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■ policy analysis

Strategic design of long-term climate policy instrumentations, with exemplary EU focus

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The Paris climate goal requires unprecedented emission reduction, while CO_2 concentrations are now rising faster than ever. Internally inconsistent instrumentation has developed on the go, not fit for deep reduction. Mainly national technology-specific instruments, for example, have made the EU pure cap-and-trade system superfluous and have fragmented electricity markets. Systematic instrumentation design requires an adequate categorization of instruments, newly developed here for that purpose. This instrument ordering links to generality and bindingness. Starting points for any instrumentation design are sparseness, completeness, and non-overlap. Details in instrumentations may further depend on specific circumstances in different countries and regions.

Planning & Control starts with technology-specific instrumentation, with subsidies and standards to reduce fossil emissions in electricity production; effective Fleet Standards for transport; dynamic standards and permits regarding industry emissions; and standards and technology subsidies squeezing out fossils use in buildings and appliances. Subsidies create learning curves. Consistency and effectiveness tend to require centralization.

Institutionalism uses two core institutional instruments. A comprehensive upstream emission tax with proceeds to the country or state level creates incentives. An open-to-all, real-time priced electricity market enables also small-scale renewables and secondary producers on the grid. Infrastructure is provided publicly. A level playing field results for mostly decentral climate action, both public and private.

Policy relevance

Technical instrument choices may seem neutral but cannot be so: policy is about choices. Two governance strategies are now mutually competing and counteracting. *Planning & Control* links to welfare theory and optimization, with broad integration of several policy goals, measurable targets, and deep public–private cooperation. *Institutionalism* has a background in history, economics, sociology, and political science, with institutions driving long-term development. Incentives and option creation are central, indicating results only roughly. There is strict public–private delimitation. These different views on governance lead to mutually exclusive sets of instruments. Explicit instrumentation strategies are required for consistency, effectiveness, and legitimacy. Internationally, *Planning & Control* requires binding country caps for (almost) all countries, UN-type. *Institutionalism* requires a limited agreement on a high rising emission tax, open for all countries to join a starting group, WTO-type. Choices are ultimately based on governance preferences.

Keywords: carbon deposit; climate governance; emission tax; instrumentation strategies; legitimacy; real-time electricity market

1. Introduction: why strategic instrumentation design?

Climate policy has developed in many countries since the Kyoto Protocol (1992), with different instruments added on the go. Global CO_2 concentrations have risen seemingly undisturbed however, with

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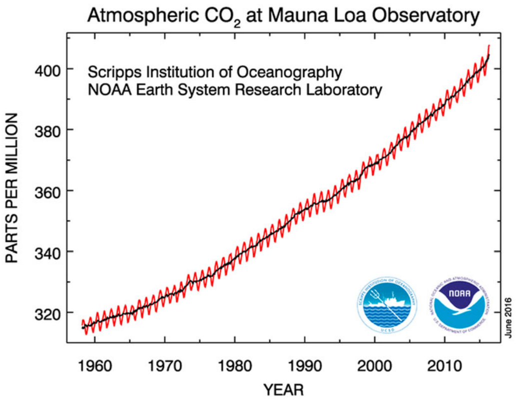

FIGURE 1 CO_2 concentration at Mauna Loa, Hawaii
Source: http://www.esrl.noaa.gov/gmd/webdata/ccgg/trends/co2_data_mlo.png, downloaded 9 June 2016.

that in 2015 being the highest rise ever (see Figure 1). The United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement now intends to limit the temperature increase to preferably 1.5°C, requiring near-zero emissions by 2050. A reduction in CO_2 emissions by only 90% implies a reduction rate of 6.5% per year, if starting now. Globally there was a rise of 2.4% per year, requiring a reversal of 9% per year. From 2000 to 2014, EU28 reduced emissions by 1.2% per year (see EDGAR, 2016), with similar US reductions. Chinese emissions rose by 7.4% per year. The EU and US reduction was supported by increasing high-emission imports as from China (Davis, Peters, & Caldeira, 2011; Peters, Minx, Weber, & Edenhofer, 2011) and a large recession. Climate policy in the last decades did not make a dent in ever faster rising CO_2 concentrations.

Deep reconsideration of climate policy instrumentation seems due, with strategies for long-term effectiveness also for broader governance reasons (see Howlett & Lejano, 2013). *Act now*, practically, for reasons of urgency, hides incompatibilities in instrumentation, detrimental to long-term success. The focus here is on fossil CO_2. Instrumentation for other greenhouse gases such as methane and nitrous oxide will be different as these emissions are hardly measurable in relation to activities. Fossil carbon emissions can be measured indirectly only but precisely: fossil fuels extracted will be emitted.

A well-considered design, thinking before doing, may ultimately be most effective and efficient, avoiding incompatibilities, aligning instruments, and reducing risks as on delays. It is incoherent to have substantial national climate policies like feed-in tariffs and premiums for renewables and nuclear energy, and closing of coal-fired power stations and emission standards in electricity production, and at the same time have a pure cap-and-trade system to reduce these emissions in the coming decades. A long-term predictable price signal, required for long-term efficiency, will not come with cap-and-trade, due to the inelastic supply and demand for emission permits. Under a pure cap system, such technology-specific instruments will lower permit prices, not emissions (see Sijm, 2005, Goulder & Schein, 2013), with Hood (2011, p. 38ff.) suggesting therefore to leave the pure cap system. Production subsidies for electricity now partly set producer prices, different for different producers and paid for differently by different users. Similar holds for net-metering for incentivizing solar PhotoVoltaics (PV). Such fixed prices, however, cannot fund secondary electricity production as from decentral battery storage. Also, one cannot have an EU-level cap-and-trade system and at the same time have a clear national emission responsibility, as permits can be traded between Member States, and similar between regions in the US and China. Such contradictions might be resolved to some extent in a practical short-term approach, like incidentally adapting the cap-volume as in the EU, based on *satisficing* reasoning (see Grubb, Hourcade, & Neuhoff, 2014). Deep transformation requires strategic choices for consistent instrumentation. Focused here at the EU and Member States, strategic design of instrumentation is as relevant for countries like China, Japan, and the US, with their States and Provinces.

