Pricing; Infrastructure Development; Research and R&D; Technology Specific Instruments;** and **Innovation Implementation Instruments**. Starting at the institutional level, different lines emerge quite logically and intuitively. In the Market Federation, a key institutional issue is the development of a real time equal-for-all electricity market, a real challenge. In the Planning Federation, this is not necessary as implementation builds very much on public-private partnerships and taxes, subsidies and prescriptions for specific technologies. In the less centralized options, EU markets cannot be set up in a generic way, with national policies fragmenting markets in different ways. Also at the member state levels, specific partial markets will be developed, with different access and prices for different groups. Lack of generic institutional development will require more detailed technology specific arrangements. At each following level in the hierarchy of instrumentation, such further choices result. They are to be made in a coordinated way, choosing effective and efficient combinations of policy instruments in the governance situation they are to function in.

Governance scenarios filled in with Building Blocks for climate policy instrumentation

The **Market Federation** has a prime focus on creating general markets with equal incentives for emission reduction for all actors. This market creation is through a number of institutional developments, filled in with an encompassing carbon tax on all fossil carbon that would leave the economy as CO_2 emissions, with a refund for CCS and at export. Supporting institutional developments include the development of an open real time electricity market and capital markets with a long time horizon. A second main domain is development of public infrastructure and public research and development for a low carbon economy. Infrastructure and longer term natural monopolies are publicly owned. There is full debundling in the energy domain so as to avoid power build-up of private firms. There are no public-private partnerships.

Technology-specific policies are mainly absent for CO_2 aspects but are substantial for non-CO_2 climate emissions, where emission measurement is near impossible. Temporary market introduction of high-risk high-potential innovations constitutes part of the instrumentation, often in relation to (experimental) infrastructure development. The EU plays a major role in global climate policy development, going for an agreement on a similar level emission tax, so as to create a level playing field with major trading partners.

The **Planning Federation** in a mixed economy focuses at directing most relevant private activities through public-private partnerships, following detailed sectoral planning and spatial planning, through substantial public funded or co-funded R&D, through technology-specific subsidies and prescriptions, and through substantial support in market introduction, also for alleviating market deficiencies. All climate policy activities are EU-wide for all EU-wide markets, virtually all markets in this governance scenario. Planning is not yet an instrument, it is specifying detailed near operational goals. The actual implementation is centered on public-private partnerships, moving firms ‘in the right direction’, aided by generic economic instruments of cap-and-trade and by technology subsidies and prescriptions, as with fleet standards. Vertical integration, the opposite of debundling, is welcomed as it allows for easier planning implementation. Firms involved in major energy and climate relevant industries are large, European-wide, with global connections. National governments are not able to exert the power for substantial changes so the focal point in implementation is the

EU, with a strengthened position of the Commission for discretionary policies, within an overall democratically agreed planning framework. The EU plays a major role in global climate policy development along these lines, with legally binding caps per country per year as the main goal.

In the **Mixed System** deviations from current EU governance are limited, with technically improved performance in a number of domains, including in the ETS with some medium term price stabilization and short term volatility. It is planning oriented but with a strong national planning focus with EU coordination. Direct EU planning is in a limited domain of globally standardized consumer products, like cars and some electric appliances. The mixed nature of governance levels hampers generic market development in the EU, especially in the energy related domain. Activities for open market creation are limited by existing national interests and national policies. The key EU role is to prevent the emergence of near monopolistic economic entities. Institutional development is limited, with a focus on maintaining a basic level of competition also in energy markets like for gas and electricity. The role of national public-private partnerships and national (near) monopolies as in nuclear energy and grids is subject of scrutiny, from the point of view of retaining a minimum of competition, with a prime active role for member states. Standardization is a prime EU domain, to allow for EU-wide competition and to keep international markets open. Standardization has a less global perspective than in the planning federation and market federation as it has to relate more to national preferences. Technology planning remains mixed, with a strong role for the national level, involving prime mover motives and substantial use of economic instruments focused at specific technologies. The EU plays a modest role in post-Kyoto climate policy development, as the guiding role of the ETS remains limited.

In the **Re-Nationalized EU,** the role of the EU is mostly focused at coordination, with only in crisis situations a delegated role for the Commission. The core action is at the level of the member states, with climate competition between them furthered by the EU. The ETS first remains at low and erratic price levels, with the substantial regulatory capacity required not brought up by the member states. It subsides under effective national policies. National initiatives like in Germany (feed-in tariffs) and the UK (carbon tax) take over. There is no role left for the EU in terms of climate specific policy instrumentation regarding technologies, except where manufacturers support EU wide rules, as with fleet standards in road transport. The strategy of the EU therefore has to shift to more indirect coordinating means as in the form of standardized information on products and technologies, essential for competing realistically in the climate domain. The EU plays no initiating or leading role in the development of global climate policy.

A table with more detailed instrument sketches is at the end of this Executive Summary.

Scenarios compared

All four scenarios may lead to the same intended climate result. However, there are differences the emission path that may be expected. Going in the direction of the Planning

Federation may give results faster than in the other scenarios. The Market Federation may start later with emission reductions but may have a better long term dynamic innovation performance. The Mixed System accepts governance as is, and makes the best of it, starting now and using well developed procedures. How long term performance may develop is difficult to fathom, as really stringent emission reductions will hurt specific business and national interests. The driving force in the Re-Nationalized EU is climate competition between countries and regions, as was a driver in the successful Energiewende measures. Keeping laggards in the system may be a most challenging task there, essential however for deep climate improvement. Also the technologies will differ between governance scenarios. In housing, for example, the market approach will lead more to variabilization of demand as through energy storages systems, while feed-in tariffs in the three planning approaches will induce more solar energy in the housing domain.

Conclusions

The story lines with instrument scenarios are not blueprints but indicate possible directions for development, each with strengths and weaknesses, and derived from that, with probabilities, not statistical but subjective probabilities. They are developed in a way that their probability is well above zero, to make them relevant in the climate policy discussion. The governance story lines seem a powerful tool to develop options for policy instrumentation and to place them in a consistent perspective. The logic of linking to governance brings the instrument discussion to a somewhat higher level than usual, also giving more room to institutions as basic instruments for effective climate policy.

The governance story lines as developed cover broad and diverging views on our future, primarily based on views regarding the economic coordination of society, with a more fundamental market orientation, liberal but not neo-liberal, versus a more planning orientation, democratically deciding on a broad set of goals in an integrated way. The second element is the level of supranationality, by necessity high in the liberal market variant, and with three levels of diminishing supranationality covered in the Planning Federation, the Mixed System and the Re-Nationalized EU, each based on a planning approach. The requirements on administrative capacity increase with more planning and with a more national instrumentation.

Do we need all four story lines for instrument scenario development? One may ask if the re-nationalization scenario is to be included, feasible and probable enough. However, in terms of probability, the re-nationalization option might score high, as this development is taking place at the moment not only with climate policy but also in broader political developments regarding EU governance. In most European countries there are anti-EU parties coming up, with re-nationalization on many political agendas. However, normal politics, keeping things as they are, with a drive at piecemeal improvement for solving problems as they come, seems at least as likely. These two scenario options are well at the table and are highly relevant surely for the short term. Their long term visionary aspects are maybe less clear. The more centralized federal EU requires a more visionary approach, be it market or planning oriented. But also these views exist, in policy preparation and in broader policy and governance discussion. Such options will develop only if actively supported, from a long term political point of view on societal governance.

The feasibility of scenarios in each story line has a political component, a socio-economic component, and an administrative component. The detailed feasibility analysis of the scenario options is not the subject of analysis here. It is not the role of scenarios to predict and choose the optimal one but to broaden the discussion on relevant options for our future in a more fundamental and systematic manner. The governance scenarios as sketched seem highly relevant for such discussions, bringing climate policy instrument choices explicitly in the domain of governance discussions.

Ultimately, the feasibility relates to the capacity of the instrument Building Blocks in the four governance scenarios to help reach the 2-degrees target, substantially if not fully. For that analysis, they have to be expanded into full instrument mixes, one per scenario, including quantification of instruments and modelling of results. Also for explicit instrument mixes this analysis towards results remains open as much instrument development will be 'on the road', reckoning with as yet unpredictable technical, socio-economic and political developments.

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Annex 1 on electricity policy in the four governance scenarios specifies how at the institutional level electricity market development would look like. Especially the Market Federation has a challenge there, to create a real time market equilibrium system accessible for all producers and users.

In different governance approaches a different set-up of electricity markets will emerge. A mixed governance EU and a re-nationalized EU will have a more fragmented market, both based on planning. The limited integration will allow for a low level of peak shaving, and hence to relatively high system costs. The pan-European Planning and Market Federation approaches have the advantage of substantial transport options with lower cost production and more and lower costs peak shaving options. The Planning Federation adds a substantial amount of peak shaving based on time-specified contracting. The liberal Market Federation option can create most cost-advantages, with real time market clearance established.

The two International Federal options can most easily and effectively integrate carbon pricing into electricity markets. The Mixed EU and the Re-Nationalized EU will tend towards subsidy systems like feed-in tariffs, not easily amenable to flexible pricing systems.

Annex 2 on transport policy in the four governance scenarios specifies how the governance approaches and instrument systems work out on different mechanisms relevant for fossil fuel use. The comparisons are made relative to fleet standards that influence only a small part of mechanisms.

The set-up of building blocks referring to person car transport is substantially different in the different governance scenarios. The Market Federation and the Planning Federation align with the mainly transnational supply and development of person cars. In these governance scenarios carbon pricing is set up so as to also cover road transport. In the mixed system, the ETS does not cover person road transport, with fleet standards as the main mechanism, with substantial costs for consumers. In the re-nationalized EU it also is fleet standards as sectoral instrument, but less strict versions implemented by the EU and some stricter standards nationally.

Overall, the federal market and planning systems cover substantially more mechanisms, and realize the same emissions reductions at much lower costs, cost being more than halved in the long term. In terms of implementation in the sector there is one difference between the federal options. The market federation has its implementation fully upstream, before the refinery, while the planning federation applies the cap and trade at the companies delivering fuel to cars, gasoline, Diesel and admixtures of these with renewable fuels, at the same level as where current “old” excises are applied. The planning variant may therefore be more vulnerable to lowering of current excises, then requiring higher allowance prices.

Table 2 Summary table: Survey of Instrument Building Blocks per Governance Scenario

	Market Federation	Planning Federation	Mixed EU System	Re-Nationalized EU
1. Institutions	• Real time transparent single price electricity market • Implicit subsidies on all energy removed • Developing BTA rules internationally • Developing international agreements on equal emission taxes • Market deficiencies covered at institutional level where possible • Strengthened competition (anti-trust) rules • Liberty in working hours	• Rules on public-private partnerships • Rules to maintain intra-EU competition	• Norms on public-private partnerships safeguarding some competition • Public banks for supplying venture capital (like EIB)	• Coordination between national rule systems • Rules for agreements on international cooperation • Prevention of non-market trade restrictions in EU
2. Carbon pricing	• Upstream carbon tax covering all fossil carbon • Proceeds carbon tax to EU, for any public spending or tax reduction • Other GHGs covered similar where possible	• Price stabilized cap-and-trade, also short term, domain expanded, also covering road transport, as through gasoline stations firms • Proceeds ETS to EU for low carbon investments	• Cap-and-trade with improved procedures for longer term price stabilization, limited domain, not including road transport, proceeds to member states • Somewhat reduced ETS target level • EU directed minimum national carbon taxes on car fuels roughly linked to intended allowance prices • Energy taxes mainly on final consumers at member state level, with some carbon reference	• EU ETS overtaken into diverging national systems, with some international trade • Agreements on coordination between national pricing systems, advisory only • Diverse national subsidy systems for emission reduction based on prime mover advantage motives • National carbon tax/excise on car fuels party mixed with fuel excises • Levels of (also) carbon excises limited by inter-country competition
3. Infra-structure	• Public ownership and development of transport infrastructure for: Persons, goods; electricity; water; IT; other long term natural monopolies • Pricing of infrastructure focused on congestion / capacity use, not funding • Spatial planning EU level well developed, not primarily focused at road transport • Standards for resolving inter-industry conflicts	• Private and public-private partnership for development of: roads, railways and gas, oil and electricity transport • Pricing of infrastructure use funding oriented • Spatial planning EU level well developed with focus on public transport and locally on walking and cycling	• Main infrastructure owned at national level, privately and in public-private partnerships with firms linked to national levels. • Transboundary electricity trade effectively opened but infrastructure development left to private firms, with EU coordination and bilateral member states agreements • Pricing of infrastructure is funding/profit oriented, part of total proceeds • Limited EU wide spatial planning • EU wide rail systems stimulated based on monopolistic cooperation between national railroad companies	• National private and public-private partnership and development for roads and electricity transport; • EU advice on supranational grid design • EU support for inter-member state high speed railways • No EU wide spatial planning

4. Research	• Basic research prime, also in RETs and R&D for high risk systems (as on decentralized intelligent systems; ..)	• Research tending to R&D for planning needs	• Research focused at valorization, tending to R&D • Little basic research • Limited EU budget	• No basic only scattered EU R&D, No broader systems development • Subsidized competitive attraction of big industries development teams
5. Techno-logies	• No inherent candidates for CO_2 • Substantial instrumentation for low emission technologies in non-CO_2 domains	• Public guidance on sectoral emission reduction tasks, with time specific targets in many sectors • Public planning of the energy supply system, including the role nuclear and of different renewables, with substantial public private co-implementation • Vertical integration of energy supply, transport and demand flexibilization for easier planning • Substantial regulation of all emission and energy relevant activities especially using subsidies and prescriptions, including building standards, emission standards for power plants, fleet standards in the transport sector, with also detailed focus at energy efficiency improvement • All transport relevant technologies subject of detailed regulation • Rules for smart meters and for demand flexibilization • Rebound of specific actions substantial, with additional technology specific policies, but rebound through spending shifts not covered • Substantial instrumentation for low emission technologies in non-CO_2 domains	• EU fleet standards with limited dynamic pressure • National deviations from international developments to create advantages for special national competencies	• EU fleet standards are only indicative, compulsory in larger countries with a substantial car industry, comparable to California fleet standards • All partial technologies are subject of public policy, different in different countries, from R&D to implementation; • Tax-type economic instruments focus on consumers only to avoid international competitive disadvantages
6. Innovation Implemen-tation	• Try-outs on novel high risk high potential systems, till creating learning curves	• A leading role for public-private partnerships in implementation of novel technologies and larger novel systems • Substantial use of feed-in tariffs, to create learning curves • Substantial planning-based low energy housing renovation	• Limited advisory role EU on implementation • A few core demonstration and proof-of–concept projects • Implementation projects based on combining some national advantages in a transnational business surroundings	• Fully national member states implementation of limited scope technologies in a transnational business surroundings

1. Governance scenarios and instrument types for building blocks in climate policy

Climate policy instrumentation in a governance scenario context

Climate policy is at a cross road, in the EU, in member states, and more broadly in the world. Diverging tendencies and options indicate different directions for instrument development and technology development. Such issues are not just administrative and technical but link to the basic fabric of society, its governance structure. When considering climate policy instrumentation, we need story lines in which to place different scenarios for instrument development. Focusing on generic market development with climate internalization leads to different choices as when focusing on the instruments to bring specific technologies in the market. Story lines lead to scenario families and next to governance scenarios filled in with climate policy instruments. Such scenarios are not predictive. They must be broadly feasible however. They are not technical scenarios either, focusing on key technology paths. Nor are they result scenarios, establishing a future level of emissions and climate change, as in the RCPs with levels of climate forcing in 2100. However, each of the story lines and the scenarios developed in them should in principle be able to help reach the 2-degrees goal, as an RCP2.6. If that is the case depends on development of full mixes of instruments, their quantification, and then: a substantial amount of uncertainty. We don't know yet how technologies will develop, how socio-economic developments will be, and surely we don't know the deviations from the normal, be it disasters or pleasant surprises like unexpected technology breakthroughs and deep cultural changes.

In building up climate policy capacity, there are four main groups of strategic considerations to reckon with in instrumentation. First, instruments should fit to the governance situation in which they are to be functioning. Strict behavioral controls in a weak governance situation will just not work. In highly market-oriented societies, market mechanisms may reduce the effects of regulation of specific technologies, as through rebound mechanisms. In more planning type societies, market developments may be overruled, leading to unnecessary costs. Such mechanisms differ depending on the governance situation. Instruments should fit to the governance situation in which they are to function.

Second, some instruments may not well go together. High subsidies on renewable electricity or prescriptive policies will not have any emission reducing effect under an effective cap-and-trade system. The locally replaced fossil production will merely reduce allowance prices, giving room for others to emit the same amount cheaper, as the effective the cap remains the same. Dynamic cap setting focused at a predetermined cap price could avoid this problem but then would imply a fundamentally different cap-and-trade system, moving from a volume to a pricing system. Conversely, such renewables subsidies and other measures might strengthen the effectiveness of an emission tax, though possibly at reduced cost-effectiveness. More complex relations are less easily recognized. Feed-in tariffs paid for by consumers will raise electricity prices while car emission standards may reduce the driving costs with combustion engine cars. Taken together, both instruments may well reduce the economic case for non-fossils driven cars like electric cars in the automotive market, which seem a requirement for deep emission reduction.

Third is the feasibility issue, related to broader political support, costs and political vulnerability of instrumentation. Technology specific measures are politically attractive because they are easier to communicate and because they can be linked to specific interest groups playing a role in the political process. Such technology specific measures may well involve substantially higher costs per unit of emission reduction than more generic emission pricing. But such abstract pricing measures do not easily create support. However, real costs of effective climate policy - that is the induced factor costs without transfer payments - ultimately are a main factor in political feasibility as well, especially with foreign competition. Subsidies on renewables bring them into the market but in doing so induce the real cost, as for substantially higher cost of solar cell electricity as compared to natural gas electricity. The transfer payments ultimately will be net zero: some pay and some receive, for creating incentives[1]. Moreover, as compared to generic instruments like upstream carbon taxes technology specific measures, market based or regulatory in nature, relate more directly to specific interest groups, with specific industries more easily claiming exemption or compensation. With more generically applied economic instruments, as for example with upstream carbon taxes, this is less easily possible, if only because the amount paid by a specific industry then is not so easily established. Such opposed mechanisms make feasibility a not so easy to establish criterion in practice.

One consideration mirroring feasibility is difficult to give a clear place in the instrument discussion. It is the bottom up actions by private parties and local public bodies like building societies and cities; see Bukowski et al (2003). Instruments may differ in the room they give to such actions and in terms of how they can be stimulate such active behavior. In a political sense the broad engagement of civil society in climate issues is essential for the long term legitimacy of climate policy and for support on adjoining public non-market actions like spatial planning, where energy and climate are only ancillary considerations. Planning systems will tend to overrule private actions, even if they use financial incentives, like the ETS does. As under a strict cap-and-trade system private actions beyond its price signal become useless as only leading to lower prices for other emitters, such a combination of instruments may undermine long term legitimacy. Market based instruments can vary substantially in the room they give to private decision makers. A generic carbon tax leaves all market based

[1] There is a broad literature on greening of the tax system or more generally environmental tax reform, see Ekins and Speck (2011) for a survey, covering both taxes and subsidies. The goals then also are broader than just climate policy.

technology decisions to private actors. They softly support a move towards less meat in the food diet and a somewhat lower room temperature. Subsidies on specific technologies, varying per technology as in the German feed-in tariffs, may well lead to very high real costs of emission reduction, for some technologies in the order of up to thousand Euro per ton of CO_2 reduced. Such real costs, induced by transfer payments, will be borne by society, unavoidably for real costs. But they don't discourage bottom up climate action as in cap-and-trade systems and make civil society very much a part of policy implementation. The enduring political support for the German feed-in tariff system very much relates to the broad-scale involvement of local private investors, now over 1.4 million. Also the prime mover motive can create strong support by those directly involved and also with those concerned with growth and employment issues. However, not all can be prime movers at the same time. The system costs borne by central electricity producers lead them to oppose further measures. Such opposition is also coming from energy intensive industries, as even if they are mostly free from net transfer payments, they still bear the real (factor) cost of successful renewables introduction. The subsidized introduction of new energy sources has winners and losers, in Germany with on balance substantial support. Subsidies on the introduction of non-fossil energy reduce the price of fossil energy. Additional energy efficiency policies are then required to counteract this undesired effect, difficult to implement and increasing the costs of policy, see Parry (2013).

Finally, there is the practical issue of emission measurement, directly or indirectly. Emissions of CO_2 in large scale electricity production can be measured indirectly only but quite precisely**,** based on the well administrated input of carbon fuels in the combustion process. Such measurement of emissions is not possible with most non- CO_2 emissions, as for example methane emissions from ruminants. Without emission measurement it is not possible to apply effect oriented policy instruments quantitatively, like emission taxes; emission reduction subsidies; emission standards; operating permits; and their tradable versions, cap-and-trade systems. Inducing more specific technology changes by other means then is the only option to consider.

With all considerations and options in place, we can proceed to define building blocks. Building blocks are not yet ensembles of integrated sets of policy mixes. They are blocks that may do a job. Some blocks combine well and some don't. At this analytical stage, feed-in tariffs for renewables are a combination of two different and in principle independent instruments: a price subsidy on electricity produced with some technology, and a tax on electricity use, in this case paid by (most) electricity users. Each has an effect on emissions, of course with interrelations with all other climate policy instruments and with adjoining policies on energy, taxing, etc. And each has broader economic, social and political ramifications.

The order of conceptual development towards building blocks for climate policy instrumentation follows the logic of how instruments may function. First governance situations are specified, not in a technical empirical sense, but as the functioning surroundings for instruments in main lines. These are specified as story lines or narratives, each with specific options for using climate policy instruments effectively. The IPCC set-up of socio-economic story lines for climate scenarios will first be adapted for that purpose, giving governance an independent place. In filling in the governance story lines there are considerations specific for climate policy in an EU and broader international context. These concern the level of supranationality in relation to governance; the administrative capacity at national and supranational level, and the role of planning and markets in societal coordination of economic activities. The options space for governance will be reduced to plausible combinations. They may be limited further to probable ones for the coming decades, a task we will not endeavor but on which we will make a few comments, as in terms of political feasibility. Next an ordering of instrument types is developed. These range from institutional arrangements with general applicability, like electricity market formation, to most specific instruments, like temporary market support of specific technologies to help overcome lock-ins and to create learning curves and economies of scale, like a temporary subsidy on specific solar cells.

Each governance story line can be filled with a most appropriate set of instrument building blocks, as a proto-scenario for climate policy instrumentation. The development of consistent sets of building blocks follows the principle of sparseness, a criterion directly linked to capacity limitations in policy development and implementation. Not starting sparsely will lead to larger numbers of instruments, requiring an increasing amount of an increasing quality of administrative capacity, the mix to be wisely developed in an increasingly complex political process. Going for dense regulation will induce the comeback of ideas on deregulation and privatization as dominated the Eighties, see Huppes (1988). So, it seems wise to first develop most generic instrumentation like institutional development for creating or repairing failing markets, and then move to general emission pricing of CO_2 and only then fill the gaps remaining in a further stepwise procedure. For gaps remaining, the same principle holds again, main and easiest sources covered first, using the most generic instruments remaining. Non-methane emissions may for example sometimes be measured, with emission taxes and market formation then similarly applicable as with CO_2. An example is N_2O emissions in fertilizer production. However, measurement of non- CO_2emissions is an exception, also indirect measurement. So in the end gaps will remain, some to be left open. Forbidding paddy rice seems hardly a feasible option.

The instrument hierarchy is applied to a number of governance scenarios specifically for the EU. They are set up in a general way however, relevant for other countries and for larger groups of countries, at a higher level including the EU as a type of country. How the EU approaches its supranational policy will depend on its own governance situation and the corresponding instrumentation of climate policy, and on the broader supranational governance situations to be reckoned with, also scenario dependent.