Should climate policy focus on specific technologies or rather on generic incentives? Such strategic choices link to different instrumentation designs, and these in turn to strategic developments in society: they are governance choices. Industrialized market-based society did not develop just technically, but has evolved through political clashes, ranging from the Corn Laws in the UK to the liberal, socio-democratic, corporatist, and communist versions of industrial society in the 20th century. The governance strategies developed here remain within the boundaries of a market-based industrialized society with substantial public tasks. Other political views, like conservative neo-liberal or anarchist anti-capitalist, might link to other instrumentation options. Relevant climate governance strategies now are *Planning & Control* and *Institutionalist*, leading to substantially different instrumentations. In both, further choices are based on customary aspects such as effectiveness, efficiency, and feasibility. The ultimate choice on strategies derives from these broader views on public governance.

The article develops general design considerations linked to the two main governance strategies as have long time been present in the Western society, and next to effectiveness and efficiency considerations, in Section 2. In Section 3, the link to climate policy instrumentation is made, developing an instrument typology for systematically filling in both governance strategies. This methodology is next applied in the results section, first for Planning & Control, Section 4, and then for Intuitionalism, Section 5. Section 6 surveys the similarities and differences between the two instrumentations, regarding effectiveness and efficiency; feasibility; and governance considerations. Section 7 gives modest conclusions. The overall goal of the article is to guide towards a better instrumentation design and to clarify unavoidable choices. This is not a one-time endeavour but one step, guiding both further research and alerting the policy domain to fundamental choices to be made.

2. Double design considerations: governance and effectiveness/efficiency

Deep restructuring of society for climate reasons requires well-designed instrumentation. Main directions in governance for the next decades form a first basis for design. Second are the more usual effectiveness and efficiency considerations. An instrument typology is to connect these two domains of considerations, here developed for that purpose.

2.1. Governance schools and governance considerations

Seemingly far away from climate policy instrumentation, deep transformations for the 2/1.5-degrees climate goal link unavoidably to basic discussions in Western society on how power relations are organized, balancing centralized power and more diffuse decentralized power, and limiting domains of central power. Deep climate policy is unavoidably connected to governance options in political theory. Constitutional options were analysed along such lines by Aristotle in Politics, 4th century BC, which are quite relevant still. Modern public governance development started with the Magna Carta (1215). The Bill of Rights (England 1689; US 1789) and the constitutions following the French Revolution all have substantive procedures to reduce direct hierarchical power in many domains. Such views also determine governance in federations and between states, on how to fill in the details of their cooperation, different in the US and the EU, and the UN, and WTO. The Treaty of Lisbon (2007) forms the background for developing climate policy instrumentation in the EU. The rights of individual countries are relatively well-protected in the EU, compared to the more centralized federal system in the US and China. The Lisbon Treaty seems, however, less specific in delimiting what cannot be regulated centrally (see for example Rosenbaum, 2013), allowing for a broader centralization than in the US. The subsidiarity principle gives only limited guidance in restricting the domains of EU power. Also in climate policy, there is substantial freedom in the EU on what can be regulated centrally or decentrally, and on what instruments to use, within the limits of legitimacy. The governance choice is open between central planning for guiding and controlling decentral actions, and central institutions for stimulating bottom-up actions.

The *Planning & Control school* is substantially linked to welfare theory, first formulated by Bentham (1776) as ‘the greatest happiness for the greatest numbers’. Modern welfare theory developed around the Second World War around Bergson–Samuelson welfare functions (see Samuelson, 1977), with Sen (1970) adding collective goals and Stiglitz focusing on market imperfections, signalling further public tasks beyond neo-liberalism (see Lofgren, Persson, & Weibull, 2002; Stiglitz, 2008). Modern economics is intricately linked to this school, which in the climate policy domain has been well-presented, as by Stern (2008) and Hood (2011). Welfare theory has broadened its domain and now also covers broad ethical issues, as discussed in Nussbaum and Sen (1993), summarized eloquently, also covering the climate subject, in Stiglitz, Sen, and Fitoussi (2009). What is best for the collectivity has to be specified and realized, requiring continuous detailed feedback. Economics thus broadened loses some of its market-based operationality, shifting to more detail in public policy. Planning & Control links to political science views, where policy develops in an interactive process between several actors involved in negotiation processes: small steps create incremental improvements (see Dahl & Lindblom, 1953; Lindblom, 1959).

Wiseman, Edwards, and Luckins (2013) surveyed 18 post-carbon strategies, all belonging to the Planning & Control mode of governance, linked to an incremental approach for emission reductions. Numerous small decisions may lack strategy however, as Dahl and Lindblom noted already. Strategies should guide individual decisions, but not as blueprint-type strategic plans. Mintzberg (1994a, 1994b) advocated a more abstract and creative approach to long-term strategic planning for firms, to guide short-term actions, relevant for public policy as well. A shift from integral modelling to operational partial quantifications follows, with overall welfare improvement offering policy guidance. Cost–benefit analysis and multi-criteria analysis cover these broader welfare considerations, including issues such as income distribution, fairness, and economic dynamics. An effective policy requires integrating specific targets in all policy actions, *mainstreaming climate* in virtually all decisions. The European Commission has its Strategic Planning and Programming Cycle, akin to the US Planning Programming and Budgetting system from the 1960s, with annual checks on the achievement of its objectives. Incremental improvements lead, however, to increasing regulatory density and complexity, detrimental to overall effectiveness (see Simões, Huppes, and Seixas (2015) for a case analysis on electricity). In the US, Sunstein (2014), a champion of cost-effectiveness and optimality, had the task in the Obama administration of simplifying rules. The European Commission has a *Vice-President on Better Regulation and Inter-Institutional Relations* for the same task. Improvements are governance-neutral seemingly, as in Sunstein's book title *Simpler: The future of government*. However, more detailed insights support increasing regulatory density, as by mending deficiencies in regulation and adapting to new circumstances. The regulatory expansion stage is now due for far-reaching climate goals, in this Stiglitz-type *Planning & Control Strategy*.