2. Governance story lines and scenarios for climate policy instrumentation

Governance story lines guiding climate policy instrumentation

The general structure of story lines, scenario families, scenarios, and filled in scenarios, with models, has been developed in and around the IPCC and has been used extensively in modelling also for the UNFCCC. However, these IPCC socio-economic scenarios are mainly policy-free, with lately some policy elements introduced as part of their socio-economic scenarios. The policy element there is more in terms of success of policy than linked to governance directions with their specific instrumentations. To create an explicit link between story lines and climate policy implementation using instruments, governance story lines are required, giving a background for reasoned choices on how climate instrumentation may develop. The baseline for all story lines and scenario development here is that in principle each scenario could reach the 2-degrees target of climate stabilization, in IPCC terms, the story lines should link to RCP2.6. Filled in at the instrument building block level, they are not yet quantified instrument mixes and hence cannot yet predict emissions and concomitant climate change. Therefore, the link is soft in answering the question: could this scenario help reach the 2-degrees goal? The governance scenarios don't depict tomorrow's policies, substantially determined by current policies. They can guide the path from now towards more long term developments to 2050 and beyond, indicating smaller steps in these different scenario directions in the short term already.

In developing climate policy scenarios, IPCC scenarios form a starting point, linked to elaborate modeling of increasing consistency and adequacy. This scenarios structure is described for example in Moss et al (2010), see the right part of figure 2.1, and is widely used in discussions and modeling efforts. It gives the causal lines between economic activities and the effects from climate change resulting. The story lines for the socio-economic scenarios have first been set up by Nakićenović and Swart (2000), in defining four basic scenario families, with story lines for each of them, see Figure 3.1 in the next section. These scenario families - often referred to after the report name as SRES (Special Report on Emission Scenarios) - still constitute the basic framework of climate scenario development, see for example van Vuuren et al (2012), with new developments and with some sub-differentiations added. Especially the link to RCPs (Relevant Concentration Pathways) simplifies the view on effectiveness off scenarios very much. In the focus on instruments for a "2-degrees" scenario, the direct link is to RCP2.6, corresponding to a climate forcing level of 2.6 W/m^2 in 2100[2]. We will use this 2-degrees/RCP2.6 framework as a basic reference, only mentioning deviations towards less effective climate policies but not investigating them. It defines our tasks ahead in terms of results. In content, the challenge is to drive most fossil sources off the market with energy sources not widely accepted, like nuclear; with unknown limitations, like biomass; or not yet developed as major system technologies like wind and solar. See Hoffert (2010) for a sobering presentation on our longer term[3] climate and energy tasks ahead, a global challenge[4].

The IPCC scenario structure, also the adapted one here with an instrument block added, can be used in two directions. In causal order, the policy instrumentation and socio-economic scenarios lead to emission scenarios; next to climate change and its effects, and ultimately to responses as in adaptation scenarios. Recently an in-between step in modeling has been added specifying climate forcing, see Moss et al (2010, p752) for the set-up of this highly complicated integrative modeling effort, linking the work of many modelling groups around the world.

The scenarios structure can also be used in reverse, specifying desirable outcomes, like reaching a “2-degrees” target. Reasoning backwards then leads to options for climate forcing, options for emissions scenarios and options for socio-economic scenarios, including technology characteristics, and ultimately the policies with their instrumentation. Van Vuuren et al (2012) link some socio-economic scenarios, with emission scenarios, to radiative forcing scenarios, to climate change, and finally to adaptation measures and effects. The range of relevant climate change outcomes has been restricted to cover only a few main lines between business-as-usual and a most effective ‘2-degrees’ variant. So this group of scenarios still covers all four Representative Concentrations Pathways (RCPs), also the ones not reaching the 2-degrees target, RCP2.6 (2.6 referring to the induced radiative forcing in W /m2 in 2100). They are linked to a number of socio-economic scenarios, five in total, named Shared Socio-economic Pathways (SSPs).

The five SSP narratives as also used in AR5 are[5]:

SSP1 Sustainability

A world making relatively good progress toward sustainability, with ongoing efforts to achieve development goals while reducing resource intensity and fossil fuel

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[2] This goal has been specified in the 2010 Cancun agreements stating that future global warming should be limited to below 2.0 °C relative to the pre-industrial level.

[3] The shorter term target of 2020, see seem well beyond any policy

4 The proven reserves of fossil are larger than our carbon budget towards 2100. Also, if developing countries build an infrastructure similar to that in developed countries, and with similar materials and technologies, that infrastructure alone, not its functioning or other consumption, would lead to emissions higher than our 2-degrees carbon budget, see convincingly Müller et al (2013). Rogelj et al (2013) indicate that emissions should be substantially reduced by 2020, to keep the 2-degrees window more or less open, a hard short term task.

[5] See the survey by IIASA from which these descriptions have been copied at: http://www.iiasa.ac.at/web/home/resources/publications/IIASAMagazineOptions/ClimateChange.en.html

dependency. It is an environmentally aware world with rapid technology development, and strong economic growth, even in low-income countries.

SSP2 Middle of the Road

This "business-as-usual" world sees the trends typical of recent decades continuing, with some progress toward achieving development goals. Dependency on fossil fuels is slowing decreasing. Development of low-income countries proceeds unevenly.

SSP3 Fragmentation

A world that is separated into regions characterized by extreme poverty, pockets of moderate wealth, and a large number of countries struggling to maintain living standards for a rapidly growing population.

SSP4 Inequality

A highly unequal world in which a relatively small and rich global elite is responsible for most of the greenhouse gas emissions, while a larger, poor group that is vulnerable to the impact of climate changes, contributes little to the harmful emissions. Mitigation efforts are low and adaptation is difficult due to ineffective institutions and the low income of the large poor population.

SSP5 Conventional Development

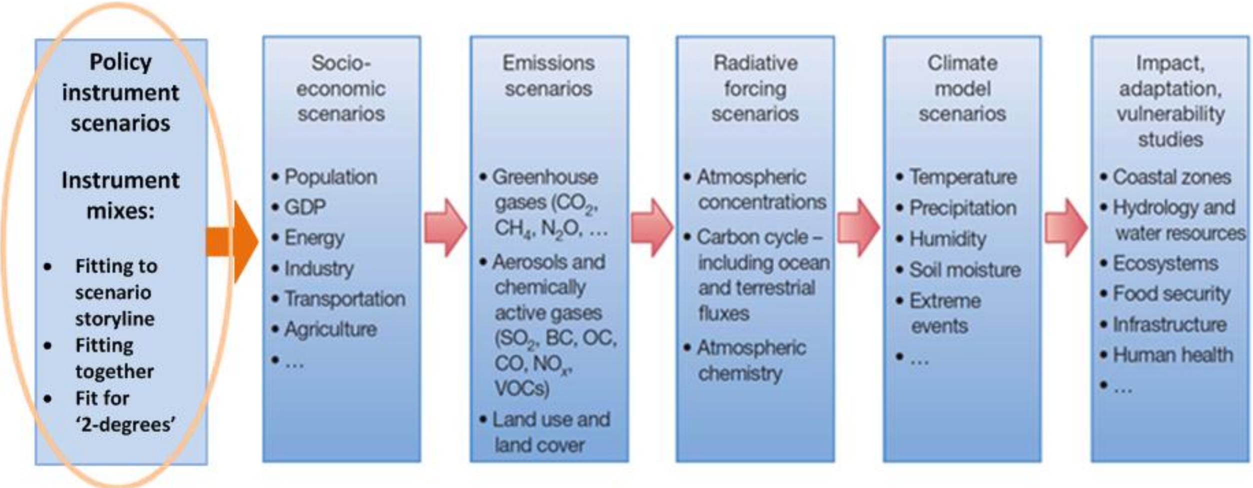
A world in which conventional development is oriented toward economic growth as the solution to social and economic problems. Rapid conventional development leads to an energy system dominated by fossil fuels, resulting in high greenhouse gas emissions and hence challenges to mitigation.

These socio-economic characteristics relate to governance but not in a direct way. SSP1, variants of it, might go in the direction of long term climate stabilization, with RCP2.6 outcomes. That would depend on how global, regional and national governance structures might develop. The four other scenarios depict disasters in a climate sense directly (SSP2 and SSP5) and also in a socio-political sense (SSP3 and SSP4), leaving little hope for effective climate policy.

Schweitzer and Kriegler (2012) give a survey of the very many scenarios that have been specified and modeled and create variants that can be constructed from them by varying their scenario assumptions. They conclude that low emission scenarios, as in the domain of 2-degrees/RCP2.6, are scarce and don't belong to the most consistent and plausible variants. One basic reason is that the SRES-type and newer SSP variants of scenarios do not contain specific climate policy instrumentation, focused on effectiveness. Even if they are named climate policy scenarios, they specify requirements and general characteristics of climate policy, as in terms of unspecified instruments for carbon pricing, assumed to be working near perfectly. They don't specify the set-up of instruments that should set in motion their working mechanisms and they don't cover issues of implementation, where reality can be far from the script. In the IPCC scenario and modeling structure, there thus is a policy neutral starting point, not yet conducive to explicit reasoning on instrument development. Realistic instruments development, reckoning with the political and administrative options and constraints, would better have its own story lines. This paper gives an entry into that subject.

Adding the level of policy instrument scenarios may complete the causal sequence logic, see figure 2.1, adding the block of active climate policy as in the oval in the figure. They could be part of Socio-economic Scenarios, but then would be mixed with other story line considerations. For the time being at least we keep them separate. Climate policy scenarios use coherent sets of climate policy instruments; these set in motion a number of socio-economic and technological developments; which in turn lead to emission scenarios; with climate forcing scenarios and climate change scenarios following; and ultimately to impacts and adaptation. A coherent set of policy instruments requires extended coverage, to reach demanding targets. Coherence also implies adherence to relevant story lines.

Figure 2.1 Expanding the IPCC scenarios framework with an instrument box



3. Governance dimensions for climate instrument scenarios

Governance story lines for the EU

Governance in the EU is not fixed forever. There are conflicting tendencies, as in renationalization of policies against a further centralization towards a more federal structure. Climate policy in Germany, UK and Denmark shows such a decentralizing tendency. Not only are these tendencies there, they also link to views on what the direction should be. Repairs to the ETS price level show the other direction. Other types of options are there as well, with different directions for development in a more political governance sense. One may see, or prefer, a more administrative-planning direction developing or one may see or prefer a more liberal market direction developing with generic internalization of climate effects, as involving generic green taxes. Such choices do not just relate to climate policy, but climate policy is part of such more generic developments and choices in governance.

Four feasible story lines have been developed showing directions for the development of governance for climate policy implementation. They lead to core options for policy instrumentation, as instrument Building Blocks. Two of them assume some level of further federalization, one leaves the mixed or hybrid nature of the EU more or less as it is, and one investigates the more decentralized option. All four of them are deep options, in principle allowing for effective EU wide climate policy with the potential to reach RCP2.6.

The two more federal options differentiate in terms of societal governance direction. One has the technology specific focus, with instruments stimulating or forcing specific technologies and products into the market. It is the ***Planning Federation****. The other leaves technologies more open, with stronger generic incentives built into a market structure, by encompassing emission pricing. It is the* ***Liberal Market Federation****. The third option accepts the different levels of policy and instrumentation, with some market and some planning elements at the central level, major initiatives at the member state level, and a core coordinating role for the EU, to align the national policies within an overall EU framework. It is the* ***Mixed System*** *we are mainly in now. The fourth option sees the key role for development of encompassing climate policy at the national level, with extreme successes as in the German Energiewende as a main guide. The role of the EU then becomes a more coordinating one, also avoiding the breakdown of the open market structure. This is the* ***Re-Nationalized EU****.*

It seems not feasible to develop a fully market based system in the current Mixed System EU, and surely this in not feasible in the Re-Nationalized EU. Markets will be more fragmented and partial, following more specific technology goals and product specific goals mostly related to member state views. The pure market direction therefore is lacking there. These two options each follow a technology-specific planning approach, differing from the federal planning approach in the more prominent role of member states in planning.

3.1. General considerations

When considering climate policy instrumentation, especially with a long term view, it is essential to fit options to overall views on regulatory regimes and to broader views on the role of the state in society. Such issues determine possible governance structures towards 2050, and beyond. As effective climate policy is a global issue, this governance analysis involves a world view, also from an EU perspective. The EU perspective on how other countries approach climate policy relates to the effectiveness of policies abroad and to their instrumentation. Transfer payments, as taxes and subsidies (of any legal status) plus real costs of emission reduction can have substantial price effects, very different for different policy instrumentation options with equal overall effectiveness. The room for maneuvering within the EU partly depends on these external factors.

How far the EU may go with emission reductions not only relates to the economic comparative disadvantages resulting from limited climate policy abroad. It also relates to the ultimate climate effectiveness of policies. Without globally effective climate policies, global emissions will rise and climate change is unavoidable. The 2050 share of EU emissions will by then be in the order of 10 percent, with EU reductions hardly having any effect on reducing climate change. High cost with no effects would tend to reduce legitimacy and political feasibility. Of course reality will be in-between, with some policies in other countries helping reduce global emissions, albeit not yet in line with the 2-degrees target. The EU fully going it alone does not seem feasible but the EU being in the vanguard of global climate policy may be a realistic option. The options for global instrumentation then are part of the considerations on EU internal climate policy instrumentation. Views on global governance options then are to be part of such considerations as well. However, EU-internal considerations on governance would play a first role, for the EU much related to balance between tendencies towards federalisms and re-nationalization of public authority.

Governance views are pervasive in all statements on climate policy and its instrumentation but mostly not explicitly. A basic distinction is that between democratic planning in all relevant domains as against a radical liberal view on optimized private markets. The instrumentation for climate policy will differ between these views, or better between governance situations as linked to these views.

The democratic planning ideal is most dominant and ultimately relates to a democratic world order, founded in to be improved United Nations institutions. At the practical organizational level Friedmann is most influential; see Friedmann (1987) and (2011). We can plan our global future together, reckoning with strength and weaknesses of different countries and groups[6], focusing on all relevant problems to be solved while reckoning with their mutual relations.

[6] A clear example of this planning approach in climate policy is in Frankel (2010), specifying caps for all countries for all years. Even if the cap is set at EU level detailed allocation on paper of emission caps per country in the EU are necessary as well, if proceeds of EU-wide auctioning are to go to member states,.

The climate problem is one of these, a main one, to be 'mainstreamed' as part of all other policies. Climate action ultimately is to be based on democratic legitimation, at a global level. Current IPCC scenarios link to this democratic world view. In that view there is a direct logic to link climate issues to issues of justice, economic development and burden sharing, and to the ethical principles behind these[7]. In the democratic planning view, these are to be brought into the UN. However, the UN has no instrumentation and implementation capacity itself currently, leaving that part of the policy process to its member states, including the EU, at least for the time being.

The same democratic view on a broad planning type of government is broadly present in the EU. In that view the EU is to resolve any and all supranational issues, reckoning with the subsidiarity principle, while improving democratic legitimation and accountability. Climate policy is one aspect of EU policy, to be embedded in broader considerations like energy policy, research policy and ultimately also broader social and economic policies. Also for the EU, policy implementation and control is virtually always at the national level of its member states. It has a much broader say in national policy instrumentation than the UN, having independent legislative power of an at least partially federal nature. Also there are sanctions for non-compliance which make regulations more binding than is possible with the UN. Again, at the national level of individual states, the same democratic planning view is present as well, advocating substantial involvement of the state in all spheres of life, and certainly in economic life. Germany does not wait for renewables to come on the market but plans their introduction, as also other energy sources have been planned, like the reduced production of coal and the more lasting use of lignite, and including the forced close-down of nuclear power stations. Similarly, the UK expands its nuclear capacity, not based on generic market mechanisms but based on subsidies and price guarantees. Only at a lower level, at deeper technological detail, market forces are used, by creating partial markets for specific technologies, like specific price guarantees for nuclear and renewables to subsidize their market entry. Though energy markets as for electricity have been opened to some extent between member states, the trade between member states is still subject to many restrictions, often related to national partial markets, and to grid capacity restrictions. Dutch producers don't receive the German feed-in tariffs, and Dutch aluminium producers don't get the low German market price for high-intensive energy producers. Also overhead costs at system level are mostly borne nationally, though the firms involved operate supranationally. There are forceful market-elements involved in for example high feed-in tariffs inducing substantial investments. But they work nationally and are different between countries both in their price levels and in their specific regulatory details. Development of EU level markets is one key element in climate policy, as larger markets can more easily deal with the

[7] However, for economic growth there are also other global organizations like GATT/WTO, IMF and World Bank. In the last Doha round in Bali (2013), the WTO shifted somewhat from an economic institution focus to a broad integrative view, as in creating room for national agricultural polices based on socio-economic aims, restricting imports and exports. The governance logic then would be to make the GATT/WTO part of the UN institutions, joining it with UNCTAD. The post-War Keynesian design of independent global institutions would then stop to exist.

intermittent nature of especially solar energy and wind power. Such institutional development links directly to governance directions, as in planning infrastructure for supranational markets through public investment or through mixed public-private arrangements. The state as an enterprise is the metaphor to have in mind: we as a nation are a big corporation, together creating our economic and broader future. In all taken together, in this democratic planning view climate policy is a multi-facetted and multi-level planning issue, from local and national to EU/regional, and ultimately global.

Opposed to this view of the responsible but quite almighty democratic state, when referring to Nordic countries of the named *coordinated market economy,* is a different view on democracy, in a more radical liberal[8] and rule of law fashion. Here private decisions are mainly remaining outside the domain of direct state involvement. This state-independent part of society includes a substantial independent public domain, with diverse mechanisms of self-regulation. This (non-state) public domain, as a moral association, also creates some safeguard against a neo-interest group asymmetric power build-up, with the most powerful taking a disproportionate share in state power, ultimately to further their private interests, as by creating rent options. It also leaves most economic decisions to private economic actors, within the institutional frameworks as are to be actively developed. This radical liberal view on governance should not be equated to the simplistic 19th century night-watchman state. Nor is it similar to 20th century neo-liberal unconstrained private market power, which may ultimately take over the state. Power build-up is to be prevented at all levels in society, avoiding public-private deals as much as possible, these going into a neo-corporatist direction. Freedom is to be protected, also against well-meaning democratic governments. As doing more seems doing better, democratic governments tend towards absolutism, to improve their performance. Also climate policy is to be focused at power-free governance as much as possible. Public tasks relate to institutional development, including internalization of external effects, but more generally cover what cannot be covered privately, from, ranging from basic research and public infrastructure to the prevention and control of natural monopolies. Such monopolies may easily come up with knowledge-based growth leading to increasing returns to scale, in the economic domain countered only by increasing market size as resulting from globalization in the last decades[9].

The radical liberal direction in governance may refrain from technology specific action in the economic domain but requires substantial public activity, in creating and maintaining markets and in all domains where markets cannot or should not function. Core tasks, in general and in climate policy specifically, relate to: institutions, with emphasis on internalization of external effects; non-market tasks related to basic research, spatial

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[8] *Neoliberal* has now a mostly pejorative connotation, especially as giving room to unconstrained business interests. That is fully opposed to the liberal view described here. See Boas & Gans-Mores (2009).
[9] Trade as a fraction of global GDP has expanded very substantially: 1960 12%; 1970 14%; 1980 20%; 1990 20%; 2000 26%; and 2010 29%.
Source: http://**data.un.org**/Data.aspx?d=WDI&f=Indicator_Code:NE.EXP.GNFS.ZS

planning, infrastructure and some elements of standardization; and to repairing some shorter term deficiencies, as in the uptake of new products in existing markets.

The institutional level is not given for eternity, as societies develop dynamically and so do their problems. Markets don't fall from the sky but are created, by intricate sets of rules, as institutions to be developed and then actively maintained. In creating markets new upcoming external effects, like on climate, are to be internalized, as completely and generically as possible. Such internalization of climate changing emissions ideally is to set an equal price on all emissions at any given moment of time. As there then is no differentiation as to source of emissions - all CO_2 emissions mix globally - the administrative set-up is to be as encompassing as possible. For CO_2 this means levying the tax as upstream as possible, at primary production of fossils and their imports, with a refund upon export and upon sequestration of the carbon taxed. The role of the state goes well beyond that market creation. Spatial planning cannot be a private affair, nor can infrastructure development and natural monopolies be left to markets. Inaction in these domains would clearly create serious problems, so state action may be due, for sure when specific interest can jeopardize the independence of the state. Other state action is due only if it can be effective and does not create too much collateral damage to other private domains. This view has formed the basis of much political theory on reducing the powers of the state, by division of power and by limiting power through procedures, like democratic procedures and the rule of law. This radical view has formed the basis of modernization and industrialization in the last four or five centuries, with starting points already in the Magna Carta, in the European Middle Ages. This liberal market view also is at the core of the globalization processes of the last centuries, intensified the last few decades when globalization truly became global by incorporating most developing countries. In this view the role of the state for sure is on a number of specific collective issues, like external defence and internal safety, the old night-watchman state. But its tasks also include social aspects like education, social care and labor relations, and all sorts of collective issues beyond the domain of self-regulation, like spatial planning, infrastructure development, a monetary system, macro-economic issues, and basic research. More specifically, the state plays role as arbiter in private conflict resolution, where private institutions are not able to do so. One further task is in the active creation of markets, never evolving "by themselves", and full of choices influencing private behavior, but only indirectly so. Simple variations in litigation rules safeguarding intellectual property rights, for example, can shift the market power of larger against smaller firms and similarly change the power of polluters against polluted. Intellectual property rights have come up only in the realm of industrialization, when they were deemed useful for progress (with a key legislation initiating role for James Watt). The radical liberal view is opposed to the neoliberal[10] view on governance which led to privatization of natural monopolies and which allows private near monopolies to develop. Countering the creation of market dominance of private parties is a constant element of this

[10] The description given by Brennan and Eusepi (2010) of neoliberalism focuses on capitalism with built-in broader social issues so as to save capitalism. Their description fits that of the planning society more than that of the liberal market society.

task, as private parties will always try to limit markets for creating undue rents. Creating relevant markets where there are basic market deficiencies in terms of environmental external effects is a major task, with the climate problem as the main global one. Prime approach in climate policy development is the creation of relevant markets, as part of an institutional development. With the climate problem, supranationality of policy can be argued for because of its global nature, shifting responsibility to form member states to the democratic EU institutions. However, the prime instrumentation in this view is not planning but market creation with internalization of climate effects, somehow linking global development to EU and national institutions.

Both lines of reasoning towards public governance have a long intellectual tradition, with some highlights here to put the diverging views in perspective. The tradition of the democratic planning state has started at planning before becoming democratic. The encompassing role of the state was influentially advocated in the 16th Century by Jean Bodin, focused at a commonwealth but with ultimate legitimation still derived from God, and opposed to a right to resistance as then came up in the protestant domain. In the Leviathan Hobbes advocated a similar generality of power, but with authority based on actual powers of the state. The step to democratic legitimation developed in the 18th century, with Rousseau, with individuals defining themselves in relation to the collective goals of the state, expressed as the general will. Max Weber developed the notion of the neutral bureaucracy implementing laws and policies for reaching collective goals. It became the instrument for all collective purposes. Combined with democratic legitimation this finalizes the concept of the democratic planning state.

The republicanist liberal reaction on Bodin was by Locke in the 17th century. This liberal position has a political starting point in the Magna Carta, already in 1215. Locke's position was mirrored by Jefferson in the 18th century, with the Bill of Rights as a core document. Adam Smith followed with a more institutional orientation: how to create the right markets, not just any markets. Much of the 19th century was about institutional reform, with the repeal of the Corn Laws as a more than symbolic step in bringing liberalism to a global level, at the cost of the national landed gentry in England. A century later Keynes can well be placed in this tradition, with his formulation of a number of most abstract institutions like for a national and international monetary order based on central banks and IMF, and the international order as in the GATT/WTO, to avoid a mercantilist breakdown as in the Thirties. The United Nations has developed in the democratic planning tradition, but with as yet little power to effectively plan and implement. Legalist concepts like 'legally binding caps' in the climate discussion don't belong to the radical liberal approach in governance but to the planning variant, with the UN as a centralist planning federation at a global level with as yet little power, see in this sense Hare et al (2010).