The *Institutionalist school* focuses at institutions as the basic and relatively stable fabric of society. They include constitutional arrangements, the legal system, the judicial system, the educational system, public–private sector delimitations, and more or less fixed normative and ethical principles. It has roots first in *historical analysis*, with Acemoglu, Johnson, and Robinson (2005), Mokyr (2004), and North (1990) indicating the broad institutional background of modern industrialization. The steam engine was not the result of technology policy. *Institutional economics* had a start initiated by Coase (1960), with a survey of the field in Coase (1999). The Coase Theorem states that a right to pollute versus a right not to be polluted may have the same economic and environmental outcomes. Other considerations then determine choice. The right not to be polluted has been chosen in the Polluter-Pays-Principle in OECD (1972), connecting to liability. The institutionalist school in the *sociology*-oriented social sciences links to systems theory, as in Parsons (1951), and more recently for example in Immergut and Anderson (2008) and Munck af Rosenschöld, Rozema, and Frye-Levine (2014). In the *political science* and *political economy* domains, there is a millennia-long Institutionalist tradition. Recently, Chang (2002) argued against the simplistic neo-liberal view of 'the' market, erroneously abstracting from the institutions which can create and regulate markets in very different ways. Carrigan and Coglianese (2011) focus on the enabling governance mechanisms. For long-term climate policy instrumentation, not practical action but institutional development is key, adjusting the most important institutions for climate reasons. Internalizing external effects is prime. The institutional approach leaves responsibility to more decentralized actors, who play an independent role within this broader fabric of society. Monopolistic tendencies are actively countered, with a reduced role of intellectual property rights (Boldrin & Levine, 2008) and a clear public–private separation. Whereas in Planning & Control other societal goals are part of climate policy design, such as alleviating energy poverty and reducing income inequality, in institutionalism income distribution is mainly determined by other institutions and policies (see Milanovic, 2016; Piketty, 2014). Other factors dominate there, requiring climate-independent policies. The generic *non-planning* structure stimulates bottom-up developments, public and private, the power of which has been shown by Ostrom (2010). This is the Ostrom-type of *Institutionalist Strategy*.

2.2. Effectiveness and efficiency considerations

Governance strategies constitute a first entry for instrumentation design. With effectiveness assumed here, efficiency is the more practical goal: the same effort with more results means higher efficiency. Quantification of long-term public and private burdens of regulation is virtually impossible. But there are rules of thumb. Low complexity, low regulatory density, internal consistency, limited distributional effects, and many more may all contribute. At a somewhat higher level of abstraction, instrumentation efficiency can be approached by two main characteristics. *Sparseness* limits the number of instruments by making them comprehensive, and *Completeness* covers all emitting activities. *Non-overlap* follows, avoiding that multiple instruments cover the same emitting activity. More applied criteria then can be placed in this framework. Efficiency considerations are operant at two levels. They first co-determine how instruments are specified for design. Sparseness as comprehensiveness is used in the ordering of instruments and for their detailing, combined with (non-)bindingness for governance reasons. Together, the governance and efficiency considerations guide the design of full sets of instruments, as instrumentations.

3. Design methodology detailed

3.1. What are climate policy instruments?

How to specify instruments for consistent design? There is no unique or best specification available, as the functions of specifications differ. *Legal status* leads to specifications like covenants, operating permits, and binding standards. The *subject of regulation* may be *result*-, *technology*-, or *behaviour*-oriented, as in emission permits, obligatory Carbon Capture and Storage (CCS) standards, and speed limits for road vehicles. Or specifications may differentiate between *objects*, like in instruments on products, installations, or behaviour. The *scope* may regard an individual person or firm, a group or sector, or a product-technology class. Fleet Standards for example have a broad scope for a limited technology domain, covering all private vehicles, in a particular class, by any producer. (See Huppes and Simonis (2009) for a survey of such specification principles.) The prime characteristic of instruments applied here is their instrumentality: what they set in motion is what they do, regardless of intentions, targets or goals, and legal status. Emission pricing, from taxes to fines, incentivizes emission reduction; an emission standard allows for actions not exceeding the standard; a continental transmission grid opens the option of continental electricity trade; product information allows for more informed choices; and a technology prescription limits the technologies that may be applied, like *no coal-fired power plants*, *no nuclear* or *zero-energy buildings*.

Climate policy instruments certainly must help reduce CO_2 emissions in the long term. Do energy measures constitute climate policy instruments? Energy-efficiency measures may reduce emissions by reducing the fossil energy input of specific activities. There is a 'huge potential for improving energy efficiency' (Grubb et al., 2014, p. 160). However, Jevons/Khazzoom–Brookes-type rebounding mechanisms (Saunders, 1992) may then follow, with cost-reducing improvements also supporting the huge potential for *increased* energy intensity. The reasons to involve energy in climate policy should be clear. If emission pricing would kill off supersonic flight, is that then part of energy policy? Conversely, if high-energy supersonic flight would produce zero emissions, why involve climate policy? With zero fossil emissions, energy efficiency becomes irrelevant from a purely climate point of view. Are energy-efficiency measures part of climate policy instrumentation? *Yes* in Planning & Control; *No* in Institutionalism.