These two basic views on governance (democratic planning vs. market-liberal) also pertain to how the governance of the European Union may develop in the decades to come, here primarily regarding governance for climate change, but always embedded in general governance principles. Again these views on the role of the state make a basic difference. In the liberal line, the political order of the EU is that of a liberal nation state with as yet very limited central power to develop the radically liberal approach to governance. Its key task in this governance approach is in liberal institution building, as against technology specific planning. For climate policy instrumentation, the correction of market imperfection is through generic emission taxes and at the pure institutional level, for example the creation of relevant open electricity markets. In the democratic planning line, goals are specified in emission caps for the EU and per member state per year, with emission rights (ETS: allowances) owned by private parties and made tradable for efficiency reasons. These outcomes are followed by all because of the democratic legitimation through the process of decision making[11], also when they differentiate at a very detailed product and technology level[12]. Without some federalist development, of the planning or the liberal nature, the EU task is a coordinating one mainly, to induce and gently force the Member states into a common framework, see Thillaye (2013)[13]. At that national level the same dichotomy can clarify basic directions for development. However, as most product markets (including both goods and services and intellectual property rights) tend to be international, surely within the EU but also beyond, purely national efforts at product market creation will tend to fail or will be constrained to as yet more local issues like labor markets and smaller-units real estate markets. In climate policy, there are tendencies towards small scale national and subnational instrument development, as with carbon trading schemes in Chinese cities, US states and small countries like New Zealand. Also carbon taxes have been introduced at such levels as in small countries like Norway and the Canadian province of Alberta[14].

At the global level the planning view on climate policy links to the UN and specifically to the UNFCCC. There is to be an overall planning and a distribution of global emission space per year to regions and countries, also based on broader justice and fairness considerations, in a legally binding international framework. Though not prescribing national policies, the realm of planning is directly involved, ultimately in specifying specific allowable emission levels per country per year; see for example Frankel (2010). It is opposed to the liberal creation of institutions for incentives, inducing countries in turn to induce equal emission reduction incentives between them, through their national mechanisms, and leaving technologies and behavioral choices open to all actual decision makers in the economy and civic society. An international agreement on aligning emissions taxes on CO_2 would be a more liberal option, not currently in discussion in the UNFCCC. The WTO is an example of such a generic institution for trade liberalization, moving country level measures in a more liberal direction, like in reducing options for subsidies and non-tariff trade barriers. The WTO is not linked to climate issues, but WTO allows for trade restrictions for national environmental considerations to which climate considerations might well be added. See in this line from a

[11] The term is from Luhmann (1969), in German: Legitimation durch Verfahren.
[12] See for a recent example EU (2014), e.g., differentiating between three types of gypsum in the application of ETS. These differentiations are subdivisions of the 615 sector NACE Rev2 Level four sector descriptions.
[13] This publication is part of the EU FP7 project Welfare, Wealth and Work for Europe (WWW for EUROPE).
[14] In these countries the emission tax takes part of the rent on natural resources that otherwise would have been collected in a different way.

WTO perspective Tamiotti et al (2009) and Tamiotti (2011)[15]. In recent Bali package, WTO moved into a more integrated planning direction, The OECD as a broader domain organization has the mix of liberalism and planning built into its organizational set-up, with a prime role for nation states to converge on subjects from an integrated - that is: planning - point of view. Overall, pure liberal or planning types do not exist, if only because different institutions are connected, each limiting the scope of the others to some extent. However, the two approaches can clearly be distinguished, as different directions of development.

Both governance directions have their corrupted version. In both versions, but easier in the planning version, business interests may link to political power so as to safeguard their private interests. This may ultimately reduce not only innovation dynamics and economic growth but may also compromise broader issues of human wellbeing, falling prey to partial interest claiming links to collective importance. See Zingales (2012) for an eloquent radical liberal view on these dangers of corruption of more ideal governance options.

These two basic approaches on governance lead to very different entries in climate policy: democratic planning also covering technologies and volumes as against democratic liberal market creation leaving technologies and volumes open to private decision makers, incentivized for the right directions to take. The global nature of the climate problem adds the international dimension by necessity, in Europe first through the European Union but next to the OECD and global level. The IPCC has developed scenarios for climate analysis, based on related but slightly different governance orientations, mainly linked to the democratic planning tradition. The next section indicates how the more general governance orientations as indicated above can be linked to the IPCC dimensions for creating governance story lines and scenarios. These will influence socio-economic scenarios in turn, with emission scenarios and a certain probability on climate change following.

3.2. Current IPCC approaches

The IPCC socio-economic scenario families have been built around two axes:

- Economic Orientation only versus also Sustainability and Social Cohesion (A - B)
- Globalization versus Regionalization (1 - 2)

The four main scenario families resulting (A1; A2; B1; B2), see figure 3.1, can be filled in with more extreme or with closer variants. Within each family, scenarios may differ as to the direction of technology development; dominance of fossils; etc. The intense globalization of

[15] There have been diverging views on this subject in two Journals. In Climate Policy 11:2 see: Gros and Egenhofer 2011 making the case for BTA; Grubb 2011 advocating supranational spending of border taxes; Holmes et al 2011 looking into dangers of hidden protectionism of BTA; Droege 2011 on conceptual issues and how the global political process might be disturbed by BTA discussions; and Voiturez and Wang 2011 on political motives behind BTA. In Energy Economics 34 (2012) see especially the Introduction by Böhringer et al (2011a) and the survey paper by Böhringer et al 2011b. On avoiding BTA see Alexeeva-Talebi and Löschel (2009). On relevant cross border mechanisms see Böhringer and Rutherford (2002) and Habermacher (2012) on a broader concept of carbon leakage. See McKibbin, Warwick J and Peter J Wilcoxen (2009) on practical irrelevance of BTA covering upstream emissions. In the long run, with further global economic integration, reality might change in this respect.

the last two decades seems to have made the two regionalization scenario family less plausible, leaving us with a world more focused on economic growth (A1 and B1), as opposed to one with a more regional and sustainability focus (A2 and B2). Solving the climate problem might be possible in both globalization scenario families. Family A1 would single out climate as the main issue, while B1 looks into broader sustainability issues but with lower growth and hence lower emission levels to correct for. Also for integrating climate policy with other policy domains B1-type scenarios would require a broader regulatory capacity. More focus on planning and deeper integration therefor might make them somewhat less feasible, with broader support and legitimacy through visibility of technology oriented action working more in favor. We will focus on the most demanding case, globalization with fast economic growth, as yet without adding climate policy. Globalization has taken place at a very high pace in the last few decades, see Streeten (2001) for a balanced long term view, and see Samini (2009) for diverse measurement options. International trade as a fraction of global GDP has doubled in four decades, from 14% in 1970 to 29% in 2010. Next to the long term reduction in transport cost, operant from the 19th century but a still developing factor, IT has opened up the speed and volume of global information exchange to unprecedented levels in the last few decades, still growing exponentially, and allowing for globally organized economic activities, including research and research & development. Trade liberalization has been ongoing since the 2nd World War, with efforts for big steps forward ongoing. That is the situation we are in now globally. The IPCC socio-economic scenarios have not been detailed for just EU or single country level, as the link to emissions scenarios is relevant at a global level only. However, story lines at a global level place the EU in a certain global governance domain. Also, the same dimensions defining global socio-economic characteristics, here further focused at governance characteristics only, can also be used to sketch EU governance scenario families.

Figure 3.1 Two dimensions and four basic story lines in IPCC socio-economic scenarios

What could be the governance approaches guiding climate policy instrumentation and implementation? Three dimensions span up an options space. Though many potentialities will not be probable or plausible, it is useful to look into them all before dismissing some. Maybe a change in governance is required for effective climate policy to emerge. The time frame to reckon with is set at 2050. As governance and policy instrumentation can move only slowly, the scenarios for 2050 would have to be guiding actions now already, and also at intermediate check points like 2020, 2030 and 2040.

3.3. Scenario family dimensions: supranationality; markets & planning; and administrative capacity

Supranationality low ← → high

With high supranationality the authority and controls are vested in the supranational body. For the EU this would imply some sort of majority decision rule (Council and/or Parliament) with substantial executive power vested in the Commission. The high level of supranationality would imply some sort of federation. With low supranationality there would be Member State dominance, with a coordinating role only for the EU. The EU is far away from a federation now, but is more than just a coordinating body. There now are diverging tendencies, in administration towards further integration, as a reaction on the banking crisis, and towards re-nationalization in climate policy in several countries The devolution of EU competence to country groups within the EU (Schengen, Euro) is another dimension creating more complexity in EU-wide regulation, and also in national regulation. This devolution is left out in the further analysis.

Administrative capacity low ← → high

With high administrative capacity implementation of also complex instruments is according to impartial rules, at the administrative level where they apply. At the supranational level the administrative capacity of the EU is limited, lacking an apparatus for implementation. This holds even more for supra-EU administrative capacity. Administrative capacity now is vested in country administrations in the Member States. EU countries differ substantially in administrative capacity. Beyond the EU there is substantially more divergence in administrative capacity.

Market centrality vs Planning low ← → high

Markets can be ordered with generic institutions, with limited public interference on technologies, volumes and behavior; that is the market centrality option with limited power of individual private parties and public bodies. Low market centrality means a more planning type of state. Markets then may play a role within a specified planning domain. The EU now is mixed in this respect and may develop more in one or the other direction. Current climate policy is in the Planning approach mainly.

3.4. EU governance in a multi-country context

Where are we now in terms of the three basic governance dimensions, in the EU and its member states, and in the world at large? As to ***supranationality***, climate policy in the EU, and also globally in the UN-IPCC context, uses concepts like *legally binding*. This suggests an authority to overrule national deviations. Both Canada and Japan discontinued their Kyoto

Protocol emission reduction commitments. For sure, the UN does not have the authority to prevent that, nor the authority to exert quantitative controls on emission levels. The EU is somewhere in between, with some elements of majority rule, and enough coverage and funding of broader domains of policy to exert pressure on non-compliant states, including formal penalties. In the environment, energy and climate domain there are several binding directives, with expansion ongoing. However, nationally diverging policies now expand in the energy and climate subject, at least in some larger countries. Germany has its feed-in tariffs, lignite subsidies and it closes its nuclear installations while the UK goes for fracking and builds nuclear power installations to help reach its national climate policy targets. When trying to repair failures in the ETS summer 2013, national governments blocked the options preferred by the Commission. There hence is a substantial but still limited amount of supranationality in the EU. The UNFCCC meetings agree on a common goal, with legally binding commitments by countries. However there is no development towards a supranational authority that can substantiate the legally binding nature of future agreements. Current obligations are voluntary.

The ***administrative capacity*** at the EU level is able in a policy preparatory sense, much stronger there than in the UN. But it is mainly lacking in an implementation sense. For policy implementation it is the administrative apparatus of the member states only, of course with directives, help and advice, but without final responsibility for the EU. The member states have diverging administrative capacities. For generic climate policies across the EU the weakest states determine overall capacity. For the ETS this restriction has been resolved by helping laggards to improve capacity and by the EU taking over some tasks. To give a non-climate example: Greece has not been able yet to set up an adequate cadaster, though the Commission would pay the main costs in setting it up[16]. Outside the EU, the divergence in administrative capacity is much broader still.

The ***market centrality vs planning*** dimension is also mixed in the EU, in the countries within the EU, and with a much wider diversity still at a global level. The EU-ETS has the language of planning, specifying emission targets and rules for the firms brought under the ETS, with rules and exemptions for specific firms and products. A recent example is in differentiating the treatment of the production of three types of gypsum, with different system boundary definitions for quantifying their emissions[17]. Only within this detailed regulatory domain market forces play a role[18]. Biofuel regulations, recently made less binding in the EU, and

[16] Due to its loss of autonomy in the financial crisis, setting up of a cadaster now is one of the structural reform conditions as specified by IMF in the Group of Three, see IMF 2013 p160 ef. It is part of market creation for trade in landed property, essential for broader investment by foreign parties not part of the still clientelism based political structure in Greece, see for example Papadoulis (2006). Most Southern European countries and Ireland have had a long and recent clientelistic tradition.

[17] An example of the detail of technical regulation is in EC (2014).

[18] The detailed nature of these regulations may well become a burden on successful innovation. Political action is a key to treatment in the ETS, the kind of action not in line with creative innovation.

fleet standards are fully in the planning domain[19]. The German feed-in tariffs are open to volumes and in that sense seem more in the direction of open market forces. However, they are fully technology-specific. In most member states, direct regulations are a main policy instrument, including the shutdown of coal fired power stations with some form of compensation. But in most member states there also are financial incentives for emission reduction. In the world at large there is substantial variation in terms of market centrality and planning in general and also in terms of the mostly still limited climate policy instrumentation.

3.5. Four directions for EU governance development

How might the EU develop towards 2050 along these three dimensions? Let us first simplify by assuming the administrative capacity variable to be a requirement, somehow to be met.

The combination of low supranationality with limited administrative capacity could hardly achieve the 2-degrees target, be it in a planning based or market based economy. The assumption then is that the administrative capacity is to be adapted to the level required. This variable then moves from a design constraint to being an evaluation criterion. We then have the type of governance dimension and the level of supranationality dimension left for developing EU governance scenarios[20]. Starting point for this development is the current situation the EU is in, with a mix of market and planning in governance and a limited level of supranationality, see figure 3.2. From there, the EU can move into a more market direction or a more planning direction, with increased supranationality, the same supranationality or reduced supranationality, as re-nationalization. Two governance scenarios then evolve quite clearly with direct relevance for climate policy instrumentation. It is increased supranationality with a more planning type versus a more liberal market type of regulations; that is the Planning Federation or the Market Federation. The administrative requirements are strong in a planning society and somewhat less so in liberal market society. Assuming roughly the same level of supranationality as now, the governance direction will not change much either in the next 35 years. That EU scenario would be mixed, as the Mixed System. Current developments would continue towards slightly more but still limited supranationality and towards a not full market type of economic coordination, with a substantial share of technology specific planning type of climate policy instrumentation.

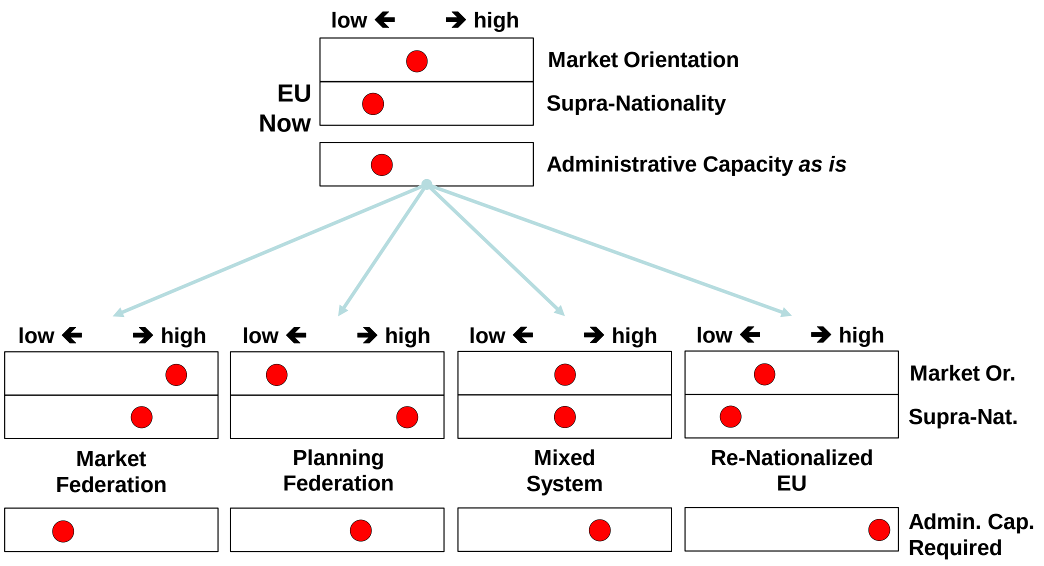
Substantial improvement in administrative capacity at EU level and in the member states would be due. Finally, current trends towards re-nationalization could continue, with moving the role of the EU to coordination between member states also in climate policy instrumentation; the Re-Nationalized EU. It seems quite difficult to increase the liberal market component in societal regulation in this option, as some market control at the

[19] A recent IMF study indicates that efficiency standards are up three times as expensive as carbon taxes for the same level of emission reduction, see Parry et al 2013. This is a pure efficiency argument, not a governance argument.

[20] The role of regions in the EU, below the national level is relevant for governance as well but is left out of account here. See the discussions in Bukowski et al 2003.

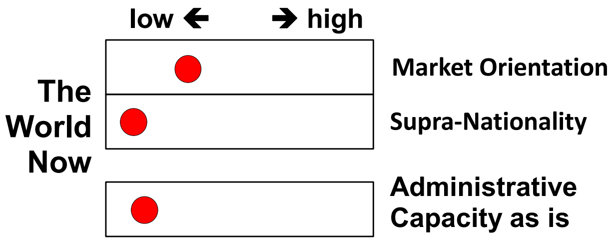
national level will be required. The re-nationalizing EU therefor will move into a planning direction only. The current discussion between the Commission and German government on the German climate policy being too national, as for example excluding foreign inputs, is an example of the power game going on in this direction. The four governance scenarios are depicted in Figure 3.2, with red dots indicating their performance in the three dimensions.

Figure 3.2 Four directions for EU governance development



There may be similar directions for development in other geographic domains. In the US, generic carbon pricing might not be possible because of state dominance and deep divisions. At the federal level some physical regulations are now in the process of being developed as for limiting emissions of new coal fired power stations, while leaving carbon pricing systems to the state level. Such a tendency, also based on strong political traditions, might continue for a long time. At a global level the divide in planning versus market creation can be seen in the UN and World Bank as against the WTO and the IMF, WTO and IMF now also tending towards a planning approach however. In that vein, climate policy has a start in the integrated planning direction. However, supranational authority will remain limited. Supranational administrative power will remain very limited as well, while in many countries the administration available for climate policy implementation will remain weak. Also, countries will differ substantially in terms of the main governance divide: planning versus market creation, overall limiting markets to specific domains and regions. Figure 3.3 indicates the very different situation as compared to the EU, while also plausible development options remain much more limited. For such an internationally weak and diverse governance situation the 2-degrees climate goal may be really difficult to reach. Aligning national green taxes, like an upstream carbon tax, might be a most feasible option for aligning often weak administrations, as they can manage excise-type taxes best. For the EU, this international context is to be reckoned with in instrumentation choices: either aligning or having border adjustments.

Figure 3.3 The World Governance situation now



3.6. Four story lines for EU governance

3.6.1. Market Federation

The market federation results from a radical ideological view on how society should be ordered, not for direct welfare reasons but to keep society open, with civic society remaining independent from government. Increasing welfare may be one of the probable outcomes. The core tasks are the active creation of open markets where possible, prevention of build-up of market power, and avoidance of public-private collusion[21]. Where open private markets are not feasible, as with natural monopolies, public provision is the alternative, not public-private partnerships. Where existing private markets are deficient - as with environmental externalities - the first line of public action is repair of such markets through internalization. Incorporating the induced cost in prices was advocated most eloquently by Pigou nearly a century ago. Where market deficiencies cannot be repaired, as with very long term risks and opportunities, public action is due, as with basic research. In non-market domains there are public tasks. Infrastructure and spatial planning are core issues here, not to be left to markets. In terms of climate policy, the creation of uniform emission taxes covering all emissions equally is the first line of public action, feasible only within the boundaries of effective measurement, as is well possible for CO_2 but not so easily for most other greenhouse gas emission. The institutional arrangement for the functioning of relevant markets then follows. These are the prime tasks in climate policy, refraining from technology specific actions except for non- CO_2 emissions.

3.6.2. Planning Federation

The planning federation links to integrated welfare views in an ideological sense. *The greatest good for the greatest number* is the utilitarian starting point with Bentham, with new representatives like Sen and Stiglitz bringing in more collective elements. Unified treatment of several goals next to the climate stabilization goal helps optimize the development path of society. These further goals will relate to justice and fairness of actions, to industrial and

[21] The recent WTO discussions in Bali showed the collision between the integrated planning view and the open market creation view. India wanted food subsidies for the poor, no problem in a free-market WTO sense, but wanted this subsidy only on Indian production, supporting its farmers. Similar national views play a role in the US and EU as well, for national political reasons, reducing the role of markets

broader economic development, to income distribution, and to specific domains more directly related to climate policy, especially energy policy.

In that process specific problems are to be solved, like compensating those who have a large or unjustified burden, repairing social issues, keeping endangered industries afloat, etc. In this process of integrated development, the EU moves into a planning direction, with rationality of the whole through EU institutions. Member states look for national advantages, as do provinces and cities within them, but are subject to some form of majority rule making guided by an overall view on optimality. Climate policy and energy policy are part of that process, with public and private stakeholders forming coalitions at a European level.

A basic difference between of the planning federation against the market federation option is that in the liberal market federation there is no direct link with such other domains of societal development. For example, income effects of climate policy there are not part of climate policy but part of overall developments, to be resolved by more general taxing and other distributional measures and specifically by improving the education level of the less educated part of society to increase their share in national income, see on these basic issues Tinbergen (1975)[22].

3.6.3. Mixed System

The mixed system is moving slightly towards supranationality but nation states restrict that move. There is no clear ideological picture; it is mixed views. Open market creation is an accepted goal, but constrained by political powerful interests. Administrative capacity is improved, to be able to better handle national requirements also regarding climate policy, but for EU-level tasks somewhat better implementation and control structures are developed as well. The mix of national initiatives, often starting based on prime mover motives, is somewhat aligned with EU initiatives. EU wide actions remain partial and limited, with a coordinating role on many subjects. The mixed nature of policy development is reflected in climate and energy policy as well, with some open pricing systems with EU proceeds, some planning elements, and some rules for national policy development. The sub-optimalities of such a system are accepted, as alternatives do not seem feasible. The fight for effective climate policy is a difficult one, with unstable coalitions. International alignment beyond the EU (as through Border Tax Adjustments) is difficult as there is no clear EU reference to uniform policy instrumentation, while intra-EU markets remain open.

3.6.4. Re-Nationalized Europe

A more Nation States Europe results from basic identity feelings, now seen as populist, at variance with supranational authority. Ideologically, identity and stability are here more

[22] See recently Christine Lagarde in her Richard Dimbleby Lecture: A New Multilateralism for the 21th Century, 4 February 2014

important than income. High costs of renationalization of governance are accepted, at least implicitly. International political stability becomes more based on anonymous globalization tendencies beyond the EU, counteracted by nationalist behavior, especially regarding mineral resources, land and water. National climate policies can have a limited impact on global emissions only, except when expected national climate costs outweigh the national costs of climate action (Barrett 2007). Frequent disasters help build up global views, with some voluntary coordination on climate action following, also by private parties (Ostrom 2010). The role of the EU in climate policy is mainly limited to conflict resolution and advice on coordination. This variant of governance may have most difficulties in developing effective climate policy for a 2-degrees target. The current re-nationalization tendencies in Germany (high feed-in tariffs, closing of nuclear, high share of local lignite) and the UK (limited and different feed-in tariffs, building of nuclear, high level of also imported renewables) show how divergence can build up in a short period of time. At the same time they show that substantial climate policy at the member state level is possible, similar to state level developments in climate policy in the USA, like in California.

3.7. Exemplary: ETS development in different governance scenarios

EU ETS development in different governance scenarios

The EU ETS may develop very differently in these four governance scenarios. In the current Mixed System EU, repairs of the ETS are based on the mixed governance structure. Some price stabilization through volume adjustments will be realized, but always with a delay and therefore with substantial medium term price fluctuations remaining. Expanding the domain of application is difficult as national agreements are required and implementation becomes a heavier burden for national administrations. In the Re-Nationalized EU repairs to the ETS are difficult and also superfluous. Developments like the UK floor tax and the German feed-in tariffs make a weak ETS irrelevant. National taxes and subsidies, and other measures, take over. In the Planning Federation, problems in the ETS are resolved through adapting the amount of allowances in the market to a predetermined rising price level with an agreed bandwidth. The domain of application is expanded so as to also cover fossil fuels in all transport. In the Market Federation, the domain of application is expanded so as to cover all fossil carbon activities. This requires a major administrative revision, as the number of firms and households brought under the system then rises to roughly a hundred million. The solution to that administrative problem is to apply the ETS at EU system boundary: at primary production in the EU and at import of fossils and derivatives, and at CCS in the EU and at exports. At full price stabilization for the full EU, however, trade becomes superfluous as all decision makers already are pressed towards the same long term and to the same short term marginal costs. This last option for ETS development might be seen as a technical option we could just follow now to improve the ETS. This seems highly improbable however given the discussion. Essentially, this line of development for the ETS would mean to change the ETS volume system into a full pricing system, as a carbon tax. It would be part of filling in the Market Federation, as a clear governance choice, different from choices in the Planning Federation and the Mixed System, while in the Re-Nationalized EU the ETS would ultimately collapse, because repair efforts are blocked.