Which further indirect instruments might be relevant? Spatial plans and public infrastructure are overwhelmingly based on other considerations, but have climate relevance. High-speed trains, for example, are part of Planning & Control instrumentation, as they help reduce fast rising aviation emissions (see Goodwin, 2012). So, beyond pure climate policy instruments, there may be a substantial number of climate-relevant policy instruments primarily linked to other domains. In Institutionalisms they are left to these other domains, while in Planning & Control they may become climate policy instruments, by *mainstreaming* (see on mainstreaming Kok and De Coninck (2007), Sinden, Peters, Minx, and Weber (2011), UNDP (2012), and Rauland and Newman (2015)), with Rayner (2010) seeing mainstreaming not as part of public policy but as a cultural bottom-up action, more connected to Institutionalism. The strategies hence differ substantially in their approach to instrumentation. Planning & Control uses many instruments to cover more specific activities including decentral and local developments, ultimately mainstreaming all public policy towards the climate goal. By contrast, Institutionalism has a few central strong generic instruments, leaving bottom-up actions to member states/provinces and private parties. The instruments typology is to cover these differences.

Institutions play a role in any strategy, unavoidably. But how are they approached? Planning & Control instruments include feed-in tariffs and net-metering for subsidizing renewable electricity production. They fragment electricity markets, making them less responsive to supply and demand changes. Other regulations then have to improve market functioning, like capacity payment for avoiding shortages, subsidy systems for secondary electricity production, and obligatory inter-country electricity transport capacity to reduce oligopoly in wholesale markets. Such repairs involve institutions, but is not primarily from an institutional perspective. In Institutionalism, there is a generic approach to electricity markets, purely for climate reasons. If useful for other goals, that is a nice coincidence.

3.2. Other approaches to instrumentation

Grubb et al. (2014) and Hood (2011) have an overall view on instrumentation, as opposed to specific instrument studies.

'Grubb' first orders policy in three time frames. *Satisficing*, following Simon (1956) and in behavioural economics Cyert and March (1963), creates short-term improvements. *Optimizing*, the core of much of economics, improves on satisficing, with medium term improvements. Deep climate policy requires long-term *transformation*, beyond the domain of satisficing and optimizing. These time frames link to three pillars for instrumentation.

Their *PILLAR I Standards and engagement for smarter choices* (p. 79ff.) links to satisficing. What should happen in main technology domains, in low-emission power; smarter buildings; cleaner production; transforming vehicles and fuels; and smarter systems? Core instrument is adapting standards. In 'barriers to and drivers of change' (p. 135ff.), they specify factors in society influencing choices, indicating the role of such shorter term policy instruments. *PILLAR II Markets and prices for cleaner products and processes* (p. 203ff.) aims to improve efficiency and optimality. Resolving market imperfections through pricing measures is a part of optimization. Reducing fossil energy subsidies is a main first step (p. 211). Specific product taxes might be transformed to more generic pricing for pollution (p. 215). Two options for emission pricing are compared based on their efficiency, favouring emission taxes for the short term and cap-and-trade systems for the long term (p. 225). Administrative implementation is not specified. *PILLAR III Strategic investment for innovation and infrastructure* (p. 311ff.) goes into the deep societal changes required, not just in the energy system, all requiring innovation and funding, also for their implementation: 'Pushing further, pulling deeper: bridging the technology valley of death' (p. 315ff.). The entire innovation chain is covered, using technology push and demand pull. Instruments include public funding of R&D and Demonstration, with subsidies and pricing schemes for strategic deployment. These create learning curves to overcome lock-in barriers and require optimization of infrastructure. The transformation pathway is given for key sectors: energy, transport, industry, and built environment, in a Planning & Control vein. The transformation of the European electricity system is for example extensively described (p. 372ff.), but technically only. Grubb has no systematic treatment of the public policy instruments involved in long-term transitions.

Hood (2011), for International Energy Agency (IEA)/Organization for Economic Co-operation and Development (OECD), takes an economist's market view on instrumentation. Emissions can be capped with permits, made tradable in cap-and-trade; they can be priced directly, as in an emission tax; or they may not have caps or prices. Other instruments are added to these basic options, always with cost-effectiveness and dynamic efficiency in mind (see Hood, p. 38ff.). Cap-and-trade, she states, is often combined with other domain-specific instruments, creating serious problems of overlap and misalignment. Varying the cap to keep the price at relevant levels creates a hybrid system, partly volume and partly price based. The emission tax then is equivalent but simpler. It can be well-combined with energy-efficiency measures and support for renewables, in order to reduce overall cost. 'As in a trading scheme, the primary justification for renewables support is long-term cost reductions' (Hood, 2011, p. 42), including creating learning curves by implementing innovations. In the case without emission pricing, undesirably, the reference is to specify what could be expected under an emission tax. Specific instruments are to mimic these outcomes, involving quantity measures such as renewable energy and clean energy standards, or pricing instruments such as *production tax credits* for particular forms of renewable electricity. There is no generic instrumentation developed, but a strong advice: 'The overall conclusion is that interactions can be managed as long as the focus is on functionality of the whole mix: coordination of the various targets, and the detailed design of instruments taking account of interactions' (Hood, 2011, p. 43). Hood remains mainly in the Pillar II domain of Grubb.

3.3. Instrument types for governance-oriented design

Instrument types are to support the main design strategies, in terms of governance and efficiency. Using this design background, the bewildering number of possible instrument types may be reduced to six main types (see Table 1) ordered as to generality and bindingness. The *institutional framework* (1) constitutes the most generic fabric of society. *Public infrastructure and spatial planning* (2) creates long-term stable use options and expectations for all actors. Publicly funded *Research and RD&D* (3) creates more specific options. Type 4 instruments, *regulating private actors*, range from information (4.1), to financial incentives (4.2), to obligatory regulations (4.3), according to bindingness. The sequence tends towards increasing technology specificity, per type still striving for encompassingness. Generic CO_2 permits per kWh require fewer regulations than permits per fossil power installation.

3.4. Public task instruments

Public task instruments cover Types 1–3. *Institutions*, Type 1, primarily create incentives and options. Liability rules, a first option (see Faure & Peeters, 2011), cannot function well for climate change, due to large numbers of emitters; all linked to large numbers of differently affected persons and organizations; substantial time-delays of highly uncertain effects; and a *fat-tailed* chance structure (Weitzman, 2009,

TABLE 1 Instrument types: from general, incentivizing, and enabling to specific and binding

Types	Examples
(1) Institutional framework	Environmental liability; generic emission tax; cap-and-trade (EU ETS); electricity markets (Unbundling Directive), etc.
(2) Public infrastructure and spatial planning	Electricity grid (obligatory high-voltage interconnections); hydrogen storage facility; CO_2 transport infrastructure for CCS; etc.
(3) Publicly funded research and RD&D	Research programmes (parts of H2020; NER300); R&D subsidy schemes; exemplary CCS; etc.
(4) Regulating private actors:	
(4.1) Informational instruments	Labelling schemes (electric appliances; NEDC measurement standards for cars); BAT information; Top Runner selections; etc.
(4.2) Financial instruments	Subsidies and taxes (non-fossils feed-in-tariffs, capital subsidies; gasoline excises; tax deductions renewables; etc.
(4.3) Standards and regulations	Generic standards (Fleet Standards; CO_2/kWh; zero-energy buildings; speed limits; etc.

2011). Instruments to internalize external climate effects, following the Polluter-Pays-Principle, are generic emission taxes and generic auctioned tradable emission permits, as in Grubb's Pillar II (p. 203ff.). Electricity market design is a second main institution, for climate reasons having to include large numbers of primary renewables producers and secondary producers. Electricity markets are currently dominated by few fossil-fuel producers and are mainly national and fragmented. The Unbundling Directive (EC, 2013), part of the Energy Union, forbids large producers from owning the transmission grid, reducing monopolistic tendencies. A real-time variable market with equal prices for all is a main institutional instrument. *Public infrastructure and spatial planning* with strong climate relevance, Type 2, include natural monopolistic transport systems, with transport and storage of electricity and hydrogen for climate reasons. Pure public provision is one option, next to public–private supply and regulated private provision. Regulated privatization may follow public provision, as in the development of the Internet. Mazzucato (2013a, 2013b) advocates the expansion of this public role, with a critique by Mingardi (2015). Defining and funding *Research*, *R&D*, *and Demonstration*, at Type 3, cover the next public task instruments. It forms the core of Pillar III of Grubb et al. (2014, p. 311ff.) regarding the long-term goal of instrumentation, to develop innovations for deep emission reductions, including their market penetration.

3.5. Instruments regulating private actors

Regulating private actors, Type 4, involves information, financial incentives, and standards.

Informational instruments (*4.1*) leave decisions to actors, without or with only limited normative pressure; they include product labelling schemes and information on available technologies as in (not yet binding) Best Available Technology (BAT) specifications. Information schemes may actively induce innovation by competition in some domains (see the Japanese Top Runner programme; Hamamoto, 2011; Nishitani & Itoh, 2014).

Financial instruments (*4.2*) may exert a stronger influence, by changing relative price levels, as in subsidies for renewable electricity production and for electric vehicles, and taxes on gasoline and on heavily emitting coal-fired power stations. Next to specific direct effects, subsidies on non-fossils increase the total energy supply, while taxes on fossils use, including reduced subsidies, reduce the total supply (see Hood, 2011 for examples).

Standards and regulations (*4.3*) are the most binding instruments, including prescriptions and prohibitions, like emission standards for power stations and speed limits for private cars. They still constitute the workhorse of environmental policy. They may stifle technological progress and require a substantial and reliable public and private administrative system. Performance specification allows for more technology dynamics than technology specification. Even restrictive regulations may induce some innovation, as through prime-mover mechanisms or just by forcing change in firms (Porter & Van der Linde, 1995; see the recent literature review by Ambec, Cohen, Elgie, & Lanoie, 2013).

The instruments at Type 4 roughly coincide with Grubb's short-term Pillar I (p. 79ff.), including the specific pricing instruments from Pillar II.

Planning & Control starts with instruments of Types 4.2 and 4.3, then 4.1, next Types 3, 2, and only if necessary Type 1. Institutionalism starts with Type 1, and next 2, with Type 3 playing a more limited role and Type 4 being avoided as much as possible.

3.6. Instrumentation strategies detailed

Using governance and efficiency considerations and using the instrument typology developed for this purpose, the two instrumentation strategies can be described in some more detail. Planning & Control starts with most important emission sources and specifies means to reduce them (see the first row in Table 2). These means are to be effective practically (row 2). Instruments are defined broadly, with *mainstreaming* of climate policy in all decisions as a main goal (row 3). There is a broad overlap with other policy domains, requiring integration (row 4). The entry for instrumentation is sectors (row 5), covering the emitting activities involved, starting with financial and binding instruments. Where implementing technology-specific instruments is cumbersome or not fast and effective enough, subsidies, purchasing programmes, and public–private partnerships create learning curves and develop markets, also covering most relevant R&D and Demonstration (row 6). Also for collective infrastructure, public–private partnerships are prime (row 7), to bring in private technical know-how and speed up implementation. Internationally, other countries join in the task, setting binding caps on their emissions, with restrictions on imports from non-joining countries (row 8).