Development of climate policy instrumentation is fundamentally different in these four mutually exclusive story lines on governance. The directions for long term development can be shown on the example of the ETS; how it can be transformed in any of these four lines to governance. The current ETS suffers from a low allowance price, as induced by over-allocation, the economic crisis, and highly effective overlapping national policies as in Germany. How may the ETS develop?

In the Planning Federation, the EU develops the means to control the market price effectively, by adapting the volumes of allowances in the market to a rough price level goal. The domain of application is expanded, so as to also cover fossil fuels in all EU transport.

Banking is controlled and administrative procedures are set-up uniformly, with direct EU controls on implementation. National climate policies, and other EU policies, are reckoned with in setting longer term caps on allowances, with active market intervention to stabilize prices in the short and medium term. Forward guidance on long term prices helps industry in its technology development and investment planning, and guides government in the support of such activities. Border controls are not part of the ETS but added where this seems most important and feasible. All allowances are auctioned, with proceeds for the EU. In the Market Federation, the ETS first is transformed administratively, towards upstream measurement. In that process, the domain of application is expanded so as to cover all fossil energy applications, also small scale like car driving and home heating. The price level, yearly rising, is set so as to roughly approach the climate emission targets. The price levels as specified in time guide industry in its technology development and investment planning. The tax is levied upstream on primary production and imports of fossil energy, and paid back upon exports and CCS. In this set-up, border controls are an integral part of the “ETS” thus transformed fully into an emission tax. Proceeds are for the EU, to its discretion.

In the Mixed System, repairs to the ETS are of a mixed nature. Some price stabilization is possible, by specific corrections on allowance volumes in the market, decided upon apiece. The slowness of the adaptation process makes an overall price planning difficult to achieve, with substantial price fluctuations remaining. There is an a-symmetry in specific interests involved as for example with energy intensive industries. With too high prices the volume adaptation will be decided faster than with low prices of allowances, reducing the medium term level of the cap effectively, and requiring catching up later. Some expansion of the domain of application is possible. The decentralized nature of administrative application leads to an administrative overlap with other financial instruments, like national fuel excises, which then tend to be reduced.

In the Re-Nationalized EU national interests dominate the development of the ETS. Price stabilization and domain expansion move to the level of the Member states. Active countries focused at prime mover advantages will set up national price stabilization mechanisms like Price Floors. All proceeds of the marginalized ETS are national.

Such diverging developments do not result from a pure analysis of “ETS-problems” and how to resolve them. The choice of governance direction determines the development path of the ETS.

This example shows how long term governance scenarios can give direction for instrument development now already.

4. A hierarchy of basic instrument types

A hierarchy of policy instruments

Instruments for climate policy differ in their generality of application. Less general instruments are more technology and behavioral specific. With more specific instruments, more instruments are required to arrive at a certain climate goal, like RCP2.6. Sparseness in instrumentation is an independent factor in instrument scenario development, for two reasons. Administrative capacity is limited both in terms of volume and quality, not just for climate policy. Also, more detailed instrumentation entails higher transaction costs, also privately, thus increasing costs and reducing competitiveness. The general strategy in all story lines and instrument scenarios is to first develop the most generic ones, and then fill the gaps far enough to be able to ultimately reach the climate target. In the hierarchy of technological generality six levels are distinguished: ***Institutional Framework; Generic Emission Pricing; Infrastructure Development; Research and R&D; Technology Specific Instruments;*** *and* ***Innovation Implementation Instrument****s. Starting at the institutional level, different lines emerge quite logically and intuitively. In the Market Federation, a key institutional issue is the development of a real time equal-for-all electricity market, a real challenge. In the Planning Federation, this is not necessary as implementation builds very much on public-private partnerships and taxes, subsidies and prescriptions for specific technologies. In the less centralized options, EU markets cannot be set up in a generic way, with national policies fragmenting markets in different ways. Also at the member state levels, specific partial markets will be developed, with different access and prices for different groups. Lack of generic institutional development will require more detailed technology specific arrangements. At each following level in the hierarchy of instrumentation, such further choices result. They are to be made in a coordinated way, choosing effective and efficient combinations of policy instruments in the governance situation they are to function in.*

When considering building blocks for climate policy instrumentation, the guidance from a normative governance perspective is one clear entry. There are more strategic considerations at place, more directly related to the nature of policy instruments themselves. Firstly, there is a long history on how to assess the costs of environmental regulation, see Christainsen and Haveman (1981) on theory and data and more recent Newell et al (2008), specifically on carbon mitigation technologies.[23] Ultimately it is the effects on economic growth that constitutes the costs, as income foregone. There is a clear relation with the volume of

[23] A more recent review is in Aiyar et al (2013), but focused at middle income countries only. Density of regulation comes out as one main explanatory variable for slowdown of economic growth.

regulations leading to reduced growth and with the nature of regulations, with technology specific and binding ones reducing economic growth more than generic financial incentives as through emission pricing. The volume-reducing effects of emission pricing, one cost element, are likely to be dwarfed in the course of decades by their better dynamic performance in terms of invention, innovation, and diffusion (Newell et al 2008 p565). The type of incentive created is a key to the dynamics of climate saving technology development: the more open-ended and generic and the stronger the incentive and the larger the long term climate saving dynamic effect will be. Technology binding instruments play a more limited role in long term dynamics and may even impede innovation[24]. Short term optimality plays a limited role only in long term development. Secondly, the administrative capacity of governments is limited, both in terms of volume of actions and in terms of their complexity. This does not hold for climate policy as such but for the total of regulatory activities of which climate policy is a part. When the administrative burden of regulation is deemed high overall, pressures towards reduction will set in. These practical aspects are mirrored in public and private transaction costs, both increasing with increased volume and complexity of public regulations, including those of climate policy. More instruments require more complex alignment procedures, with more regulatory capacity needed and with more constraints both on private initiatives and on further public policy development, as political administrative lock-ins.

Reckoning with these two broad domains of mechanisms combined leads to relatively simple strategic guideline for instrument development for the 2-degrees goals: sparseness. Sparseness translates into looking for building blocks of a most encompassing and simple nature. Public actions for the market introduction of specific technologies constitute the most detailed level of instrument development, while institutional arrangement of a general nature can be most simple in nature and most encompassing in their application. The negative version of the sparseness principle is not to squander our limited instrument resources: for a given effectiveness to be realistically expected less is better in an instrument sense, in all governance approaches. The sparseness principle can be formulated in terms of a hierarchy for instrument development, in choosing prime instrument blocks in any of the four directions for governance scenarios. Start at the most generic level of institutional development, with a special place for most generic tools for internalization of climate externalities. Then go to the public provision domain, in terms of public infrastructure and research of a long term nature, where market provision cannot function. For gaps still remaining, more technology specific instruments can be developed, with information as the least disturbing but soft option, financial incentives following and technology prescription as the most infringing option. Financial incentives for specific technologies, as with investment subsidies and feed-in tariffs, may overlap with generic internalization as through carbon taxes. From an efficiency point of view, the different carbon prices involved constitute an

[24] With feed-in tariffs on specific technologies covering their additional cost relative to a main alternative in the market, the incentive to develop more cost-effective technologies is reduced. Finon & Menanteau (2003) compare feed-in tariffs to direct regulatory instruments, which have a lower dynamic potential so they conclude.

avoidable suboptimality, unless it is temporary, to overcome lock-ins and to create learning curves. This then would not be general technology policy but market introduction of specific technologies. The temporary incentivization of novel technologies towards broader market diffusion[25] constitutes the sixth main category of climate policy instrumentation.

4.1. From institutional framework to inducing market introduction of innovations

The six main categories of public action distinguished follow the order of generality. Institutions constitute the most encompassing framework, followed by internalization of climate emissions by their pricing. Next, basic research is not focused on marketable technologies, and in that sense is generic. Public infrastructure, like railways, roads and harbors, and standardization, as on smart meters for smart grids, tend more towards specific technologies. This also holds for public provision in the case of natural monopolies. The next jump is made with instruments regarding specific technologies, like emission standards for coal fired power stations or subsidies for wind power parks or on electricity produced from solar cells. Prescriptions and these economic incentives have in common that they relate to specific technologies, furthered on or off the market with harder or softer means. At the most concrete level there is active market introduction of specific technologies, as with high but temporary subsidies on specific technologies using feed-in tariffs. The most direct market intervention is temporary public provision of market products, as is common for example in disaster relief situations.

[25] See Scrieciu et al (2013) for a treatment of dynamics beyond the purely economic analysis. Their multiple goal analysis tends to a planning approach however, not to be linked so automatically in a policy instrumentation context.

4.2. Exemplary filling in of instrument types

4.2.1. Institutional Framework

Institutions tend to be broader than just relating to climate changing emissions. They constitute the more generic fabric of society, also relating to its governance structure. Educational systems, social security systems, labor regulations, and taxing systems all have their domain but relate to climate change. Not fixing working hours per week or year can reduce working hours per person; setting up taxes in a generic way can avoid clientelistic tax variations (part of what OECD sees as fossil subsidies). All such generic institutions have their generic deficiencies, which may be relevant for climate change. More open financial institutions can better fund long term energy saving investments; more stable macro-economic policy can avoid short term panic with climate threatened firms; etc. Closer to energy and climate considerations is the instruments for spatial planning, not yet the planning itself but the legal and administrative framework. There seem to be substantial options, not used actively. Here some barriers to effective planning might be removed.

There also are institutions with a more direct relevance for climate change. A first and main example would be to bring climate change damages into the normal legal domain of tort law, involving strict-and-several liability. See for an extensive survey Grossman (2003) and for the basic discussion on this subject Calabresi and Melamed (1972). This route could lead to the most basic form of internalization of climate external effects. However, the practical options are limited due to problems with jurisdictions, the time delay of effects, the chance nature of effects, the very large number of direct emitters and indirect sources, and the very high number of persons and organizations suffering the damage in the course of time. In the environmental domain tort law has played a role in Japan, where one emitter caused heavy local health damage, Minamata mercury disaster. This then led to broader principles and next practice for regulation so as to avoid the limitations and vicissitude of litigation. In the line of protection of basic entitlements, the more practical solution is through public pricing of externalities. At the institutional level, the choice on how to set up internalization of external effects roamed some time. The institutional discussion on the Coase Theorem opened up broader instrument options than Pigouvian taxes, the main line till then. Under certain circumstances, like very limited transaction costs, subsidies not-to-emit may work out similar to taxes (fees, etc.) on emissions. This institutional discussion was ended in the agreement on the Polluter Pays Principle, as formulated with broad consensus by the OECD (1975). Subsidies for ‘not emitting’ are not to be part of the legal and policy framework. Practice is stubborn however. The abolition of subsidies in the energy and climate domain is a recurrent theme in OECD publications (measured at over 400 billion dollar[26]), as for short term effects

[26] IEA, see: http://www.iea.org/publications/worldenergyoutlook/resources/energysubsidies/

subsidies are attractive, also politically. For long term climate policy development they are not to be on the list of institutional development however, though specific short term support measures to overcome lock-ins may be applied for creating learning curves for specific technologies, as temporary instrumentation. For generic policy emission pricing is the instrument to be used, see option 2 below. Internalization through generic emission pricing may be seen as part of the institutional structure of society.

The set-up of markets, beyond litigation rules, is highly relevant for energy, both for primary energy production and also for secondary production. Examples where legal rules have been created or bended amass in the energy domain, most visible for nuclear energy where liability has been reduced substantially below what would be normal in a business practice, different in different countries, with some unification in the EU. The BP spill in the Gulf now leads to multi-billion damage payments, based on US legal rules, ultimately raising fossil fuel prices.

For renewable energy to take a substantial share in the energy market, electricity markets play a key role, with problems of intermittent and often unpredictable supply. Current energy market designs have difficulty to cope with these variations and with linking to also variable demand.

Prices for specific technologies and for specific demand groups are regulated in various ways in different countries, access rules differ and ownership structures differ, with some unbundling introduced but re-bundling (vertical integration of production and transport) taking place as well. A more detailed analysis of this key issue for climate policy in the institutional framework is in Annex 1. Options for market creation are sketched there in relation to the governance approaches as have been described above.

At the supranational (supra-EU) level, the WTO rules for border tax adjustment based on environmental concerns are a global institution, highly relevant for EU and national climate instrumentation. If national industries paying a substantial carbon price cannot be protected from undue foreign competition, such a policy instrument will be vulnerable politically, for economic and social reasons. Germany has made exceptions as to who should bear the cost of renewables feed-in, giving exemptions for export industries for that reason. Such exemptions go against the spirit of the single market in the European context if not against the letter of the Lisbon Treaty. In each governance option, the allegiance to WTO rules and similar more regional rules as may come up, is to be actively developed, also in terms of adaptation of WTO rules to allow for effective national and regional climate policy.

For emission levels the volume of economic activities is a main determining factor, with institutional arrangements geared mostly to maximize growth, also if this goes against wishes of individuals being pressed to work more than they would like. After the economic crisis of the Eighties options for part time work have been opened up in the Netherlands. Broad segments of the population, also male, have used this opportunity, resulting in substantially lower working times per person as compared for example to the US. According to OECD statistics[27] the US worker works 1790 hours per year versus in the Netherlands 1381 hours, a difference of 30%[28]. The retirement age is relatively low in the Netherlands as well, though rising recently due to active public policies. In the long term, using productivity increases partly for working time reduction, as advocated by Samuelson in the Nineteen Fifties already, and in a more general sense by Keynes and Marx before, could contribute very substantially to GHG emission reduction and alleviate other environmental problems as well. Reducing net growth from 3% to 1.5% would reduce GDP rise by 25% in less than half a century. This could be the single most important institutional measure for emission reduction, by just opening up options aligned with private preferences.

4.2.2. Internalization of climate effects through GHG emission pricing

There is a very substantial literature on options for generic emission pricing of climate changing emissions, the pricing approach, as through emission taxes, with volumes following and the volume approach, as though tradable emission permits, with prices following. The volume approach has been implemented in the EU in the ETS, and at a more limited scale in many other countries. Carbon pricing has been introduced in many countries, but with limited price levels and often still limited domains of application. The history of the pricing versus volume approaches shows a starting point with classical economists and a new practical twist by Baumol (1972) and Baumol and Oates (1988). The American experience with tradable cap systems for NOx and SOx led to a surge in that approach, linked to permits-to-be reduced in the most effective way. At that time, the set-up of Kyoto protocol and ETS followed that approach, linked to existing environmental policy in non-climate domains. Since then, most economists have turned back to the pricing approach; see the recent reader by Aldy and Stavins mostly in this direction, and the shift in position by the nestor of climate economics and politics, Nordhaus, from (2007) to (2010,2011,2012). See Keohane (2009) for an exception. His arguments for the US[29] however relate to assumed political acceptability in the US using free allowances and the need for detailed planning in time.

These two basic options for generic emission pricing can be connected to governance approaches. Cap-and-trade systems like ETS translate into firm-specific caps, with branche and firm specifications for applicability and exemptions[30], based on other than climate policy considerations. In this sense ETS and similar systems belong to a planning approach, deciding on what is best at a detailed business specific and technology specific level. Generic carbon pricing through emission taxes can be set up through upstream taxation on carbon content of fossils, creating a broad domain of equal application through market forces. Exemptions for

[27] See: http://stats.oecd.org/Index.aspx?DataSetCode=ANHRS
[28] In the Netherlands in the Eighties this involved adaptations in rules on social security and pensions systems to better allow for part time work. The (limited) reduction in weekly hours resulted mainly from private negotiations. Both these adaptations were guided by the SER (Socio-Economic Board) a neo-corporate structure in the institutional domain in the Netherlands.
[29] Many American economists in the taxing direction think about carbon taxes specifically for the US, see for example Metcalf (2009) and Metcalf and Weisbach (2009.
[30] Freely received allowances function as subsidies in such a generic CAT system. Not falling under the system has a subsidy aspect as well.

specific users like small firms or export industries are beyond the technical applicability of the instrument. In this way the generic carbon tax belongs to the market approach. At a more detailed level compensating subsidies are possible.

These different options find their place in the instrument scenarios, as higher level building blocks. The carbon tax discussion has a background in economic optimality reasoning, going back to Pigou, who stated that the level of the emission tax should be equal to the marginal damage caused. This principle is adhered to by many economists, with substantial empirical analysis; see Tol (2008) for a survey and evaluation. The discussion on limits of economic reasoning on the value of externalities was systematized by Baumol (1972) and (1988) indicating the practical problems of such an endeavor. One specific characteristic of climate damages is their chance nature: low chance – high impact options may well dominate the evaluative analysis, as Weitzman (2009) has shown. The high impact damages due to run-away climate change are in the domain of social and economic disruption well beyond where marginal damage methods of economists are applicable; the Fat Tail is dominant but difficult to quantify in economic terms. It is by necessity a higher damage than specified by the traditional economic method as surveyed by Tol (2008) and even relative to results using lower discount rates as in the Stern Report. In the realm of nuclear analysis the disaster element is a main reason to oppose nuclear energy. The social disruption of disaster is however much more regional than with climate change.

Both for the cap-and-trade and for the carbon taxing instrument, the Baumol approach holds: Setting a cap at a moving target based on collective reasoning or setting a rising price to move towards that predetermined target level. In this respect the two instruments do not differ.

How to determine the level of the cap and the level of the emission tax, the Baumol way, is the more practical issue to resolve, as based on modelling of long term economic and technological development, depending in other governance and socio-economic scenario developments, and reckoning with broader international developments also in the climate policy domain.

There is a broad discussion on the dynamic nature of the target and the tax level: rising constant or lowering. For emission reduction targets the trajectory may be high reductions early, a constant rate of reduction as in the ETS, or much higher reductions later, each option technically fitting to the 2-degrees target, potentially, see the RCP2.6 scenarios. For the generic carbon tax, the argument for a lowering rate is to avoid the risk that primary fossil producers will put their resources on the market as soon as possible, to avoid the rent reduction they will have at later dates with the higher tax[31]. That is the Green Paradox. The model by Sinn (2008) and the revision by Edenhofer and Kalkuhl (2011) is slightly more

[31] Carbon pricing, cap or tax, will reduce the rent of the intra-marginal producer by lowering producer prices, see Dong and Whalley (2011). Induced renewables, as by feed-in/ subsidies, have a similar price lowering effect, but at higher overall energy use.

complex. They have the same result that under certain circumstances producers may speed up production with a rising emission tax. However, reality may be more simple than modelled. As there are substantial time delays in speeding up oil and gas production, the Paradox would be delayed, by well over a decade. The risk of too high costs relative to lower future prices would be substantial. Also, starting with a high tax right away in climate policy is unlikely politically[32]. There seems to be a broad agreement now that emission taxes should rise, for two different reasons. One is that with rising emissions the damage per unit of emission will rise, see already Ulph (1994). Damages would include the risks of climate run-away. The other is that the cost of emission reduction will be higher now than in the future as alternative energy sources have not yet been well developed. Along these lines, the emission tax should start low and rise predictably, then level off, and might then later be lowered, if other energy sources have developed to out-compete remaining (then cheaper) fossils. Knowing the ultimately required tax levels now is not easy as marginal abatement cost curves cannot be known reliably, they are not stable in time, and they don't cover more complex behavioral issues, see Kesicki and Ekins (2011).

4.2.3. Infrastructure for public and private use

Where markets cannot work or should not work there may be a public task, depending on governance views. These tasks may cover spatial planning, the physical infrastructure as for transport, the handling of natural monopolies, standardization in case of opposed interests, and provision of goods and services with a broader social importance like health and education. How such tasks are approached depends substantially on the governance direction the EU will move to. Spatial planning and infrastructure are pervasively important for energy use. Meadow shopping malls require substantially more transport than in-city provisions. Cycling, for example, has become a major issue in German speaking countries in the last decades, reversing commuter behavior, and linked to higher density cities. Such movements have picked up momentum in major cities around the world, with Bloomberg's New York as catchy example. Public infrastructure is a major determinant for volumes and modal split of transport, also in relation to congestion based or cost funding pricing systems. Other transport systems as for electricity and possibly for CO_2 (for CCS, Carbon Capture and Storage), ammonia, oil and natural gas, may require some form of public provision as well, depending on the governance approach[33].

Standardization, health and education have a less direct relevance for climate change.

[32] Especially for the EU now as energy prices in main trading countries US and China will be structurally lower than in the EU in the coming two decades, according to IMF studies.

[33] In interesting variant is the oil and gas transport system in the North Sea. The British government considers policy to force private companies to open up their infrastructure in the North Sea to each other, in order to lower production costs and increase production, see Parker and Kavanagh 2014.

4.2.4. Basic research and development

Research for long term developments belongs to the domain of public funding, because the risks involved are high and the time horizon is long, especially for basic research with as yet unclear commercial applications, is nearly fully in the public domain. For short term and medium term research and development, the role of public funding depends on the governance views involved, and on the specifics of the technology. For deep innovations with very high investment requirements public development is often dominant. Major technological developments like IT and the Internet have nearly been fully funded and developed by public organizations; see for a strong statement on this subject Mazzucato (2013). In a multi-author statement, Arrow et al. (2009) made the case for substantial, predictable, private industry independent public funding programs, also crossing the boundary from basic research to Research and Development towards implementation, as substantially novel technologies also tend to be risky in their implementation, with substantial chances on failure. At a global level, funding of research for renewable energy and energy efficiency has not been rising much in the last two decades. However, patents in this domain, also specifically for solar power and wind power, have been rising very fast in recent years, with a leading role for Japan, the US and China, and a small and diminishing role for EU countries, see Bettencourt et al (2013). Overall patent development is explained by the volume of energy technologies and the volume of publicly funded research. However, the country of volume need not be the country using that experience in research. Some basic research and resulting patents would not necessarily be connected to the energy and climate domain, as in micro-level technical physics and materials science, while being a key element long term for relevant technology development.

The governance approach followed will lead to different choices on the role of basic research and the role of public investment in infrastructure.

4.2.5. Technology specifications overruling market behavior

This is the domain of traditional environmental policy, with operating permits; operating standards; product/technology specifications; product/technology taxes, product subsidies (like permanent feed-in tariffs and tax exemptions). Also softer instruments like information on product/technology performance public purchasing programs may be seen as part of this category. What unites these instruments and contrasts them with generic pricing internalization of category 2 is that they are linked to specific technologies. Exemptions for small firms or exporting firms in contributing to the cost of feed-in tariffs relate to electricity supply; they are not even generic subsidies to a sector. Instruments implementing obligatory percentages of renewables relate to specific renewables.

The number of possible instruments is substantial, also because they can be applied in varying combinations. The number of specific products and activities these products can be applied to is sheer limitless as well. The number of different products on the market ranges in the millions, with a fast turnover. There are EU regulations ranging from standby switches on very many electric and electronic products to emissions of coal fired power stations.

A strategy to reduce technology specificity is to regulate environmental performance as opposed to technology composition or functioning. Effect oriented policy instrumentation may reduce long term cost of regulation, see Huppes and Simonis (2009), as it does not so much hamper innovation.

The sparseness principle would reduce the regulatory load as much as possible, as by generic measures applying to larger groups of products with a substantial emission impact. Main examples are fleet performance standards for person cars and building regulations regarding energy use and energy supply systems. In current transient policy, the share of renewables in fuel for combustion engines is a key instrument. However, for arriving at the 2-degrees target, it probably is necessary to apply CCS to biomass for energy. This would mean that biomass is to be used in electricity generation, with a high level of CCS, not in distributed applications where capture is not possible. Its role in car fuels therefor can only be very limited in the long run towards 2050: combustion engines will have to be phased out by then, replaced by electricity or other non-fossil based intermediate energy carriers like hydrogen, ammonia, methanol, etc. In the aviation domain it does not matter much if biofuels are used and then not sequestered or if fossils are used and then not sequestered. The cost also in term of energy use to produce aviation fuels may well be higher for biomass based aviation fuel than for their fossil variant. The analysis of technology specific policy instrumentation within an overall climate policy framework cannot be straightforward, as indirect/secondary system consequences are to be taken into account, including but going well beyond rebound effects.