The Institutionalist strategy is fully different. It starts with analysing and correcting main market deficiencies with climate relevance (row 1). The set-up of instruments follows the Polluter-Pays-Principle, also for remaining emissions (row 2). Climate policy instruments are defined narrowly (row 3). The single climate focus is set up so as to leave as much space as possible for other policy domains and their instrumentation (row 4). Sectoral entries are avoided as much as possible, as are technology-specific instruments which then would follow (row 5). After having main institutions developed, the adjoining infrastructure follows, to enable decentral mostly private developments. Next, mostly generic research follows, incidentally guiding subsidies into potentially climate-relevant directions, as public research, and only incidentally using subsidies for private development (row 6). Where governments act in infrastructure and monopolistic markets, they do so by purely public supply (row 7).

TABLE 2 Strategies for instrumentation design detailed

	Planning & Control strategy	Institutionalist strategy
1	From technical-economic sources analysis; to solution specification; to solution implementation for reducing climate emissions	From socio-economic problem analysis; to repairing the market deficiency of external effects of climate emitting activities
2	'Practical effectiveness principle'	Polluter-Pays-Principle
3	Instruments defined broadly, as public policies reducing specific emissions, ultimately as mainstreaming 'all' policies	Instruments defined narrowly as public actions creating effective climate incentives, with enabling infrastructure
4	Broad overlap with other policy domains like for energy, income distribution, and employment	Single focus on climate, leaving other domains to other instrumentation
5	Sectoral approach, with main sectors: energy, industry, buildings and appliances, transport	Generic approach, avoiding sectoral specificness and specific technologies as much as possible
6	From specific technologies (Type 4) upward: From technology and behaviour policies; to focus on innovation with demonstration and creating learning curves; to public–private partnerships and publicly paid and regulated infrastructure; to repairs in negatively affected institutions	From generic institutions (Type 1) downward: From generic incentive creation; to enabling conditions; to solving specific market problems remaining, first in infrastructure and research, and finally incidentally subsidies for specific climate-relevant private technologies
7	Public–private partnerships for most relevant collective supply of key technologies and infrastructure	Public supply of natural monopolistic infrastructure; correction of monopolistic market tendencies
8	International cap agreement, specific per country, as many countries as possible, normative based, with compensations and retributions	International incentive agreement, open to all to join at the same conditions. Development policy is not part of climate policy

International agreements are limited mainly to the set-up of similar emission tax systems, using a most favoured nation approach, open to all to join on the same conditions (row 8).

These generic policy approaches will be detailed in the next two sections, filling in instrumentation for the Planning & Control and the Institutionalist strategy.

4. Design results: instrumentation in the Planning & Control strategy

Planning & Control starts at specific technologies and their implementation, using financial instruments and standards and regulations, and linking these to subsidies for R&D and Demonstration and to other means to create learning curves to speed up implementation of low-emission technologies. For systematically covering all emissions, the economy is viewed in terms of four main sectors covering all emitting activities: energy, transport, buildings and appliances, and industry. Bottlenecks in infrastructure are resolved most speedily in public–private partnerships. Institutions may be involved incidentally, to solve specific problems as they come up. Planning & Control instrumentation makes an instrument like the current European Union Emissions Trading Scheme (EU ETS) superfluous. Table 3, left column, gives a survey of instruments for Planning & Control, and the right column for Institutionalism.

TABLE 3 Planning & Control and institutionalist instrumentations

	Planning & Control instrumentation	Institutionalist instrumentation
Type 1 Institutions	Cap-and-Trade fading; some regional electricity market repairs	Cap-and-trade into emission tax, encompassing, upstream, predictably rising to '$300 in 2050'
	Transmission interconnection rules	Equal for all real-time priced continental electricity market
	Increased patent protection for climate reasons, compensation for developing countries	Reduced patenting options, for generic reasons
Type 2 Infrastructure and its standards	Reducing natural gas distribution grid connections; limited bilateral supergrid	Public ownership infrastructure: electricity, hydrogen, CO_2 transport for CCS Extensive supergrid
	Public–private partnerships in infrastructure	Public systems with high-risk and monopolistic tendencies (like the Internet)
Type 3 Research	Primarily RD&D, and public–private partnerships for market development	Primarily basic Research and some R&D
Type 4.1 Information	Like Japanese Front Runner BAT descriptions	Like Japanese Front Runner Public reference databases on processes and technologies
Type 4.2 Financial	Feed-in premiums; renewables subsidies; capacity payment; including tax reductions	Possibly regional/local? No capacity payment; no tax reductions
	Preferential public purchasing	–
Type 4.3 Binding	Emission standards per kWh produced, − 7% p.a.	–
	Installations standards, many	[For other reasons than climate]
	Total Fleet Standards, − 11% p.a.	–
	Housing emission standards, new to near zero All existing stock on timeline to zero	If so, up to regional and local considerations. [coastal, windy, sunny, etc., regions all different]
	Product standards, many	[For other reasons than climate]

4.1. Energy sector

The energy sector abandons fossils and accommodates the dominant role of renewables coming up. Squeezing out coal is the first task, later followed by most of natural gas, at national levels. Direct actions like closing older coal-fired power stations are followed by standards. These specify emissions per kWh of any fossils-using producer, going down to (near) zero by 2050. Capping emissions with tradable permits would reintroduce a national cap-and-trade system. Trade-linked, this would reconstitute a sort of EU ETS. Such a pricing system belongs to the Institutionalist strategy, transformed there into the simpler and more effective emission tax. Emission standards are the clear and relatively simple alternative in the electricity domain, reducing fossils use barring CCS (Carbon Capture and Storage). Increasing renewables is with technology-specific subsidies and related taxes, including pricing, as dominant instruments. Electricity markets become more national and fragmented, only partly resolved by replacing feed-in tariffs with feed-in premiums and capital subsidies. Electricity market functioning is limited, also requiring capacity payment to avoid breakdowns of mainly national grids. Bringing all production and all grids under national control is nearly unavoidable (see convincingly, Finon, 2013). Díaz-González, Hau, Sumper, & Gomis-Bellmunt (2014) indicate detailed requirements on country grid codes to accommodate intermittent renewables. With electricity production covered in the energy sector, the instruments for three other sectors are to be added: transport, buildings and appliances, and industries.