4.2.6. Innovation implementation

Implementation of novel technologies may receive public support for facilitating their introduction. The main reason for public policy in this domain is that existing ripened technology systems may create a lock-in, preventing novel technologies from ripening to similar levels. Potentially interesting technologies therefor may remain interesting forever, entering the *valley of death*.

Several mechanisms can overcome the lock-in on existing technologies. They are the creation of learning curves by having market volumes established combined with the introduction of the relevant infrastructure. If markets had strong enough incentives to do so, the public task would be limited. (Of course businesses appreciate to be subsidized.) However, overcoming lock-ins itself may be risky, not only too risky for private action but not always worth the effort from a public point of view. The combustion motor with the highest design efficiency, higher than Diesel, is the Stirling engine, conceptually developed in 1816. Many a fortune has been lost on its introduction, all failing (except in reverse use, for cryogenic cooling). A recent attempt is their highly subsidized introduction as micro combined heat and power installations in the UK[34]. Such experiments can be highly successful, or fail, making them

[34] The quantitative contribution is limited to around 5% compared to high efficiency natural gas boilers, a recent evaluation has shown, see Carbon Trust: http://www.carbontrust.com/media/77260/ctc788_micro-

subject of possibly relevant public policy. Such experiments better not be at a full EU level but at smaller scale try-outs, like at country or regional level, but large enough to create the potential learning effects. Especially in the case of infrastructure, the technology chosen may well create a lock-in itself. Implementation of a hydrogen infrastructure system for transport energy, ethanol and ammonia systems will have lost in advance. The example of the internet shows a core function worthwhile implementation, in that case for military reasons, with a roll-out for non-military functions following quite directly.

4.3. Building blocks and instrument mixes

Combinations of several instruments covering the same products and activities may be complementary, mutually supportive, or mutually detrimental, see Simoes (2013, especially Ch2) for a conceptual analysis with some case applications in the electricity domain. Especially when system effects are taken into account, such combinatory effects may be substantial. A well-functioning effective cap-and-trade system combined with substantial technology subsidies may not have additive effects. If the cap-and-trade dominates, the subsidies are given to no avail, only making the emissions for others cheaper due to lower emission permit prices. If public policy based introduction of low-emission technologies dominates (as by subsidy or regulatory obligation) the price in the trading system is reduced. The creation of learning curves may be a good climate motive for specific subsidies, in order to lower the costs of transformation to a low carbon society. This reasoning holds only if the disturbing effect on emission prices is not to strong, which would reduce innovations in all other domains, or if the cap could be adjusted reducing it with the additional reductions coming from the subsidy system.

More complex, active subsidized supply of renewables may lower energy prices, with limited effect on fossil production. Lower rents of producers will reduce the production of highest cost production sites only. The subsidized energy system will expand (as in the Jevons Paradox), with only limited emission reduction. Realistic modelling (as opposed to classroom modelling) of such mechanisms with a long term view is not easily done.

Similarly, local improvements may prevent more fundamental system improvements, as when forcing the car industry to improve its combustion engine performance, thus delaying the introduction of renewables based non-combustion technologies, including the electric car.

The relation between CCS policies and other policies is important as CCS will play a major role in reaching deep emission reductions, mostly related to electricity production. The costs of CCS are substantial relative to the cost of electricity without it. These costs are to be borne by some sort of subsidy, including emission credits earned in a cap-and-trade system or rebates in a carbon tax system. These instruments may induce CCS, with differing time horizons involved based on pricing levels in time, see van ‘t Veld and Plantinga (2005). As CCS has to

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chp_accelerator.pdf . However, the options to contribute to peak demand reduction have not been included in that analysis, important to reduce system cost of intermittent renewables.

pass through learning stages, the innovative aspects of their inducement are to be reckoned with, see Finon (2011). Strict emission permits on coal fired power may induce CCS, if the instrument is properly set up and infrastructure is available. Feed-in tariffs, of a temporary nature, may not induce investment in CCS, as CCS requires a substantial infrastructure with a long time horizon of use.

In general, combinations of instruments with a different nature are to be checked on possible negative interferences. Cap-and-trade systems combined with subsidies like feed-in tariffs work out mutually detrimental, with effects of each single instrument not adding up to the total, with cost increasing. Generic emission pricing combined with technology specific subsidies and prescriptions may combine adversely, requiring more efforts than either option expanded to the effort singly. There is substantial research on the cost of different approaches to instrumentation, and their combinations. In general, combining generic market approaches with technology specific instruments will increase costs for reaching the same climate emission reductions. For the domain of road transport this has been investigated in a number of studies brought together in Anderson et al (2011). See Annex 2 for a survey of mechanisms involved. An economy-wide econometrical analysis by Parry et al (2013) shows the combination of generic carbon pricing with technology-specific regulatory measures. The outcomes indicate cost for the same emission reduction to be two to three times as high for the combination as for the single generic carbon pricing instrument alone.

Such assessments are essential when designing and evaluation instrument mixes in climate policy instrumentation.

5. Instrument building blocks for four EU governance story lines and scenarios

Governance scenarios filled in with Building Blocks for climate policy instrumentation

*The **Market Federation** has a prime focus on creating general markets with equal incentives for emission reduction for all actors. This market creation is through a number of institutional developments, filled in with an encompassing carbon tax on all fossil carbon that would leave the economy as CO_2 emissions, with a refund for CCS and at export. Supporting institutional developments include the development of an open real time electricity market and capital markets with a long time horizon. A second main domain is development of public infrastructure and public research and development for a low carbon economy. Infrastructure and longer term natural monopolies are publicly owned. There is full debundling in the energy domain so as to avoid power build-up of private firms. There are no public-private partnerships.*

Technology-specific policies are mainly absent for CO_2 aspects but are substantial for non-CO_2 climate emissions, where emission measurement is near impossible. Temporary market introduction of high-risk high-potential innovations constitutes part of the instrumentation, often in relation to (experimental) infrastructure development. The EU plays a major role in global climate policy development, going for an agreement on a similar level emission tax, so as to create a level playing field with major trading partners.

*The **Planning Federation** in a mixed economy focuses at directing most relevant private activities through public-private partnerships, following detailed sectoral planning and spatial planning, through substantial public funded or co-funded R&D, through technology-specific subsidies and prescriptions, and through substantial support in market introduction, also for alleviating market deficiencies. All climate policy activities are EU-wide for all EU-wide markets, virtually all markets in this governance scenario. Planning is not yet an instrument, it is specifying detailed near operational goals. The actual implementation is centered on public-private partnerships, moving firms 'in the right direction', aided by generic economic instruments of cap-and-trade and by technology subsidies and prescriptions, as with fleet standards. Vertical integration, the opposite of debundling, is welcomed as it allows for easier planning implementation. Firms involved in major energy and climate relevant industries are large, European-wide, with global connections. National governments are not able to exert the power for substantial changes so the focal point in implementation is the EU, with a strengthened position of the Commission for discretionary policies, within an overall* *democratically agreed planning framework. The EU plays a major role in global climate policy development along these lines, with legally binding caps per country per year*[35] *as the main goal.*

In the ***Mixed System*** *deviations from current EU governance are limited, with technically improved performance in a number of domains, including in the ETS with some medium term price stabilization and short term volatility. It is planning oriented but with a strong national planning focus with EU coordination. Direct EU planning is in a limited domain of globally standardized consumer products, like cars and some electric appliances. The mixed nature of governance levels hampers generic market development in the EU, especially in the energy related domain. Activities for open market creation are limited by existing national interests and national policies. The key EU role is to prevent the emergence of near monopolistic economic entities. Institutional development is limited, with a focus on maintaining a basic level of competition also in energy markets like for gas and electricity. The role of national public-private partnerships and national (near) monopolies as in nuclear energy and grids is subject of scrutiny, from the point of view of retaining a minimum of competition, with a prime active role for member states. Standardization is a prime EU domain, to allow for EU-wide competition and to keep international markets open. Standardization has a less global perspective than in the planning federation and market federation as it has to relate more to national preferences. Technology planning remains mixed, with a strong role for the national level, involving prime mover motives*[36] *and substantial use of economic instruments focused at specific technologies. The EU plays a modest role in post-Kyoto climate policy development, as the guiding role of the ETS remains limited.*

In the ***Re-Nationalized EU,*** *the role of the EU is mostly focused at coordination, with only in crisis situations a delegated role for the Commission. The core action is at the level of the member states, with climate competition between them furthered by the EU. The ETS first remains at low and erratic price levels, with the substantial regulatory capacity required not brought up by the member states. It subsides under effective national policies. National initiatives like in Germany (feed-in tariffs) and the UK (carbon tax) take over. There is no role left for the EU in terms of climate specific policy instrumentation regarding technologies, except where manufacturers support EU wide rules, as with fleet standards in road transport. The strategy of the EU therefore has to shift to more indirect coordinating means as in the form of standardized information on products and technologies, essential for competing realistically in the climate domain. The EU plays no initiating or leading role in the development of global climate policy.*

The governance story lines can be developed into policy instrument scenarios, here one sketch per storyline specifying main building blocks in instrumentation, using the following order: Market Federation; Planning Federation; Mixed System; and Re-Nationalized EU. In

[35] See Bosetti and Frankel (2009) and Frankel (2010) for a reasoned approach with quantification.
[36] The prime mover motive is part of the Porter Hypothesis, see Porter & van der Linde (1995).

each story line the building blocks for climate policy instrumentation follow the line of sparseness, with different outcomes per instrument scenario. Per story line first key elements in the institutional framework are specified; second the carbon pricing is detailed; third infrastructure tasks are specified; fourth, research directions are indicated; fifth directions for technology-specific instruments are specified; and sixth basic reasons are specified for operational introduction of technologies in markets to overcome lock-in and create learning curves.

5.1. Instrument Building Blocks for the Market Federation

The market federation has a relatively large number of institutional framework items, an encompassing carbon tax, substantial public ownership of infrastructure, substantial basic research and a low number of technology specific actions, focused at non-CO_2 emissions where emission taxes cannot be applied as emission measurement is (mostly) not possible. The EU plays a major role in global climate policy development along these lines.

Major institutional changes relate to adjusting and creating markets, and adapting some other institutions relevant for reduced emissions. Adjusting and creating markets first concerns electricity markets. These are to be unified in the EU with a single price for all, and open to non-EU producers and users. Core element is real time market matching of supply and demand, requiring substantial changes in the fixed prices structure of current markets. A more detailed description on electricity market development is in Annex 1, also for the other governance scenarios. Repairs are due broader in energy markets opening up competition as by breaking down vertical integration (ownership unbundling), with public ownership of nearly always monopolistic infrastructure to avoid undue build-up of market power. Also in many instances relevant information is not supplied, especially by oligopolistic firms, requiring some rules on labelling, similar to food labelling.

International institutional developments relate to building options for international agreement on same carbon tax systems and levels, and creating a clear opening for border tax adjustment with countries not having similar carbon taxes. Specific market deficiencies, as with lack of access to borrowing for emission reducing measures, are resolved where possible. For smaller private organizations, lack of access to capital now is common. Opening up markets for small lenders and making them transparent is an institutional task. Private investment in household energy saving is a domain example. Where funding of long term investments is difficult, the measures are not to organize renovation for sustainability, but to improve the working of capital markets. Where markets cannot function for basic reasons like with natural monopolies and with the non-excludable public goods, public provision may be due, see below under infrastructure.

Finally, a number of current arrangements as in labor and pension institutions can be adapted to open them up to individual preferences as on working times per week, per year and over the life time.

Emission pricing for CO_2 is encompassing, uniform and at stable predictably rising tax levels. To create a fully level playing field in this respect, fossil carbon is taxed at primary production and at import of fossils into the EU, with a refund at export and at CCS. The all-pervasive nature of energy use and CO_2 emissions is tackled through market mechanisms to be created if not already present. As emission measurement is not possible for most non-CO_2 emissions, emission pricing mostly is not possible for these substances. Contrary to neo-liberal ideas, the radical liberal market federation has substantial public ownership, including much of the infrastructure for transport of persons, goods, and information, which tend to monopolistic supply with substantial non-rivalness in use. Main parts of the transport infrastructure for CCS are also publicly owned with carbon storage paid for through a refund of the carbon tax[37]. Normalization as in ISO usually is private affair but may require public rules when opposed interest cannot be aligned. Current standardization activities for demand flexibilization technologies might be aligned better for example[38]. Spatial planning is a major non-market domain with close connections to energy use, requiring a shift away from the focus of private car use to more integrated planning for also public transport, cyclists and pedestrians, and for overall motorized traffic reduction.

There is substantial basic research in this governance scenario like on nano-technologies with energy transformation potential and more “DARPA[39]-type” research, on high potential and high risk system innovations, like on decentralized intelligent system cooperation required in unified electricity markets. Such research endeavors may continue towards innovation implementation, in terms of infrastructure, or up to a level where private economic activities can complement or take over, as now is the case partly with the internet.

There are no technology specific regulations (subsidies, prescriptions, etc.), except for technologies with non-CO_2 emissions.

Publicly supported market introduction is focused at a limited number of lock-ins and a limited number of technologies with high potential inducing learning curves by volume creation. To avoid overall market disturbances and new lock-ins these are at a limited scale, in specific sectors, regions or countries. The exchangeable car battery system as being introduced in Israel could have been a typical example. Housing renovation to reduce energy use and GHG emissions are not part of market introduction programs, being induced by more generic measures already. Owners will focus at insulation and demand levelling measures, as opposed to measures in the Planning Federation and the other planning approaches.

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[37] The tax and refund payments can be conceptualized as a Carbon Deposit System; see Huppes (2011). The deposit is paid when carbon enters the system by primary production and imports, with a refund upon export and CCS. All carbon lost on the way; that is having been emitted as CO_2, is taxed implicitly, at the level of the deposit.

[38] In this technology domain there is overlapping standardization ongoing in Europe and the Pacific rim, easily leading to incompatible systems, with the Open Smart Grid Protocol (OSGP) of ETSI, the European Telecommunications Standards Institute, and of the US-East Asian Allseen Alliance Initiative (https://allseenalliance.org/). See Essers (2013) on the Allseen Alliance.

[39] DARPA (Defense Advanced Research Projects Agency) has played a key role in IT developments ranging from hypertext systems and the computer mouse to computer communication and the internet. The focus is on short to medium term project funding with high risk and high potential, and with potential military relevance. The design requirement on the internet data transport system was that it was to withstand a nuclear attack, making it highly reliable regarding other failures as well.

Table 5.1 Instrument Building Blocks for the Market Federation

1. Institutions	• Real time transparent single price electricity market • Implicit subsidies on all energy removed • Developing BTA rules internationally • Developing international agreements on equal emission taxes • Market deficiencies covered at institutional level where possible • Strengthened competition (anti-trust) rules • Liberty in working hours
2. Carbon pricing	• Upstream carbon tax covering all fossil carbon • Proceeds carbon tax to EU, for any public spending or tax reduction • Other GHGs covered similar where possible
3. Infrastructure	• Public ownership and development of transport infrastructure for: Persons, goods; electricity; water; IT; other long term natural monopolies • Pricing of infrastructure focused on congestion / capacity use, not funding • Spatial planning EU level well developed, not primarily focused at road transport • Standards for resolving inter-industry conflicts
4. Research	• Basic research prime, also in RETs and R&D for high risk systems (as on decentralized intelligent systems; ..)
5. Technologies	• No inherent candidates for CO_2 • Substantial instrumentation for low emission technologies in non-CO_2 domains
6. Implementation	• Try-outs on novel high risk high potential systems, till creating learning curves

5.2. Instrument Building Blocks for the Planning Federation

The planning federation in a mixed economy focuses at directing private activities through public-private partnerships, following detailed sectoral planning and spatial planning, through substantial public funded or co-funded R&D, through technology-specific subsidies and prescriptions, and through substantial support in market introduction, also for alleviating market deficiencies. All climate policy activities are EU-wide for all EU-wide markets, virtually all markets in this governance scenario. Planning is not yet an instrument, it is specifying detailed near operational goals. The actual implementation is centered on public-private partnerships, moving firms 'in the right direction', aided by generic economic instruments of cap-and-trade and technology subsidies. Vertical integration, the opposite of debundling, is welcomed as it allows for easier planning implementation. Firms involved in major energy and climate relevant industries are large, European-wide, with global connections. National governments are not able to exert the power for substantial changes so the focal point in implementation is the EU, with a strengthened position of the Commission for discretionary policies, within an overall agreed planning framework. The EU plays a major role in global climate policy development along these lines.

One core issue at the institutional level is how to regulate public-private partnerships, where collusion and cronyism are to be reduced as much as possible. This institutional development partly is through joint public-private ownership, partly through preferential contracting, and partly through obligatory technology specifications set up in relation to options of advanced firms. Overlapping combinations are possible, which together could reduce competition very much, a problem to be resolved as far as possible.

The cap-and-trade system evolves from the current ETS so as to cover all major fossil energy uses and is price stabilized at predictably rising, but short term fluctuating levels These levels are lower than the carbon tax in the Market Federation, as there is substantial other climate policy instruments adopted. There is full auctioning of permits, with proceeds central to the EU, for spending on climate saving and energy-saving purposes, including cost of joint action and of research and R&D.

Infrastructure development for all major energy supply, transformation and use systems is Europe-wide. Much of the infrastructure is privately owned, by firms having the infrastructure as part of their vertically integrated activities, through (co-)ownership or other contractual arrangements. This holds for energy firms, a few Europe-wide firms remaining, and also for long distance high speed rail systems.

Public research funding is geared to medium term planning. Therefore research efforts tend more to R&D. There are clear requirements on the climate relevant valorization potential of projects.

Technology related policies, including their volumes, are based on detailed planning.

Technologies required for planning implementation and not coming from market activities spontaneously are brought into the market by subsidies, prescriptions, and restrictions on bad alternatives, covering a broad domain of products, technologies and behaviors. In the electricity domain, smart meters are defined and prescribed, to allow for some peak shaving.

The planning process includes non-CO2 greenhouse gases which cannot be regulated based on emission measurement. The same set of technology specific instrument mixes applies there as well. Diffuse and difficult to predict emissions like N2O emissions from agriculture tend to be left out of active policy domain, as is the case also in the Market Federation.

In the market implementation stage of novel technologies and behavior, public guarantees and public participation in private market activities are used extensively. Feed-in tariffs (temporary ones) are also used extensively to create learning curves for technologies in their production and use. Housing renovation to reduce energy use and GHG emissions are part of market implementation programs, focused at insulation and renewables like solar PV.

Table 5.2 Instrument Building Blocks for the Planning Federation

1. Institutions	• Rules on public-private partnerships • Rules to maintain intra-EU competition
2. Carbon pricing	• Price stabilized cap-and-trade, also short term, domain expanded, also covering road transport, as through gasoline stations firms • Proceeds ETS to EU for low carbon investments
3. Infrastructure	• Private and public-private partnership for development of: roads, railways and gas, oil and electricity transport • Pricing of infrastructure use funding oriented • Spatial planning EU level well developed with focus on public transport and locally on walking and cycling
4. Research	• Research tending to R&D for planning needs
5. Technologies	• Public guidance on sectoral emission reduction tasks, with time specific targets in many sectors • Public planning of the energy supply system, including the role nuclear and of different

	renewables, with substantial public private co-implementation • Vertical integration of energy supply, transport and demand flexibilization for easier planning • Substantial regulation of all emission and energy relevant activities especially using subsidies and prescriptions, including building standards, emission standards for power plants, fleet standards in the transport sector, with also detailed focus at energy efficiency improvement • All transport relevant technologies subject of detailed regulation • Rules for smart meters and for demand flexibilization • Rebound of specific actions substantial, with additional technology specific policies, but rebound through spending shifts not covered • Substantial instrumentation for low emission technologies in non-CO_2 domains
6. Implementation	• A leading role for public-private partnerships in implementation of novel technologies and larger novel systems • Substantial use of feed-in tariffs, to create learning curves • Substantial planning-based low energy housing renovation

5.3. Instrument Building Blocks for the Mixed System

In the mixed system deviations from current EU governance are limited, with technically improved performance in a number of domains. It is planning oriented but with a prime national planning focus with EU coordination, and direct EU planning in a limited domain of standardized consumer products, like cars and some electric appliances. The mixed nature of governance levels hampers generic market development in the EU, with limited activities for open market creation which by near necessity hurts existing national interests. The key EU role is to prevent the emergence of near monopolistic economic entities. Institutional development is limited, with a focus on maintaining a basic level of competition also in energy markets like for gas and electricity. The role of national public-private partnerships and national (near) monopolies as in nuclear energy and grids is subject of scrutiny, from the point of view retaining a minimum of competition, with a prime active role for member states. Standardization is a prime EU domain, to allow for EU-wide competition and to keep international markets open. Standardization has a less global perspective here than in the planning federation as it has to deal more with national preferences. Technology planning remains mixed, with a strong role for the national level, involving prime mover motives. The EU plays a modest role in global climate policy development.

At the institutional level, EU regulations maintain a basic level of competition, counteracting the market control tendencies of the planning approach. EU-wide provision of venture capital shifts to public funding, as by expanding the role of the EIB.

Carbon pricing evolves into a long term price stabilized system, by volume adaptations to maintain intended price levels. Short term fluctuations remain as corrections are delayed, being part of a political process involving large firms and member states. The short term adaptations reduce the long term level of the cap. Policy for domains not under the ETS are coordinated by the EU but implemented at the national level, as with a mix of capital subsidies on technologies and product subsidies like feed-in tariffs, belonging to the domain of technology policy and technology implementation. As other, also national, climate policy instruments are being applied the allowance prices remain low, not inducing heavy investment in emission reduction and behavioral change. More generic national climate and energy taxes are focused at consumers, to avoid international competitive disadvantages. Some minimum tax levels are specified by the EU, as on car fuels, linking that level to the intended level of the allowance prices.

Infrastructure development at the EU level remains at an incidental project level, with coordination between member states as the core of policy. Rules for intra-EU supranationality are developed, as for example to allow energy companies to come to more cost-effective arrangements, with both EU and national support using flexible legal arrangements. National governments try to develop circumstances conducive to the development of national low carbon industries. Public infrastructure like roads and airports are privatized, with pricing systems focused at funding and profits, as opposed to reducing congestion costs. Pricing of infrastructure is funding/profit oriented, infrastructure development and operation being mostly part of activities of vertically integrated firms. EU-wide high speed train lines are developed through national co-operation involving the mainly national railroad companies. Airline companies participate in development of high speed rail lines to co-ordinate such developments with their aviation operations, including airport infrastructure development.

Research shifts away from basic to more applied research with a time perspective at not too distant valorization, as in the KETs (Key Enabling Technologies) strategy40. Integration of private R&D in publicly funded programs is advanced, also with fiscal instruments. Technology development is stimulated at EU level, but with a limited budget due to continuous budget constraints. These constraints are operant at member state level as well.

Technology specific policy instrumentation is the core domain for reaching the deep climate targets of the 2-degrees goal. Technology specifications are used extensively, also for activities under the carbon market, but especially for those not covered in the ETS. The car sector is a main example, with fleet standards as a major instrument, but with a limited dynamic pressure to avoid negative impacts on national car industries abroad. Where industries are transnational and powerful, regulation remains at the EU level; in more national markets national regulations may have a limited role, as virtually all industries become export oriented. In such situations specific technologies are developed and implemented through subsidies, including tax exemptions, and through public-private arrangements to reduce risks for private partners, as through guarantees, loans, participation and preferential public purchasing. An important motive for national technology policies and for participating in EU-wide programs is the prime mover advantage, also in its negative variant of not lagging behind.

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[40] See EC 2011 and EC 2012. The enabling technologies involved are: Micro- and Nanoelectronics; Advanced Materials; Nanotechnology; Biotechnology; Photonics; Advanced Manufacturing Systems.

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For innovation implementation the same public-private reasoning is applied, and mainly the same instrument mixes. The EU is involved in a limited number of core demonstration and proof-of–concept projects, as in the climate domain with CCS projects. Otherwise, member states are main actors, with a limited advisory and coordinating role for the EU. National programs for emission reduction are co-focused to a substantial degree on national security of supply considerations. For renewable and nuclear energy investments, temporary price subsidies/guarantees, as in national feed-in tariffs, are a major instrument, again used also from a perspective to create national prime mover advantages. Housing renovation to reduce energy use and GHG emissions are part of market implementation programs, focused at insulation and renewables like solar PV.

Table 5.3 Instrument Building Blocks for the Mixed System

1. Institutions	• Norms on public-private partnerships safeguarding some competition • Public banks for supplying venture capital (like EIB)
2. Carbon pricing	• Cap-and-trade with improved procedures for longer term price stabilization, limited domain, not including road transport, proceeds to member states • Somewhat reduced ETS target level • EU directed minimum national carbon taxes on car fuels roughly linked to intended allowance prices • Energy taxes mainly on final consumers at member state level, with some carbon reference
3. Infrastructure	• Main infrastructure owned at national level, privately and in public-private partnerships with firms linked to national levels • Transboundary electricity trade effectively opened but infrastructure development left to private firms, with EU coordination and bilateral member states agreements • Pricing of infrastructure is funding/profit oriented, part of total proceeds • Limited EU wide spatial planning • EU wide rail systems stimulated based on monopolistic cooperation between national railroad companies
4. Research	• Research focused at valorization, tending to R&D • Little basic research • Limited EU budget
5. Technologies	• EU fleet standards with limited dynamic pressure • National deviations from international developments to create advantages for special national competencies
6. Implementation	• Limited advisory role EU on implementation • A few core demonstration and proof-of–concept projects • Implementation projects based on combining some national advantages in a transnational business surroundings

5.4. Instrument Building Blocks for the Re-Nationalized EU

In the Re-Nationalized EU, the role of the European Commission, Parliament and Council is mostly focused at coordination, with only in crisis situations a delegated role for the Commission. The ETS first remains at economically irrelevant low and erratic price levels, with the substantial regulatory capacity required not brought up by the member states. It is first repaired on paper and then effectively collapses. National initiatives like in Germany and the UK take over. There is no role left for the Commission in terms of climate specific policy instrumentation. The strategy of the EU therefore has to shift to more indirect means, like coordination, at several levels. The EU plays no initiating or leading role in the development of global climate policy any more.

At the institutional level there is a focus on the alignment of national rule systems and the prevention of non-financial trade restrictions coming up. Such actions may seem far away from climate policy but may be essential in stimulating competition between countries in terms of low carbon technologies and behavior. Without such climate oriented competition the re-nationalized EU will probably not be able to approach the EU 2-degrees emission targets. Climate competition between countries could be based on principles like fair information on embodied emissions, an EU task, with allowable market disadvantages for example for below-average EU performance. National access-to-market rules and financial instruments are to be brought in line with EU regulations, mutually. Also transnational mechanisms can be bent to national applications, as in setting up voluntary standards, also globally, implemented in at least some major EU countries to create dynamic ‘Porter-type’ advantages. Non-complying countries would then lose market share and profits in such activities, with a serious risk of decline.

Carbon pricing would shift mainly to the national level, first in relation to the ETS, as with price floor systems, UK-type, with proceeds spent as on subsidies for market introduction of especially national products. Ultimately there will then be a shift to a national emission tax system if the ETS price systematically falls below the national emission tax levels. Green taxes, in a generic version, are the context for this development. National emission trading schemes seem quite impossible to implement in the mutually very open member states economies. Indicative coordination on emission tax levels is an EU task here.

Housing renovation to reduce energy use and GHG emissions are part of market implementation programs, focused at insulation and renewables like solar PV.

Table 5.4 Instrument Building Blocks for the Re-Nationalized EU

1. Institutions	• Coordination between national rule systems • Rules for agreements on international cooperation • Prevention of non-market trade restrictions in EU
2. Carbon pricing	• EU ETS overtaken into diverging national systems, with some international trade • Agreements on coordination between national pricing systems, advisory only • Diverse national subsidy systems for emission reduction based on prime mover advantage motives

	• National carbon tax/excise on car fuels party mixed with fuel excises • Levels of (also) carbon excises limited by inter-country competition
3. Infrastructure	• National private and public-private partnership and development for roads and electricity transport • EU advice on supranational grid design • EU support for inter-member state high speed railways • No EU wide spatial planning
4. Research	• No basic only scattered EU R&D, No broader systems development • Subsidized competitive attraction of big industries development teams
5. Technologies	• EU fleet standards are only indicative, compulsory in larger countries with a substantial car industry, comparable to California fleet standards • All partial technologies are subject of public policy, different in different countries, from R&D to implementation • Tax-type economic instruments focus on consumers only to avoid international competitive disadvantages
6. Implementation	• Fully national member states implementation of limited scope technologies in a transnational business surroundings

5.5. Comparison of building blocks between governance scenarios

Scenarios compared

All four scenarios may lead to the same intended climate result. However, there are differences the emission path that may be expected. Going in the direction of the Planning Federation may give results faster than in the other scenarios. The Market Federation may start later with emission reductions but may have a better long term dynamic innovation performance. The Mixed System accepts governance as is, and makes the best of it, starting now and using well developed procedures. How long term performance may develop is difficult to fathom, as really stringent emission reductions will hurt specific business and national interests. The driving force in the Re-Nationalized EU is climate competition between countries and regions, as was a driver in the successful Energiewende measures. Keeping laggards in the system may be a most challenging task there, essential however for deep climate improvement. Also the technologies will differ between governance scenarios. In housing, for example, the market approach will lead more to variabilization of demand as through energy storages systems, while feed-in tariffs in the three planning approaches will induce more solar energy in the housing domain.

The two Federal governance scenarios seem robust and able to deal with the deep emission reductions required, with quite opposed approaches to instrumentation[41]. The Mixed System depends substantially on adequate contributions to the instrument development process of

[41] In climate modelling, instruments are assumed to be effective in the way emission taxes would work, allowing for optimal technology choices. An exception, in principle covering a broader set of policy instrument options, is in Deetman et al (2013). It takes technologies as starting point.

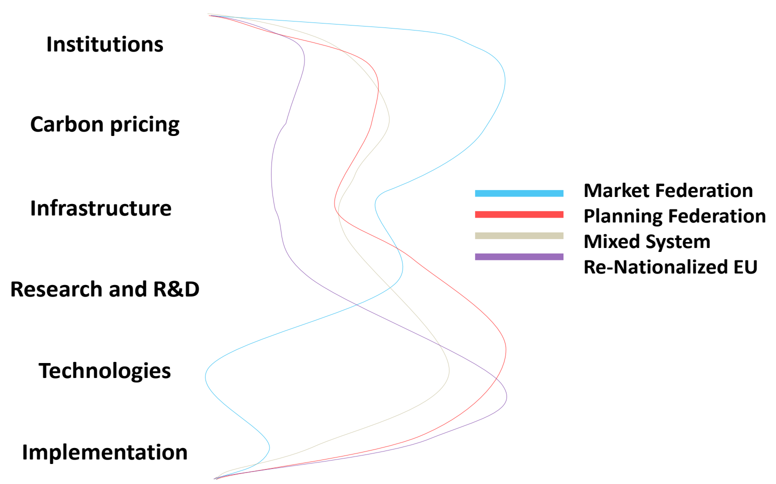
major EU countries. Current divergence in national versus EU instrumentation need to be resolved, to develop the limited domain ETS as an effective instrument. The Re-Nationalized EU will have severe problems in getting to the 2-degrees target, as economic incentives remain limited and markets for novel technologies are fragmented, with high costs for renewables to be produced nationally, fed mainly into national grids.

All instrument technology oriented policies and their market implementation require a high quality in administrative implementation and a high administrative capacity, in terms of sheer manpower. Especially the re-nationalized scenario will have a substantial administrative burden, reflected in private costs of regulation. They have the political risk of capture. These burdens and risks are highest in the re-nationalized governance situation.

The EU going-it-alone is not a feasible option: high cost without climate effects will not be accepted by industry and voters. The different governance situations in the EU are matched by different approaches to international agreements. Both the federal options can deal well with supra-EU climate policy developments, albeit in very different ways. The Mixed option will have more difficulties to get to an international alignment in climate policy instrumentation due to the substantial amount of diverse technology-oriented policies. The Re-Nationalized EU will not be able to have a serious influence in supra-EU climate policy instrumentation, a further reason not to be optimistic on the 2-degrees climate success of this governance option.

The four instrument scenarios are typified as to where they have their most important emission reduction impact, see Figure 5.1. As there is substantial interrelation between different instruments and instrument types, this visualization can be done in a sketchy manner only.

Figure 5.1 Importance of different instrument types in four climate governance scenarios



6. Conclusions

The story lines with instrument scenarios are not blueprints but indicate possible directions for development, each with strengths and weaknesses, and derived from that, with probabilities, not statistical but subjective probabilities. They are developed in a way that their probability is well above zero, to make them relevant in the climate policy discussion. The governance story lines seem a powerful tool to develop options for policy instrumentation and to place them in a consistent perspective. The logic of linking to governance brings the instrument discussion to a somewhat higher level than usual, also giving more room to institutions as basic instruments for effective climate policy.

The governance story lines as developed cover broad and diverging views on our future, primarily based on views regarding the economic coordination of society, with a more fundamental market orientation, liberal but not neo-liberal, versus a more planning orientation, democratically deciding on a broad set of goals in an integrated way[42]. The second element is the level of supranationality, by necessity high in the liberal market variant, and with three levels of diminishing supranationality covered in the Planning Federation, the Mixed System and the Re-Nationalized EU, each based on a planning approach. The requirements on administrative capacity increase with more planning and with a more national instrumentation.

Do we need all four story lines for instrument scenario development? One may ask if the renationalization scenario is to be included, feasible and probable enough. However, in terms of probability, the re-nationalization option might score high, as this development is taking place at the moment not only with climate policy but also in broader political developments regarding EU governance. In most European countries there are anti-EU parties coming up, with re-nationalization on many political agendas. However, normal politics, keeping things as they are, with a drive at piecemeal improvement for solving problems as they come, seems at least as likely. These two scenario options are well at the table and are highly relevant surely for the short term. Their long term visionary aspects are maybe less clear. The more centralized federal EU requires a more visionary approach, be it market or planning oriented. But also these views exist, in policy preparation and in broader policy and governance discussion. Such options will develop only if actively supported, from a long term political point of view on societal governance.

The feasibility of scenarios in each story line has a political component, a socio-economic component, and an administrative component. The detailed feasibility analysis of the scenario options is not the subject of analysis here. It is not the role of scenarios to predict

[42] This approach to piecemeal integrated policy goes back to Simon (1959) and Dahl as presented more recently in Dahl et al (2003). The focused system changes affecting many decisions in the same direction tend to get out of view, as towards democracy or towards neo-liberalism in the Thatcher-Reagan era.

and choose the optimal one but to broaden the discussion on relevant options for our future in a more fundamental and systematic manner. The governance scenarios as sketched seem highly relevant for such discussions, bringing climate policy instrument choices explicitly in the domain of governance discussions.

Ultimately, the feasibility relates to the capacity of the instrument Building Blocks in the four governance scenarios to help reach the 2-degrees target, substantially if not fully. For that analysis, they have to be expanded into full instrument mixes, one per scenario, including quantification of instruments and modelling of results. Also for explicit instrument mixes this analysis towards results remains open as much instrument development will be ‘on the road’, reckoning with as yet unpredictable technical, socio-economic and political developments.

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Annex 1: Instrument building blocks for electricity policy in four governance scenarios

Governance based institutional developments of smart EU electricity markets sketched

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> *"First, governments need to ensure the transparency of power generation costs at the system level. When making policy decisions affecting their electricity markets, countries need to consider the full system costs of different technologies.*
>
> *Second, governments should prepare the regulatory frameworks to minimise system costs and favour their internalisation."*
>
> Source: Foreword of OECD (2012b)

Introduction

The introduction of a substantial amount of renewables in a fast growing electricity market is a key element in decarbonizing the economy, to be combined with a substantial reduction of the amount of fossils. Wind and solar energy will play a substantial role in this transformation. These sources, and wave and tidal energy similarly, have two characteristics in their supply very different from fossil and nuclear energy and from bioenergy. These characteristics are the intermittent and difficult to predict variations in the time of supply and the near zero marginal costs of production. Whenever their supply is available, producers will tend to deliver, pressing production with non-zero marginal costs off the market. Nuclear, next with higher but still low marginal costs, has opposed characteristics. It is fully predictable but only slowly variable. Many other non-fossil options have similar varying characteristics; see Hoffert et al (2002) for a survey. Electricity demand is highly variable as well, but not linked to renewables supply variation. These variations are daily, seasonal, and incidental. Matching supply and demand independently, on a supply basis only, would require a substantial flexible reserve capacity, and would require a substantial grid expansion. The cost of these system overheads could well become higher than producing electricity in old-fashioned fossil and nuclear installations. Combinations of storage options and demand variation may substantially reduce system costs, easing the introduction of renewables. Demand variation has untapped options. It requires a reaction of consumers in line with supply options, shaving peaks and filling troughs in demand and reacting to the intermittent supply of renewables. Final demand variation can be combined with options for stored systems like hydro storage and battery systems but may also include non-electricity routes as through hydrogen or ammonia production, together reducing system costs. Increased manoeuvrability of demand, combined with increased manoeuvrability of supply, also for nuclear power, allow for large scale introduction of intermittent renewables in the electricity system.

For effective management, and in the longer term for dynamic system improvement, electricity markets are to reflect the variations in supply and demand. Producers, storers and final users all are to know the price signals somehow in order to adjust their behaviour accordingly. This link between supply and demand can be established in different ways, depending on governance mode and grid system level. It may be done more from a planning perspective allowing for some delay in linking supply and demand with higher supply manoeuvrability requirements or more from a liberal market creation perspective, with real time integrated markets, see Neuhoff (2005) on technical details. And it may be from a centralized Europe-wide grid perspective with a European markets, or from a more national grids perspective with some links and coordination between member state markets.

The options for market creation differ for the four governance situations most relevant for climate and energy policy: the radical and international Market Federation; the international Planning Federation; the limited supranationality Mixed EU, moderately innovative; and a most conventional substantially Re-Nationalized EU. The differences between the Mixed EU and Re-Nationalized EU are gradual only, as they both have substantial planning elements, involving Member State level policy instrumentation for electricity supply and renewables. The instrument specifications given here concern sketches in main lines, giving directions. The discussion starts with a number of policy documents on electricity market creation in the EU and the US, of a mostly planning nature. The reasoning involved links directly to an OECD study by Keppler and Cometto on system costs and system design in electricity systems with large shares of renewables (OECD 2012)[43].

Discussion on flexibility in electricity markets in the EU and the US

Both the EU and the US are actively developing electricity markets to squeeze peak demand for achieving substantial reductions of system costs. In systems with increasing shares of intermittent renewables peak shaving becomes more important. The European Commission has published a Commission Staff Working Document on this issue (SWD (2013) 442 final, Brussels, 5.11.2013), on ‘Incorporating demand side flexibility, in particular demand response, in electricity markets’. It states how markets can be set up to allow for active demand side participation so as to create demand flexibility reckoning with supply options. This document reflects some very different views on governance regarding market creation,

[43] The title focuses on nuclear but the treatment is full system, under the assumption of intermittent renewables having a substantial share in electricity production, with requirements on increased maneuverability of nuclear energy supply.

ranging from a more planning type to more fully market type approaches. Such opposed views are not specified, with their different mutually conflicting options now put together. Examples are numerous. In section 2 there is on open choice between time-variable electricity prices versus incentive payments for demand shifts, the time-variable electricity price belonging to the liberal school. However, incentive payments then compare to a reference situation, requiring detailed information on the electricity users or detailed contracting on his behavior, as with peak amounts of use per (fixed) time of the day. Section 3.1 on reward schemes indicates that providers specify a time differentiated retail price in advance, so consumers can adjust their behavior. This planning part would however kill the flexibility on the supply side of the market, and make the link with demand flexibility quite loose. A next option specified is fixed electricity prices with a premium to shift to lower load periods, leading to contract specifications diminishing the independence of consumers in their choices. For quite personal and variable reasons it may be inappropriate for individual consumers to be bound to a peak volume. Such contractual relations between providers and consumers will create an intermediate market, to take the risk for not having real time equality in supply and demand as is required for electricity at any moment in time. In section 3.2 of the document standardized technological solutions are surveyed. Modulating energy use of household appliances "directly from the system" would give companies direct influence on private household appliances, quite directly against liberal principles. On smart metering it states that they are "to register consumption in sufficiently differentiated time periods to enable billing which reflects shifts of consumption to low-price periods". The liberal market option of single price real time markets is fully out of view here. It seems quite impossible to establish if there is a shift or a reduction relative to some reference situation, while the core issue from the liberal point of view, the supply of real time market price data, is not mentioned.

The Commission document does not address the issue of the climate policy adapted market prices themselves, like if they are to reflect some form of emission pricing or not. Market creation as discussed is at one level higher, the institutional level, with issues like emission pricing to be addressed later, within the markets as are to be created.

There is a similar US discussion on demand response, where the US seems to opt for the planning option only, as contrasted to the more varied but conflicting EU views. Several policy documents address the issues involved (FERC 2010; National Action Plan for Energy Efficiency 2010; De Martini 2013; FERC 2013). They all align to the same indirect planning approach. The National Action Plan on Demand Response states: "Activities identified in the National Action Plan that lend themselves to being accomplished by private entities would be accomplished using private funding. The work of these private entities would be coordinated with that of federal, state, and local agencies through the Coalition." The Coalition is a group of all involved, both public and private parties. It is only partly comparable to ACER[44] (Agency

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44 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:211:0001:0014:EN:PDF

for the Cooperation of Energy Regulators) which however organizes public or near public bodies only, to be aligned with private actions. The decentralised state level role in US electricity generation limits options for larger scale institutional development.

The tendency in the EU and US to specify policy and market formation at the level of producers, consumers and regulators reduces the market institutionalization discussion to the margin, loosing potential benefits in the process. There may be good explanations for a low market efficiency development, see Wolak (2013). These constraints relate to vertically integrated market power of larger producers, and limited grid capacity reducing system size and hence competition further[45]. Both issues are dealt with in the EU, but not with clear success as yet. The unbundling activities have had limited and temporary success, with detailed mixed regulation continuing; see for example EC (2013b).

In the EU and US discussions, smart meters and advanced metering infrastructure [46] tend to be technology specific without reckoning with specific market design options. Especially time delayed systems are at variance with development of a transparent real time market. There are some standardization developments crucial for real time market development. Standards for communication are developed by private actors not explicitly presuming specific policies on market creation. The European Telecommunications Standards Institute (ETSI) has defined an Open Smart Grid Protocol (OSGP)[47], in line with ISO/IEC 14908, specifying how information flows between grid actors and apparatus can be standardized. Such standardization could fit a more planning type of market development, at any spatial scale level. Only if actively allowing for real time system management, these standards would fit also into more liberal governance systems. More specific standardization on apparatus management, as in the Allseen Alliance (see Esser 2013) is a further requirement. These standards should be fully compatible. With different mainly European groups involved in the OSGP (see http://www.osgp.org/) and in the Allseen Alliance mainly American and East Asian groups, divergence can easily slip in[48]. Whatever the exact nature of standardisation may be, it should allow for very short communication and reaction times for real time market clearance. If not, they would block a real time market development.

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45 Current regulations make the flexible introduction of biobased renewables virtually impossible regarding trade between countries, as an advance and ex post notification is required, see http://ec.europa.eu/energy/gas_electricity/doc/com_2013_public_intervention_swd06_en.pdf. We assume that such practical governance issues are ultimately non-issues, resolved in due time along the lines of the different governance scenarios.

46 A good survey in Wikipedia: http://en.wikipedia.org/wiki/Smart_meter and http://en.wikipedia.org/wiki/Advanced_Metering_Infrastructure#Advanced_metering_infrastructure

47 http://en.wikipedia.org/wiki/Open_smart_grid_protocol

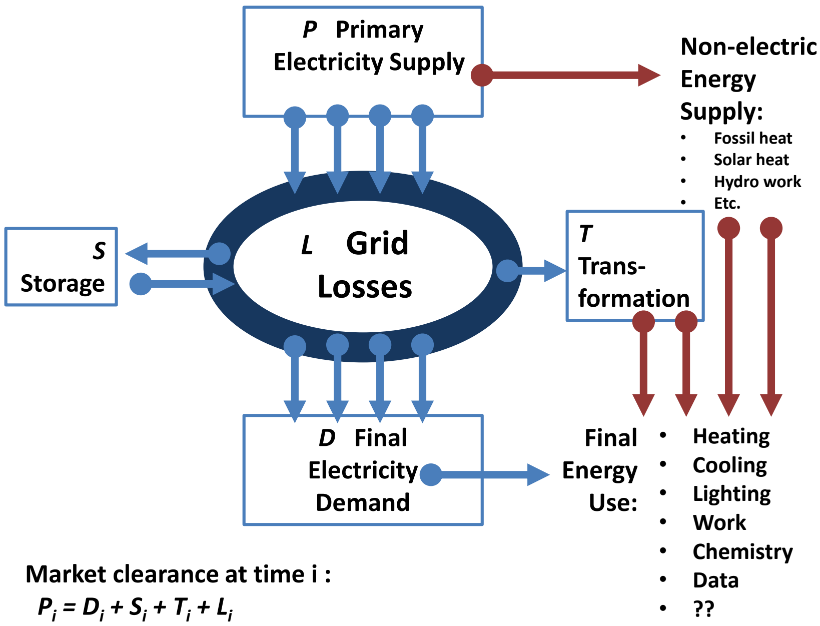
48 There might be a coordinating role here for the Commission.

Technical-economic requirements on the electricity system

The core tasks in market creation for electricity are the matching of supply and demand at any moment in time and the creation of incentives for most relevant investments. The electricity market has a number of characteristics deviating from more usual product markets. First, it is continuous and variable at the demand side. Given limited options for demand variation and storage, it also has to be continuous and variable at the supply side. Second, the grid is by near necessity monopolistic: there are no competitive grids as this would require excessive investment costs. Grid pricing systems therefor are to be based on regulation, be the grid owned privately or publicly. An exception may be to have some parallel lines in a supergrid at a pan-European level, then to be developed. At best this supergrid would be oligopolistic however. Third, many renewables have extremely low marginal costs pressing all other producers out of the market at the moment they can supply. This cost structure is similar to that of nuclear energy, but even more extreme as compared to coal and natural gas. However, nuclear supply is stable and predictable while wind and solar are not, while natural gas is easiest to vary. Fourth, the spatial structure of supply and demand tends to become more spread out over Europe, because of an increasing share of wind and solar where they are most cost-effective and with the location of fossil and nuclear power plants tending to be closer to deep water cooling options, while hydro storage options, the cheapest storage options now, are mainly located in mountainous regions. The increasing regional differences resulting are a main reason to increase the size of the market from the mainly national level now to the European level. At that level there is also a more spread out demand structure over the day due to differing time zones.

Storage options and variable transformation options can help stabilize the market, reducing the variable part of primary production capacity otherwise needed, see Figure A1.1. Storage and transformation can absorb supply when it tends to exceed demand, and can deliver back at peak times. Reduction of peak final demand similarly reduces requirements on variable production capacity. With such market stabilization realized, peak requirements on the always limited grid capacity are reduced as well. Overall transport volumes may well increase per unit of final energy demand due to the location of new primary production and storage options, requiring grid expansion already. The increasing share of electricity in final energy use will require a grid expansion as well. Peak shaving of demand reduces grid capacity requirements however. If real time markets are well developed, this third factor may become dominant. System costs could be reduced not only through peak shaving but also through trough filling.

Figure A1.1 Market clearance in the European electricity market



The technical options for supply diversion and market stabilization in demand are complex and multiple. Most energy producing, transforming and using systems can combine elements of primary production, storage, transformation and demand peak shaving. A fuel cell driven plug-in hybrid car would use electricity based hydrogen (transformation) from a hydrogen grid not only for driving but also to produce electricity to the grid at peak times (indirect storage). It could take electricity from the grid in its batteries at off-peak times, and deliver back to the grid in peak times (storage). Also fossil power plants can shift between heat and power to some degree, with coal fired power stations becoming more flexible on shorter notice. The ideal market would equitably induce all options for variation in primary production; for storage; for variable transformation; and for peak shaving in final electricity demand.