4.2. Transport

Transport is the most homogeneous of the three sectors and is covered by relatively generic Type 4 instrumentation, expanding on current Average Fleet Standards, also covering CO_2 from other fossils such as natural gas. Fleet Standards are transformed to predictably reduce emissions by the total fleet sold, not just the current average emission per car. Compensation for mass and share of non-fossil drive vehicles in the fleet is removed, regulating fossil emission vehicles only, including hybrids. Lifetime direct emissions per vehicle type constitute the first element in the standard, based on expected lifetime in kilometres, multiplied by emissions per kilometre, and realistically measured. These simplifications allow for full coverage of all road vehicles, including trucks. The number of vehicles sold per type is the third element. The emission volume in tonne CO_2 credits for a fleet-year then equals lifetime driving distance per type; times emission per km per type; and times number of cars sold per type, and added over all types, as somewhat similar now in US-CAFE (Corporate Average Fuel Economy) standards (see ICCT, 2014). If the expected emission volume exceeds the fleet credits volume, the producer has to obtain additional credits from other producers or adjust his fleet. A fine for non-compliance, not too extreme, may create some short-term flexibility. Fleet Standards per year lead to delayed emission reduction in the entire transport fleet of all ages, as the vehicle lifetime is well over 10 years. Standards for the new fleet are, therefore, advanced on the emission target for the full fleet. For near-zero emissions by 2050, the Fleet Standards should be reduced by 95% by 2040 at the latest. The reduction rate is 11% per year starting now, higher if later. Aviation first remains bound to hydrocarbons, some bio-based, with much later transformation to zero emission for the full fleet. R&D for high-energy density systems is prime for aviation and useful for road transport as well.

4.3. Buildings and appliances

For heating in buildings, now dominant natural gas is phased out. A generic prohibition of natural gas connections in new buildings is easy to implement, avoiding costly refurbishing later, as now planned in several countries. Zero-fossils heating and cooling standards are introduced to avoid shifting to other fossils, such as oil, LPG, butane/propane, and coal. For existing stock, medium term emissions reduction first involves subsidies for better insulation, heat-recovering ventilation, smart glass, etc. However, producing insulating materials may now induce substantial CO_2 emissions (Rosselló-Batle, Ribas, Moià-Pol, & Martínez-Moll, 2015). Long-term heating and cooling in existing buildings must also be solar thermal and electric, using heat pumps as already extensively used in Japan, with possibly also hydrogen fuel cells. Zero-emission systems become obligatory in a refurbishing cycle, time-specified for all buildings, with subsidies easing the process. Instruments to create learning curves, at Type 3, focus on promising systems, such as combinations of heat pumps, heat/cold storage, solar heat, and geothermal heat. Their implementation with technology-specific instruments seems complex, especially when natural gas is still available. Appliances based on coal, oil, and natural gas, like terrace heaters, will be phased out. Electric appliances are covered with generic energy standards, like currently vacuum cleaners in the EU. They will use near-zero emission electricity by 2050 anyway.

4.4. Industries

Industries are most diverse to regulate. Fossil heating and power are phased out in this strategy by phasing in generic prohibitions and prescriptions where possible, and with BAT-based technology prescriptions in other cases, and with information and subsidies to ease the changeover. Some phaseout may be difficult, like for large emitters in iron and steel production, and clinker production for cement, refineries, and chemical industries. For iron and steel, public R&D on non-cokes-based production might have long-term success, as in using hydrogen for reduction. Clinker production will increase as coal use and hence coal-based clinker production will decrease substantially. Reducing cement use is to reduce emissions, which may involve green concrete options, to be developed and prescribed. Refineries will process a fraction of the current oil volumes by 2050, with traffic decarbonized. They continue production for the chemicals industry, coatings, plastics, asphalt, and tars. A rising share of subsidized CCS will be imposed on all remaining industries with fossils-derived emissions, with credits tradable between them. The cap-and-trade system, implemented in industry only partly in the EU, becomes superfluous and will be abandoned.

4.5. RD&D, infrastructure, and institutions

Public RD&D funding is focused at technologies close to the market and with subsidies on entering the market so as to create learning curves and speed up the introduction of low-emissions technologies. Examples are in renewables and nuclear subsidies as in price guaranties and investment subsidies, and similar for new battery developments, smart meters, and solar synthesis gas production.

Infrastructure requirements as for incorporating far-away renewables in the grid are subsidized or implemented in public–private partnerships. As electricity remains a mainly national affair, international grid connections are negotiated mainly bilaterally, with relatively limited requirements for long-distance transport. Unbundling as in the EU is under pressure, as renewables depress proceeds from fossil producers, due to lower prices and lower utilization rates. Capacity payment is required for security-of-supply reasons. Hydrogen supply for fuel cells as used in cars has only limited storage and transport infrastructure. Such infrastructure is based on security-of-supply reasoning. In low-solar and low-wind periods, stored hydrogen can deliver relatively cheaply. Creating incentives remains a challenge in a fragmented electricity market.