The central aim in developing the continuous variable real time electricity market is that all options for equalizing supply and demand are used to the level where their marginal costs are below or equal to what is required for efficient market clearance. In such a market real time change in the use of electric appliances is to be possible, requiring a management system with communication options between all. Standardization for such active management of electric appliances (including all, like also cars) is developing, as “the internet of things” using Qualcom standards in the platform as set up by major producers in the Allseen Alliance (see Esser 2013). Quantitative planning is fully impossible for short term market clearance and also for longer term innovation and investment. Real time market clearance does not allow for a separate clearing house step either: the market is cleared continuously in trading. Current standards developed for smart metering are not compatible with real time markets as they allow for a delay in reaction.

The development options for the electricity market relate to the four governance situations as distinguished [in the main document]. In the long term these options may differ substantially. The pathways from now towards each option may differ substantially again. The building blocks sketched cover the long term only.

Governance options considered

From the four options distinguished in the main report, the liberal market federation goes farthest in market creation, with the planning federation following with a large scale more limited market development. The current EU governance situation and a renationalization of climate and energy policy will lead to very different options again. The re-nationalized EU is at the other extreme, with small scale markets with detailed but limited scope planning. The markets involved relate to production and use, and also to the operation of the grid. Electricity grid operation cannot function as a market directly, being a natural monopoly mainly. The way grid operation is organized will also differ between governance options. In the planning federation the logic is to go for public-private partnerships with some vertical integration; in the market federation for full public ownership and near full unbundling; and in the other two options for a more hybrid system of more loosely connected planning based national systems, not creating the full-fledged European market. Assuming at least some unbundling, grid operations are based on pricing rules and investment planning rules. The grid pricing rules very much determine options for market creation. The full-market option requires a real time link between supply and demand, including the markets for storage and transformation. The links to other dynamic markets, as for natural gas and hydrogen in decentralized heat and power generation, are to be open as well. How these may develop is according to very similar governance approaches, there also including storage and peak shaving, and further transformations like to more easily storable liquid energy carriers. Ultimately these are shaped by the same principles, depending on the dominant governance approach.

As other options derive from less full development of markets, the order of treatment is starting with the Market Federation, next the Planning Federation and which then is related to the less supranational options, the Mixed EU and the Re-Nationalized EU option.

A cost-effective market system

The optimal market system links all actors in primary and secondary electricity production with all intermediate and final electricity users, through one single priced market system. One special characteristic of electricity, it flows at near speed of light, requires real time equality between production and consumption, at any moment in time, involving both load equality and frequency stabilisation. In such a situation, real time trading can only be automated electronic trading, with real time acceptance of clearing at time of trade execution. Such trading systems have become possible only recently based on fast communication systems. The organization of markets may be regional, as with current short-term (but not yet real time) electricity markets[49]. They then would have to be aligned through an inter-market super-trade system, with real time clearance as well. Conceptually and effectively such a system would function as a single market. The market would be directly accessible for all electricity producers and users, as legal entities, and would be mainly automated at the technology level. Some producers would have to plan production variation in advance, long term for maintenance, and shorter term based on market expectations. This holds for large system primary production with high marginal costs, like coal, gas and biomass fired power stations. Low marginal costs systems like nuclear will have smaller variation of production only, also for technical reasons. All small scale low marginal costs systems, like wind and solar, will produce fully independently of market prices. Most storage systems and secondary producers have some short term variability in production. End use in industry, transport and private households have widely varying options for variation, also depending the period of adaptation to shortages and excess supply. Electric furnaces may vary use on the very short term on minutes only, while electric car battery systems may have broad flexibility in loading and reloading, depending on time of day and highly variable personal preferences (like: 'not driving my electric car today').

Automated trading is possible only in technology implemented trading systems, at the time of trading independent of personal choices. The supply and demand options of electricity have a next special characteristic: the electricity is distributed through the grid with at any grid module a limited capacity only. Grid development and operation are to be compatible with trade, and unavoidable restrictions in capacity are to be reflected in markets and their prices.

How markets can develop depends very much on the governance situation envisaged. Main lines of market development are sketched for the four main governance approaches distinguished in the CECILA2050 project, WP3.

Market Federation

The market federation has the power to design and implement a real time single price EU-wide electricity market. Institutional design is the prime step, creating the rules for how the market can operate.

1. Institutional Framework in the Market Federation

Designing grid institutions in the market federation

Grid pricing is not aimed at grid funding but on avoiding supply and use disturbances, comparable to congestion pricing on roads for traffic jam avoidance. The grid is publicly

[49] The problems of market organization are analyzed by Ströhle et al 2012, assuming however that markets increasingly will be regionalized, with market power problems to be resolved at that scale level. Here we assume European level market development, least so in the re-nationalization option.

owned and operated according to a set of simple rules. These rules lead to a price specification in real time for use of the grid by suppliers and users.

1. Grid prices are specified in real time for all sections of the grid.
2. There is one grid price per section, equal for all grid users.
3. Price per section depends on the share in its total (unidirectional) use in real time.
4. The grid price P is the sum of all grid section transport prices, with grid section cost (C_s) divided by one minus the section Capacity Use (CU_s): $P_s = C_s / (1 – CU_s)$
5. The supply sections of the grid are those between a specific supply source and the first split off point in the grid, the use sections are all other sections.
6. The supply part of the grid, the part till the first split-off point, is fully paid by the supplier, be it privately owned him or publicly.
7. Grid price for users are specified based on the real time capacity use factor in the distribution grid, rising to extreme prices at near 100% capacity use.
8. Supply in counter-direction to the electricity flow at grid entry is not charged by a grid price.
9. Investment planning for the grid is based on avoiding a close to 100% capacity use factor in extreme peak periods, avoiding black-outs.
10. The capital costs of the grid if not covered by grid transport pricing are funded publicly, from any revenue source.

Designing electricity market institutions in in the market federation

Market creation is by a number of simple rules, similar to trading at public financial markets.

1. There is one real time electricity price for all suppliers and users, also for small scale producers.
2. The real time market is an automatic one.
3. The price is determined by supply and demand, including grid transport prices.
4. There are no special taxes or subsidies on electricity production or use, but there are taxes on climate emissions for producers.
5. Traders are allowed on the electricity market, both at the supply and the demand side.
6. Electricity costs per billing period consist of the time integrated price x volume, paid to the grid operator and to the producers according to their share in production.

Elements not to be covered in in the market federation

There is no public specification of smart meters; appliance requirements; avoided cost subsidies; off-peak subsidies, decentralized-production subsidies, … .

There is no feed-in tariffs (like in Germany and many other countries); price guarantees (as for nuclear power in UK); technology specific subsidies (as in all EU countries); obligatory closing of old installations (as in most EU countries); etc.

Capital subsidies would be useful for speeding up the introduction of CCS and non-fossil energy. Somewhat higher carbon prices are a more logical option in this governance scenario, without capital investment subsidies.

2. Internalization of 'Climate' in the market federation

Emission taxes set at a level to realize climate goals are installed, at predictable (rising) levels towards 2050, and then adapted to goals as set by then. This is mainly independent of the design of the electricity market. These emission taxes are part of private electricity production costs. There may be taxes, subsidies and regulations also for reasons of security of energy supply and because of other environmental issues.

There is no specific reason to consider cost prices in the electricity production markets, as is not relevant in most other markets either. Electricity producers base their investment decisions on expected costs and expected proceeds; that is their role as producers.

3. Basic research in the market federation

There is no basic research needed to develop electricity markets. Applied research on technologies, organizations and contracts are part of private research and development.

4. Infrastructure for public and private use in the market federation

The infrastructure implementation in terms of the electricity grid is by public planning and fully public supply as there is a natural monopoly involved. Natural monopolies cannot be resolved through markets. Building and maintenance of the grid can be done by private contractors but operating the grid cannot. The natural tendency towards monopolistic behavior, keeping capacity down and prices up, can only be counteracted by collective investment rules, like obligatory investments at a certain level of (expected) peak capacity use.

5. Prescriptions overruling market behavior in the market federation

There are no additional prescriptions required for the functioning of the electricity market.

6. Innovation implementation in the market federation

Innovation implementation may be limited, as involving novel contract types and methods for risk reduction for smaller market parties. In terms of technology, some research on power conversion and on dielectric materials for high-voltage systems might be useful.

Planning Federation

1. Institutional Framework in the planning federation

The fully developed real time market is not realized in this governance option. The rules are aimed at steering a number of activities towards specified planning goals, like the share of renewables and nuclear in the electricity market, and rules for smart grid and smart metering.

Designing grid institutions in the planning federation

The main grid is owned by private organizations and partly with public participation, as public-private partnerships. Producers may participate in transport and distribution grid ownership.

The following rules apply.

1. All grid planning is based on public decision making.
2. All grid costs are born by end users.
3. The pricing rules are based on cost funding, including reasonable profits.
4. There is no time differentiation in grid costs allocated to users.
5. In monopolistic/oligopolistic markets as created the owners, also as public-private partnerships, tend to act as monopolists, requiring the permanent development of additional rules to avoid too much rent seeking.
6. Investment decisions for the European main grid are based on detailed grid planning by the European Commission, for the national distribution grids based on national plans dominated by national governments.
7. Access to the grid by producers is based on public rules, transformed into contractual relations between the firms involved, including rules for time specified grid pricing.

Designing electricity market institutions in in the planning federation

Market institutions are developed at the level of specific technologies and behaviors.

1. Producers receive a differentiated price so to incentivize low carbon technologies.
2. Access guarantees for non-fossil energy create stable market expectations for these producers.
3. Price differentiation between different user types is allowed, like lower prices for export industries.
4. Time based price differentiation, as during the day and seasonal, is based on matching to average use, by statistical means; it is not real time pricing.
5. Different traders link user groups to suppliers.
6. Vertical integration is limited to avoid market power of larger parties.

Price guarantees make flexible pricing cumbersome, though not fully impossible.

2. Internalization of 'Climate' in the planning federation

Some form of emission pricing will be established, not covering all emissions and with exceptions for major market powers, like export industries. Emission pricing would be overlapping with price guarantees for non-fossil (like feed-in; price guarantee, price subsidy, in the UK: Renewable Strike Price[50]), creating different incentives for emission reduction in different technology domains related to electricity production, and with uneven costs borne by different electricity users.

3. Basic research in the planning federation

[50] See: https://www.gov.uk/government/news/new-energy-infrastructure-investment-to-fuel-recovery

Electricity supply and demand systems seem well developed. Some research on system design in relation to uncertainty and resilience might be useful, specifically for planning purposes.

4. Infrastructure for public and private use in the planning federation

The implementation of the grid infrastructure is in public-private partnerships, with public participation in private companies and public rules on the operations of these firms.

5. Prescriptions overruling market behavior in the planning federation

The close to monopoly market structure will lead to conservatism in technology development. Novel technologies will have to be forced into the electricity markets. One key element in cost reduction is the prescription on specification of smart meters, to be regularly revised, and prescriptions on their active implementation.

6. Innovation implementation in the planning federation

Novel techniques are to be implemented through public action, like new versions of smart meters, and new versions of flexible use and storage apparatus.

Mixed Governance and Re-Nationalised EU

In Mixed Governance and Re-Nationalized EU, planning will be the predominant mode of governance, with institutions developed along the same lines as those of the Planning Federation. Markets are partial and organized by public bodies and power producers together, with a coordinating role for traders. With more emphasis on country level regulation, and limited supranational power, electricity networks will remain more national, with contractual relations for cross border electricity transport and trade. Trans-European transport will remain limited while flexibility of prices will be more limited. Costs of electricity production will therefore be higher on average for the EU and for most EU countries. Introducing CCS and non-fossil energy will require subsidies, to be borne somehow, further fragmenting electricity markets. A key task for the EU will be the prevention of cost competition between countries, each trying to subsidize its export markets. The currently most advanced Member States climate policies, in the UK and Germany, tend to technology specific planning, see on such German planning, reckoning with mixes of policy instruments, the Renewables Energy Platform (2012).

Summary

In different governance approaches a different set-up of electricity markets will emerge. A mixed governance EU and a re-nationalized EU will have a more fragmented market, both based on planning. The limited integration will allow for a low level of peak shaving, and hence to relatively high system costs. The pan-European Planning and Market Federation approaches have the advantage of substantial transport options with lower cost production and more and lower costs peak shaving options. The Planning Federation adds a substantial amount of peak shaving based on time-specified contracting. The liberal Market Federation option can create most cost-advantages, with real time market clearance established.

The two International Federal options can most easily and effectively integrate carbon pricing into electricity markets. The Mixed EU and the Re-Nationalized EU will tend towards subsidy systems like feed-in tariffs, not easily amenable to flexible pricing systems.

Annex 2

Instrument building blocks for road transport policy in four governance scenarios

Instruments for person car transport: from fleet standards to generic pricing

Gjalt Huppes

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Sectoral Policy on Road Transport: Why and How?

Different governance scenarios lead to different instrument building blocks, with more technology specific actions for more planning oriented and for more national oriented types of governance. In a sectoral analysis road transport is a major cause of emissions directly and also indirectly related to the production of cars and infrastructure.

For climate policy, detailed policy instruments for road transport have been developed, with a focus on fleet standards, both in the US and the EU. The logic for such physical regulatory measures may seem compelling: what you regulate is what you get. However such convictions might better be based on a comparison of options, and on an analysis of the mechanisms they set in motion, also reckoning with mutual interferences of overlapping instruments. Such instrument options will differ depending on the governance style envisaged. In line with the main document, we distinguish four long term governance approaches for the EU, the Market Federation; the Planning Federation; the Mixed System; and the Re-Nationalized Approach. Starting from these approaches, different instrument options emerge, each with different domains of application and where the domain is limited, with additional instruments to fill the gaps.

More encompassing instruments, not just focused at road transport, may already cover all or part of the road transport sector, as now is the case for some upstream activities like steel production and refineries falling under the ETS. Cap-and-trade systems, like the EU-ETS, may be set up broader so as to also cover road transport emissions, as is assumed in the Planning Federation. The ETS could be adapted for that purpose, to apply upstream at production and import of gasoline, Diesel and LPG, or even more upstream, at the inputs to refineries, or even further, at the primary production and imports of fossils energy carriers. Then all emissions by car fuel use and all emissions related to electricity production for electric and hybrid cars, and all upstream emissions for car production and infrastructure production would be covered. In the planning federation, application of the price stabilized and domain expanded ETS is with the companies providing fuel to the cars. Similarly, a carbon tax at primary extraction and imports of fossil energy would also cover all direct and indirect emissions of road transport. Between all-covering carbon pricing and sector specific fleet standards lies a broad domain of intermediate options. Before looking into these, from the different governance perspectives, it is good to see which mechanisms are relevant for emission volumes, and how these might be covered by typical instruments. First however there are some data on the divergence between fleet standards and actual fuel use per average car in the fleet. These do not cover effects on the volume of the fleet or the driving distance per car per year.

Fleet standards and actual use

Fleet standards are measured in laboratory situations, referring to a car type but not to specifics of the car used in measuring. Such a car may be treated for lower air resistance, by filling slits. It may be without energy using additions, like broader tires, and it may be weight reduced. Such static differences are not so relevant in the long run. Such elements are not part of the discrepancy described here.

More relevant is that car producers adapt their designs to the test procedures, not to actual driving conditions. Air disturbances like side winds, higher speeds performance, electrical appliances all contribute to overall performance but are not part of the test.

Most relevant is that there are many more mechanisms determining driving behavior in a given fleet. A fleet standard does not influence the cost of accelerating and driving fast. They don't cover the decision on modal choice, taking the train, tram or bicycle.

There is disturbing dynamic difference between fleet performance standard and actual performance of the same fleet, relative to a base year. The data in figure A2.1 are based on German fleet data, gathered by Spritmonitor; see Mock et al (2012). They give the percentage reduction in the average CO_2 emission value of new passenger cars in Germany since 2001 according to different data sources: manufacturers' type approval values (weighted by number of user entries in *spritmonitor.de*), values reported by spritmonitor.de users (same weighting as for manufacturers' values) and official CO_2 monitoring data. Similar deviations for type-approval vs. real-world values were also found for non-CO_2 emissions; see for example, Carslaw (2011) on UK data. The disconnection between fleet standards and emissions shows more clearly in a broader data set by Mock et al (2013), see figure A2.2. Especially the most relevant UK and German data (15.00km/yr) show a fast growing divergence. Such short period and partial comparisons have their drawbacks. Ideally, the full fleet, all ages, would be covered with a decomposition of factors determining dynamic development. For example, fuel prices have risen in the period covered by the ICCT studies, contributing an emission reduction independent from fleet standards effects.

Figure A2.1 Actual and norm emission data for the German car fleet, 2001 to 2010

Source: Mock et al. (2012)

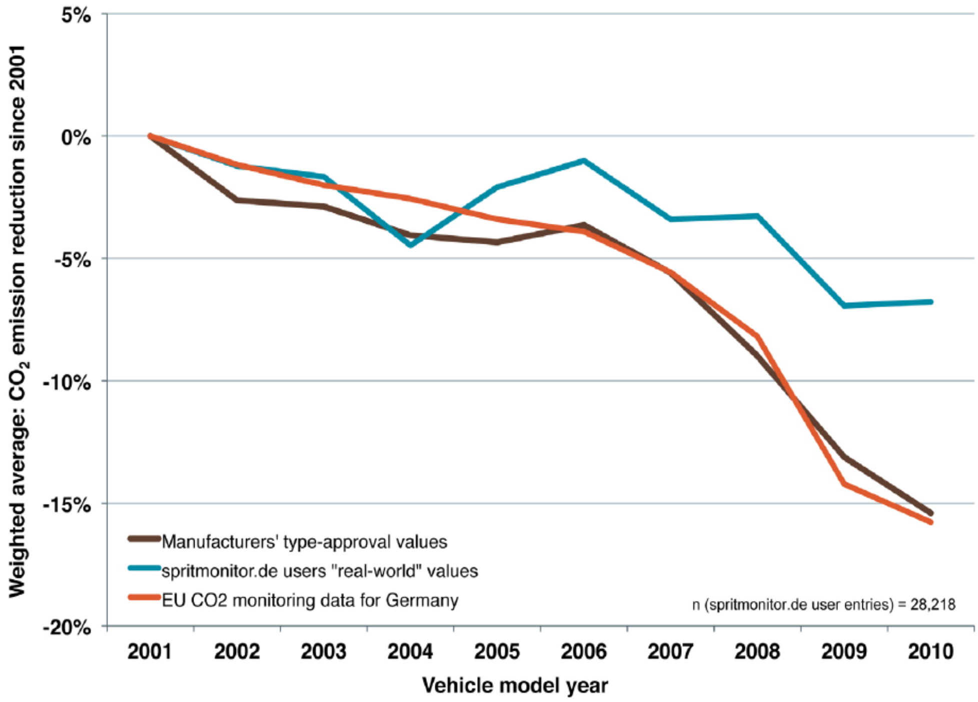
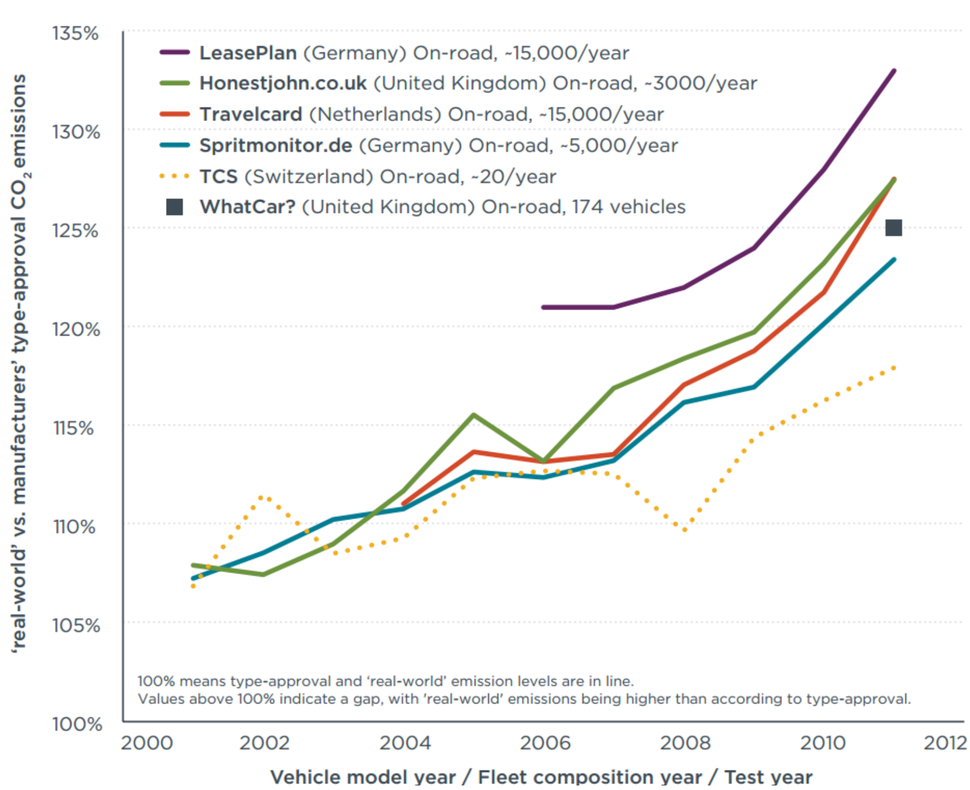


Figure A2.2 Actual emissions with equalized fleet relative to norm emissions of that fleet (= 100%)

Source: Mock et al (2013) page i



Mechanisms determining road transport emissions

Direct emissions from road transport come from the car exhaust of each combustion vehicle. Per vehicle, it is the technology, the driving style and the driving distance which determine fuel use and emissions. The driving style covers elements like speed, acceleration, and stationary fuel use. For the fleet, there are several system characteristics which further determine fleet emissions. The fleet size and structure are major ones, covering types of cars, the share per type in total kilometrage, and (overlapping) the age of the fleet, especially important in case of technology dynamics. The fuel composition is a determinant of emissions as well, with shares of biofuels as a key variable, and other (partly) fossil fuels coming into the market, like natural gas, hydrogen, electricity etc. Finally, the total of kilometers driven is a main determinant of fleet emissions. Production of cars and end-of-life handling also require energy and emissions , higher for electric cars than for combustion drive cars. From a still wider systems view, a change in car transport can be related to other activities and their emissions. A modal shift from car transport to a mix of rail and air transport detracts from the realized emission reduction in road transport. Other dynamics may have a long term influence as well, like infrastructure development. Cheap gasoline in the US, roughly half the price compared to Europe and Japan in the last half century, has led to larger cars, larger distance shopping malls, less compact spatial planning, and larger commuting distances, with roughly double fossil fuel use. Redressing that, as through higher gasoline prices, also requires substantial changes in urban infrastructure, away from car transport and with more integrated higher densities of activities and lower commuting distances. Urban planning can work the other way directly, allowing for closer to home shopping, with lower traffic emissions. Railroad and bus infrastructure, carpooling, and working at home or close-by may all contribute to less traffic, while causality may work the other way as well: more expensive road travelling will reduce traffic volume by such mechanisms.

Other dynamic elements relevant for emission reduction may relate to lock-ins. The combustion engine has been improved for a century, and –due also to regulatory efforts like fleet standards - is still improving substantially. The lock-in will therefore be strengthened with current fleet standard policies, requiring stronger additional policies to induce a shift to electricity as energy carrier. Other dynamic mechanisms may seem farfetched but should be kept in mind. Top of the market hybrid cars can accelerate much faster than their plain combustion sisters, possibly setting a trend: 2-ton vehicles now can accelerate to 100km/h in less than 5 seconds. Similarly, the SUV has been an escape route for fleet standards in the US[51]. It has been marketed aggressively, becoming the major profit engine in US car industry

[51] In the US the CAFÉ standards, the first use of fleet standards instrument, was introduced in 1984. CAFÉ differentiated between Utility Vehicles, including SUVs, and cars for person transport with lower allowable fleet emissions, with the Utility Vehicles next becoming the

for 2 decades. Such aggressive marketing, with elements like a focus on safety for wife and children, has set the full fleet moving towards that high energy type of heavy cars. Having the hybrid power, the human urge towards driving faster is easier to accommodate, with pressure on authorities to increase speed limits.

Whatever the exact nature may be of such mechanisms, and how they work out dynamically on emissions is difficult to establish. A rough indication is based on studies comparing fleet standards with more encompassing financial incentives; see Anderson et al (2011) for a survey. The same amount of emission reduction would cost twice as much for fleet standards as compared to a carbon tax, a number of studies show, using different methods. These studies cover only a limited number of other mechanisms. They surely don't reckon with perverse mechanisms, like giving a Fiat 500 as a present to the Maserati buyer, to get the fleet standard back in the right direction. The difference in overall gasoline use between the EU and Japan vs the US points in the same direction. There has not been any difference in available technologies, so pricing and related mechanisms would ultimately explain the high gasoline use in the US as compared to the EU and Japan.

Next to direct emissions there are upstream emissions in fuel production and in car and infrastructure production and maintenance. The non-use stage in combustion person cars is around 10% of the use stage, higher for electric vehicles (Hawkins et al. 2013). For infrastructure no reliable data are available. However, the global build-up of infrastructure to Western levels will require more than the carbon budget corresponding to the 2-degrees target (. These non-use sectors may be covered by generic pricing instruments also covering car use, equitably, and by more specific sector policies there, with possible overlaps and gaps. The current ETS covers some of these upstream activities, like steel making and refinery emissions, but not most of the other activities in the chain. In the electricity sector, high feed-in tariffs for renewable electricity production, increase the costs of electricity and so strengthen the lock-in on the combustion car. In most countries feed-in tariffs now are low. German feed-in tariffs are so high as to have a strong effect on electricity prices, raising them by more than 7 cents per kWh. They thus contribute to the combustion engine lock-in, but do so in Germany primarily.

For the dynamic improvement of long run performance, setting in motion a most broad set of mechanisms seems essential, with incentives and costs proportional to ultimate emission reduction induced.

Carbon pricing versus fleet standards

The main comparison here is between carbon pricing also covering road transport as against physical regulation as in fleet standards. How do they differ? Several behavioral mechanisms

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most common car type in the US. The European fleet standards cover vans as well but still have to make a boundary where the fleet stops, e.g. vans also used or usable for person transport, buses, etc.

are covered by direct carbon pricing and not with fuel standards. First, the standards should not close down major car producers, so they are a bit under the average of all companies together and then only slowly becoming more stringent. This means that some companies with a profile with smaller cars can adapt their fleet, taking over some market share from producers of high emission cars, or high end producers can acquire small car brands in their fleet. This induced behavior has costs without emission reduction. These costs may be lowered by additional rules as on credits per type, transferable by the company or tradable between companies. Second, the fleet size will shift, as small cars will be sold more, with higher numbers of cars per family/person. Third, the share of high emitting cars in total kilometrage may rise, relatively, as the small car may be used less. Fourth, the fleet standard does not give an incentive for car drivers to adapt their driving style. Driving sportively and fast makes a substantial difference in fuel consumption. Additional legislation may cover some elements of driving style, but only as maximum speed limits. Fifth, the standard does not create incentives for a modal shift in transport, as from shopping by car to shopping by bike or walking. So sixth, physical fleet standards will not support long term developments in physical planning will not support such modal shift choices, as with distance to supermarkets being higher. Such effects can be seen in cheap gasoline countries like the US, as compared to Europe and Japan. The behavioral choices not covered by the fuel standard cannot easily be covered by additional instruments. Lower speed limits are a main exception. Finally the fleet standards don't cover the non-use part of the life cycle and they don’t cover the road infrastructure, together a substantial and rising part of person road transport emissions. Most deeply, they don’t cover possible problem shifting through indirect effects like increases in air short distance air travel.

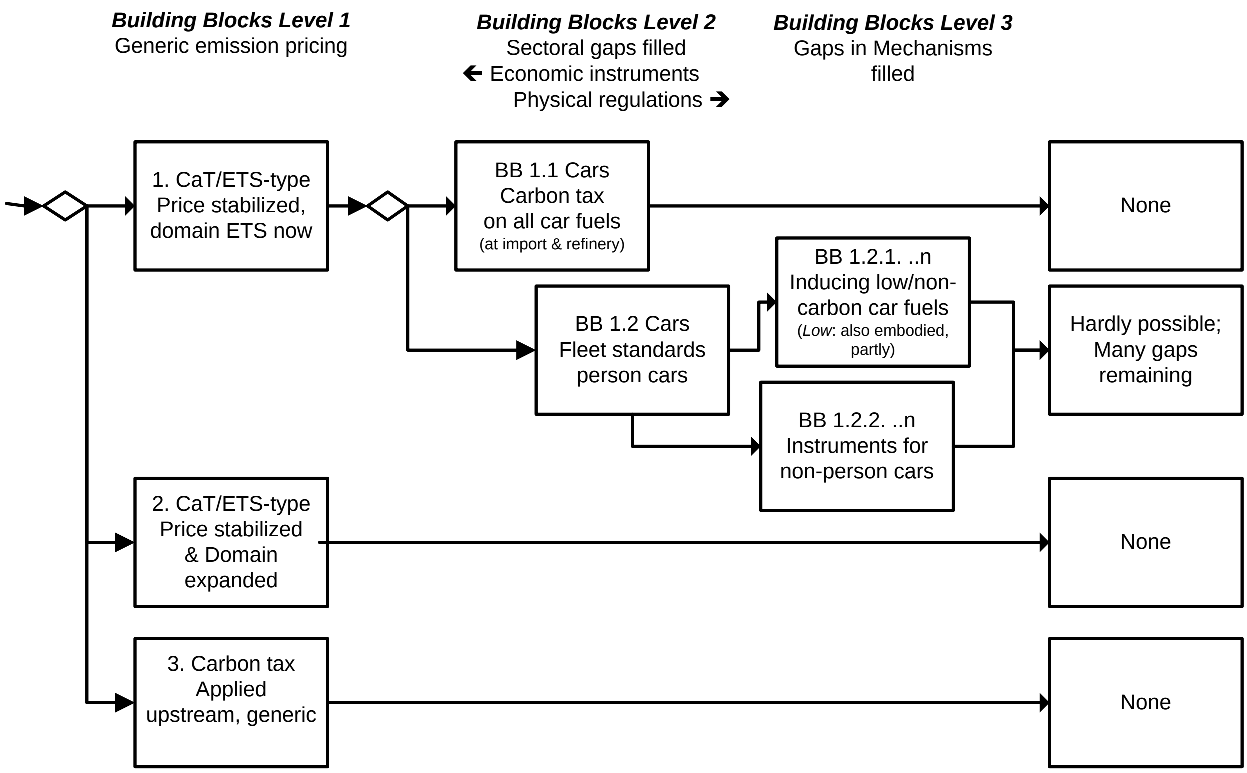
General carbon pricing can apply to all emissions related to car driving, not only covering the use stage but also the full emissions in the life cycle of the car including maintenance, the emissions related to infrastructure production and maintenance, and the emissions related to shifting behavior to other transport modes and to other ways of spending income.

There are different instrument options to cover car driving emissions. A carbon excise on fossils based fuels is one option, possibly in parallel with a cap-and-trade system not applied to Diesel and gasoline fuels. It is administratively easy but politically more vulnerable than other options. The second option is to enlarge the ETS cap-and-trade domain to also cover CO_2 emissions from cars. This can be done through upstream application, administratively similar to the excises option[52]. The carbon price would not be road transport specific, equal for all under the system. This reduces political vulnerability. The carbon tax on primary fossil production would be the most generic option, covering all fossil based emissions equally. The comparison in the literature between carbon pricing and fleet standards does not differentiate between these different carbon pricing options. See figure A2.3 for a decision

[52] There is a fundamental difference in combining with other instruments to reduce emissions. Adding effective fleet standards would only free allowances, to be sold to non-car transport uses, not leading to a net emission reduction.

tree, referring to direct emissions only, not the production of cars and the construction and maintenance of infrastructure.

Figure A2.3. Decision tree on instrument building blocks for direct person car emissions



There is extensive empirical analysis on the comparison between carbon pricing and fleet standards, covering only the use stage. The empirical analysis on mechanisms induced by these two instruments does not cover the modal shift and further indirect mechanisms. However, the comparison between direct CO_2 emission pricing through fuel prices and implicit pricing through fuel standards already indicates that the cost for a given emission reduction of the total fleet are two to three times as high for fuel standards, see the summary paper by the editors in Anderson et al. (2011). From a regulatory point of view, the lack of differentiation between fossil and non-fossil fuels (including electricity) in the fleet standards is to be resolved by additional regulations. It cannot be seen from the composition if ethanol, hydrogen or electricity to which extent they are based on fossil fuels, directly or indirectly. The options vary as to technology and location and range from near zero percent fossils to over one hundred percent fossils. This holds not only for hydrogen and electricity but also for biofuels, see Kaufman et al (2010) for a survey also of methodology issues. A broadly applied carbon tax would not create that additional regulatory problem. Upstream emissions would be covered by the generic carbon pricing or more limited carbon pricing, with supplementary up source carbon tax on fossils. The emissions price would show up in the cost price of for example hydrogen for fuel cells and the ethanol price for biofuel. If biofuels next are also subsidized, this price information is lost.

A survey of some mechanisms covered by different building blocks is in Table A2.1.

Table A2.1 Mechanisms covered by instrument building blocks for person car transport

Generic pricing:	**Price stabilized cap-and-trade, limited domain** **For: Re-Nationalized EU**			**Price stabilized cap-and-trade, limited domain** **For: Mixed System**			**Upstream Carbon Tax / Domain extended & price stabilized ETS** **For: Market + Planning Federation**		
Sector & Building block:	**Car Sector Building Block 1: Carbon taxes on car fuel, additional**			**Car Sector Building Block 2: Fleet standards**			**Car Sector Building Block None: No gaps, no additions**		
Gaps / side effects	**Covered Fully**	**Covered Partially**	**Gap Remaining**	**Covered Fully**	**Covered Partially**	**Gap Remaining**	**Covered Fully**	**Covered Partially**	**Gap Remaining**
Fleet size	Yes	--	None	No	No	Fully	Yes	--	None
Fleet structure	Yes	--	None	No	No	Fully	Yes	--	None
Fleet driving characteristics	Yes	--	None	No	No	Fully	Yes	--	None
Fleet driving volume (incl. carpooling)	Yes	--	None	No	No	Fully	Yes	--	None
Buy smaller lower fuel use car	Yes	--	None	No	No, counter	Fully	Yes	--	None
Older inefficient cars off the fleet	Yes	--	None	No	No	Fully	Yes	--	None
Driving style: acceleration	Yes	--	None	No	No	Fully	Yes	--	None
Driving style: speed	Yes	--	None	No	More speed limits	Partially	Yes	--	None
Other 'non-car automobiles ' not covered / induced	Yes, if domain expanded	--	None	No	Broader standards domain?	Mainly	Yes	--	None
Modal shift to non-road transport	Yes	--	None	No	No	Fully	Yes	--	None
Shift to lower embodied carbon fuel	Yes	--	None	***Adjoining instruments*** ***Needed. Data?***	Premiums non-fossil cars, tradable	Very partially	Yes	--	None
Shift to non-combustion cars									
Solar panels for battery loading	Yes	-	None	No	No, counter	More than fully	Yes	-	None
Move closer to work	Yes	-	None	No	No, counter	More than fully			
Infrastructure for other modal mix	Yes	--	None	No	"Going against the market"?	Partially	Yes	--	None

Costs of regulations with similar effectiveness

Whatever the exact nature may be of all mechanisms related to car driving emissions, and how they work out dynamically, is difficult to establish. A rough indication is based on studies comparing fleet standards with more encompassing financial incentives. See Anderson et al (2011) for a survey and Parry for a broader econometric analysis. These comparisons do not cover all mechanisms, leaving out for example spatial planning and an increase in the number of cars. These studies don't reckon with perverse mechanisms coming up, like giving a mini-car as a present to a 500 horsepower hybrid racing machine, to get the fleet standard back on track. Within that slightly limited domain, the same amount of emission reduction would cost twice as much for fleet standards as compared to a carbon tax, a number of studies show, using different methods. The difference in overall gasoline use between the EU and Japan versus the US points in the same direction: gasoline in the EU and Japan has been roughly double price in the last decades compared to the US, with gasoline use per person being half the US amount. There has not been any difference in available technologies, so pricing and related mechanisms would ultimately explain this high gasoline use in the US as compared to the EU and Japan.

Instrument building blocks relevant for road transport, per governance scenario

Market Federation

The market federation has an encompassing carbon tax as the generic climate policy instrument, covering road transport emissions as any other emissions. It is applied upstream on primary fossil production and fossil imports, with Border Tax Adjustments on products with a high emission profile. It covers all mechanisms in road transport, except public infrastructure and some standardization issues, and maybe not all dynamic aspects, including some lock-ins. Relevant for a shift to electricity in road transport is the key institutional development of a real time electricity market, allowing car batteries to load and unload so as to make a profit for their users and peak shave electricity use.

Public road infrastructure is optimized by congestion road pricing in the busiest areas, helping reduce traffic emissions by reducing traffic volume. Real bottlenecks are resolved, to avoid extreme prices and the social cost of not having adequate transport, also reckoning with other transport modes. London and New York have very limited private car transport, but an extremely effective public transport and taxi system.

The price level of the carbon tax translates into a cost contribution for fossil fuels in road transport. A price of 50€ per ton CO_2 translates into a cost contribution of 0.13€ per liter of

Diesel, and one of 500€ per ton into 1.34€ per liter[53]. That is roughly double the current European price level of Diesel, and a similar increase for gasoline.

Table A2.2

Instrument Building Blocks Road Transport for the Market Federation summarized

1. Institutions	Real time transparent single price electricity market
2. Carbon pricing	Upstream carbon tax covering also all transport fossil fuels
3. Infrastructure	Public ownership and development of: roads; electricity transport, pricing capacity use oriented; standards for energy transport systems; ??
4. Research	Basic research only, as on decentralized intelligent systems; nano-technologies
5. Technologies	None ??
6. Technology Implementation	Some (mainly regional) try-outs of novel systems, creating initial learning curves

Planning Federation

The planning federation has a domain expanded ETS type cap-and-trade system, with stabilized prices, adapting volumes so at to arrive at prices which also create dynamic incentives. The domain expansion covers car fuels. He price of allowance (emission permits) will tend go down during recessions and due to other emission reducing measures like high renewables feed-in tariffs and demanding fleet requirements. Reducing the number of permits brought on the market can keep the price above a stated lower limit. The allowance price may go up when economic growth surges, with additional allowances brought on the market to prevent short term economic losses. For car users, these changes will be reflected in changing gasoline and Diesel prices. Such a price stabilized cap-and-trade system moves in the direction of a carbon tax possibly with a more limited domain of application and with a different administrative set-up. Bringing road transport under the system (and similarly for aviation and water and rail transport) is done at the level of fuel production and imports, possibly with exemptions as for fuels used in a competitive domain or in exports. Uniform allowance price levels throughout the EU result from allowance trading between sectors and countries.

As the planning federation has effective implementation capacity, the price-stabilized cap is a real cap. There then is no banking required as the EU trading body functions as a bank already, and there are no reservoirs left from past over-allocation. Planners could leave it at

[53] CO_2 emissions per liter of diesel burnt (kg) = 2,67. Source: U.S. Environmental Protection Agency. Emission Facts: Average Carbon Dioxide Emissions Resulting from Gasoline and Diesel Fuel.

that market based solution. That is not probable however, as planning needs control, by specifying not just emission targets but also the means of getting there, aligned with other goals. Transport policy will be a separate planning domain, linked to other domains, with climate concerns built into it.

Though emission pricing may start to be similar, the planning approach will tend to diverge from the liberal market approach. There will be more road building than in the Market Federation to resolve congestion problems as they come up. There will be adjoining measures to have a forced introduction of the (expected) most relevant non-fossil drive technologies. These technologies concern drive technologies like (hybrid) electric cars, methanol, hydrogen or ammonia cars, or still other power systems. There will be active choices on forcing non-fossils into the transport market, including those based on wind and solar power. Infrastructure for new energy carriers for road transport will actively be developed and implemented.

The near stable rising price level of the allowances is aimed at the same overall emission target as with a Market Federation, both aimed at remaining within the 2-degrees future. What exactly that price level will be is uncertain however, as private parties do not know the options of all other private parties. A higher allowance price would be required in each period to have the same dynamic effect as the emission tax. The additional planning measures, assume to be effective in the Planning Federation, will however by necessity lower the price of allowances. The lower price reduces incentives for low carbon transport systems further, also in the short term. Together these mechanisms may be difficult to align towards the 2-degrees emission reduction target. The lower incentive for long term low emission systems also leads to higher requirements on public support for long term R&D. Basic research in the Planning Federation will be focused more on the shorter term than in the Market Federation. The choice of transport system and its energy supply will therefore be much more a public one than one coming from market forces. The risk of lock-ins will be higher, leading to higher costs if left in place, and also higher cost to amend wrong choices, if that would be possible. Overall, the costs of equal emission reductions in the transport sector will be higher in the Planning Federation than in the liberal Market Federation.

Table A2.3

Instrument Building Blocks Road Transport for the Planning Federation summarized

1. Institutions	Rules on public-private partnerships
2. Carbon pricing	Price stabilized cap-and-trade, domain expanded, also covering road transport
3. Infrastructure	Private and public-private partnership and development of: roads and electricity transport; pricing funding oriented
4. Research	Research tending to R&D for planning needs
5. Technologies	All transport relevant technologies subject of regulation, especially using subsidies and prescriptions;
6. Technology Implementation	Some (regional) try outs of novel technologies and systems, creating initial learning curves

Mixed System

In the mixed system, the overall planning capacity of the EU remains limited as Member States will limit the regulatory power of the EU. A price stabilized cap-and-trade system with agreed upon predictably rising prices will not emerge. Only incidental emergency measures will be taken to prevent of full breakdown of the ETs. Also the domain expansion of the ETS will not come about so as to cover the road transport sector. The ETS will therefore be a burden on grid electricity using cars only, requiring stronger measures to get such non/low fossil transport on the road. For the 2-degrees emissions target in 2050, fossil fuels will ultimately have to be substantially abandoned, replaced by other systems. The EU can play a partial role only in the Mixed System, as a main difference with the Planning Federation is the independent role of Member States in climate policy. The EU will play more a coordinating than a planning role. As car markets are pan-European, the car types will be the same, but with different fleet compositions within countries also due to national policies. The incentives for introducing low-carbon transport will differ per country based also on non-car policies. Currently, electricity prices in the EU range from 0.12 to 0.28 Euro per kWh, including the minor cost of ETS. The highest prices are in Germany, making the shift to non-fossil traction most difficult there. EU fleet standards remain in the administrative realm of the EU, with member states safeguarding the interests of their industries as much as possible when next steps are to be made to move to the much reduced 2050 emission target.

The assumption here is that climate policy will be effective, how overtly optimistic this may sound, also covering substantial reductions as from road transport. The role of biobased fuels is limited in all governance options which reach the 2-degrees target, as heavy emission reductions require CCS in biomass use, possible only with centralized incineration. Getting all hands on deck will imply different cost of emission reduction in different sectors. For car transport, the national policies will have to compete with EU fleet standards or are to be complementary if they are to play a role in EU emission reductions. For complementarity they may be focused at ancillary measures on mechanisms not covered by fleet standards and not by the (adapted) ETS. Some direct regulations are possible, like speed limits. National taxes can be varied to introduce specific car types, like has been done in the Netherlands where hybrid cars received a substantial market share through tax rebates. Such subsidy policies are well possible at a national level, though implying a rise in other taxes. Also public infrastructure for low-emission road transport can be developed, like driverless road systems and public transport and including the infrastructure for novel energy carriers. The sum-total of all national policies and EU policies will have to deliver the “80% emission reduction”. As EU policies regarding road transport are relatively weak in this scenario, stronger national policies will have to do the job.

Table A2.4

Instrument Building Blocks Road Transport for the Mixed System summarized

1. Institutions	Norms on public-private partnerships safeguarding some competition; ..
2. Carbon pricing	Price stabilized cap-and-trade, limited domain, not road transport; national

	carbon taxes on car fuels added to fuel excises, not linked to cap prices
3. Infrastructure	Private and public-private partnership and development of: roads and electricity transport, pricing is funding oriented; standards on technologies like safety, mutual compatibility of systems
4. Research	Research tending to R&D, little basic research
5. Technologies	EU fleet standards with limited dynamic pressure; National deviations from international developments to create advantages for special national competencies
6. Technology Implementation	Limited advisory role EU on implementation; Most implementation technologies oriented based on creating national advantages in a transnational business surroundings

Re-Nationalized EU

In re-nationalized climate policy, the role of the EU is reduced, relative to the Mixed System. The EU cap-and-trade system has collapsed under the pressure of effective national policies, as are assumed here. The EU power is derived not so much from the political processes in EU parliament and the European Council, but through transnational powers playing a larger role. Car industries have merged internationally and empower EU action where divergent national policies are too costly and lead to competitive disadvantages relative to non-European producers. Agreements on fleet standards lag behind real life developments. National policies are linked to main industries, but the competing nations look for prime mover advantages. Betting on where they think they have such an advantage, they force their national industries and their markets into the desired direction. The advent of driverless cars as promoted by Google gives an idea of how this might work, with countries like Denmark and the Netherlands subsidizing such development and taking away legal and procedural barriers in order to come first.

This governance scenario has a lower plausibility for 2-degrees climate success than the other ones.

Table A2.5

Instrument Building Blocks Road Transport for the Re-Nationalized EU summarized

1. Institutions	Coordination between national rule systems; rules for agreements on international cooperation; prevention of non-market trade restrictions in EU; ..
2. Carbon pricing	Agreements on coordination between national pricing systems, advisory only; many national systems based on prime mover advantage motives; national carbon tax on car fuels party replacing fuel excises; increases in excises limited by inter-country competition; ..
3. Infrastructure	National Private and public-private partnership and development for roads and electricity transport; advice on supranational grid design; ??
4. Research	R&D, scattered, no systems view; subsidized competitive attraction of big

	industries development teams; ..
5. Technologies	Fleet standards with little impact; all partial technologies subject of public policy, different in different countries, from R&D to implementation
6. Technology Implementation	Fully national implementation of limited scope technologies in a transnational business surroundings

Looking for economic instruments first, the fuel excises could be raised by the level of the carbon tax, rising each year. This building block could be well aligned with the coverage of the cap-and-trade system, for example applied at all fuels coming from refineries and at all fuels imported (minus those fuels covered by the cap-and-trade system, as on air transport). With this addition, car driving could effectively become part of the generic carbon pricing system. All behavior related to car driving would then be covered in the same way as with domain expanded cap-and-trade and with upstream carbon taxes. The second option for economic instruments is to implement encompassing road pricing, preferably differentiated as to the emissions per type of car involved. Differentiation as to speed, so as to cover speed dependent emissions, seems one bridge too far. Also, a tax on kilometers driven per year based on car administration would work out very similar. A next option, still farther away from driving behavior, would be a tax on car purchases equal to the expected life time emissions of the car. The expectation can be based on past experience with similar cars, like as heavy, as powerful, or same fuel use per kilometer. The actual number of kilometers driven, nor the driving style, would be reflected in the tax. The tax could be paid per year, based on expected emissions per year of each car type. The interesting thing to note is that most of these taxes already exist, though not related to CO_2 emissions goals but mainly for public budget purposes.
The final instrument considered is based on physical regulation: the technical emission requirements. The expected emissions per car type are specified as the basis for this instrument. The requirement next is specified for a fleet of car types as sold by one brand or one car producer. The fleet specifications may for all cars used for person transport, or differentiated as main uses.

Conclusions

The set-up of building blocks referring to person car transport is substantially different in the different governance scenarios. The Market Federation and the Planning Federation align with the mainly transnational supply and development of person cars. In these governance scenarios carbon pricing is set up so as to also cover road transport. In the mixed system, the ETS does not cover person road transport, with fleet standards as the main mechanism, with substantial costs for consumers. In the re-nationalized EU it also is fleet standards as sectoral instrument, but less strict versions implemented by the EU and some stricter standards nationally.

Overall, the federal market and planning systems cover substantially more mechanisms, and realize the same emissions reductions at much lower costs, cost being more than halved in the long term. In terms of implementation in the sector there is one difference between the federal options. The market federation has its implementation fully upstream, before the refinery, while the planning federation applies the cap and trade at the companies delivering fuel to cars, gasoline, Diesel and admixtures of these with renewable fuels, at the same level as where current “old” excises are applied. The planning variant may therefore be more vulnerable to lowering of current excises, then requiring somewhat higher allowance prices.