Institutional development remains limited. Safeguarding the options for interregional and international trade in electricity and hydrogen constitutes one element, primarily by standardization. Smart meters are standardized to allow for use-time differentiation, but not real time. To support novel low-carbon technologies, patent protection may be expanded.

4.6. International agreement

International agreement in Planning & Control specifies a binding emission cap per year, reducing CO_2 emissions from now to 2050 by well over 90% in the EU and most developed countries (see Hare, Stockwell, Flachsland, & Oberthür, 2010). The total cap trajectory and the principles for cap allocation are to be established, not getting all countries on board. Agreement partners verify their emissions administratively, also requiring control on their emission planning. Strong patent protection is combined with reduced fees/payment for developing countries. Border Tax Adjustments (BTAs) compensate the lower cost of unrestricted production abroad. Dynamic quantification is difficult however, as induced cost is part of total cost developments, also forming the basis for advantageous mutual trade. Long-term BTA prices can hardly be specified now. If low, BTA would not be so relevant.

5. Design results: instrumentation in the institutionalist strategy

Instrumentation in the Institutionalist strategy has prime focus on most generic public instruments and avoids technology-specific regulations as much as possible. Actual emission reductions will result mainly from decentral and private actions as are incentivized and enabled.

5.1. Institutions

Institutionalism starts with generic institutions, Type 1, adding more specific instruments where important markets are absent or inadequate. There are two core Type 1 instruments at a central level in the EU, and similar in the US and China. The ETS cap-and-trade is stepwise transformed into a predictively priced, upstream administered, comprehensive emission tax. Second, an open-to-all, equal-priced, real-time, near continent-wide electricity market is established. Together these create the main incentives and options for a low-carbon society. This generic central (EU-wide) instrumentation leaves further policies and actions mostly to lower administrative levels, including Member States in the EU, and to private parties, which then will be incentivized and enabled bottom-up (see Rayner, 2010 on bottom-up action, and a more general discussion in Ostrom, 2010). There is no reason to specify emission volumes per year, Planning & Control way, also not for lower administrative levels. Fleet Standards, and much more, are abandoned. Monitoring of emissions remains relevant, to inform decentral action. (See Table 3 for a survey, next to the Planning & Control instrumentation.)

5.2. Encompassing emission tax as carbon deposit

The CO_2 emission tax is implemented upstream at the level of primary production of fossils and their imports including derived fossil energy products, as also proposed by Metcalf (2008) for the US, and refunded upon export of such products and upon approved CCS, paid from the tax proceeds. All fossil CO_2 emissions are taxed this way, as a carbon deposit (see Huppes, 1993, p. 343ff., 2011). Similar options, but with less clear system definitions, were present already in an OECD publication (Victor, 1992). Tax and refund at external borders are not BTA (confusingly named Border Carbon Adjustments by Droege [2011]), but an administrative part of the emission tax.

The administrative implementation is at the Member State level in the EU, but may be more central as in China and the US. The tax is not Pigovian, equal to marginal damages, but follows Baumol (1972), set at a level sufficiently high to in principle reach the climate goal. The tax rises linearly, like the British Columbia Emission Tax (Min-Fin-BC, 2014) and the UK Price Floor Tax (Revenue&Customs, 2010/2012). The UK Price Floor Tax would rise by around \$5 per year (£1≈\$1.25), starting in 2012, leading to a CO_2 price in 2050 of around $250 per tonne. Combining with some modelling outcomes, a provisional high estimate is $300–400 by 2050. A $300 CO_2 tax would correspond to a tax per barrel of oil of $135. The oil price would be long-term depressed by reduced demand, say $40 per barrel of oil for producers. The price for buyers then would be around $175 in 2050, surpassing somewhat the peak price of 2008, giving electric cars substantial advantage. Total tax proceeds are distributed over Member States (similar to States and Provinces) according to their share in total EU emissions, and internationally over countries joining. This creates an incentive to not 'forget' emissions, as that would mean forgoing proceeds. Proceeds first rise, but will go down to low levels with low CO_2 emissions towards 2050; there is an end to the tax.

5.3. Single priced continent-wide electricity market

The electricity market is a single (near) continental market, with real-time variable, equal prices for all primary and secondary producers and users. There are hundreds of millions of them as with decentral renewables production and transport batteries used for secondary production. Grid balancing is market based, with a substantial role of secondary production from storage and of end-use variation with instantaneous reaction. (See Baron (2015); Palensky and Kupzog (2013), and Yigit, Gungor, and Baktir (2014) on requirements and options.) Storage for secondary production is based on variable pricing only. Smart grids and the Internet of things are purely private, based on market incentives. The single EU/continental grid and market involves a Super Transmission System Operator (S-TSO), linked by HVDC (High-Voltage Direct Current) grid lines to all regional/national publicly owned and operated transmission systems with their TSOs. Such a supergrid is physically developing in China. The real-time price includes transmission costs paid to the grid operators, based on real-time congestion pricing (see Verzijlbergh, De Vries, & Lukszo, 2014 for requirements and *NordPoolSpot.com* for current developments in this direction). Net-metering and price guarantees are abandoned, being at variance with real-time pricing. Heat pumps with heat storage outcompete natural gas, aided by emission pricing. Battery-electric and fuel-cell electric cars and vehicles cover their cost partly by active market operations, leading to grid stabilization (see Huppes et al., 2015; Palensky & Kupzog, 2013). Hydrogen fuel cell cars can play a key role during larger no-wind and no-sun periods, using large-scale public hydrogen storage. This design for a single large-scale electricity market goes well beyond the *European Target Model* for electricity market integration (see ENTSOE, 2014) and the multi-objective 2015 Energy Union Strategy. Other institutional measures may include the reduction of patent protection, to increase the speed of climate innovation, also reducing reasons to compensate developing countries (see, contested, Boldrin & Levine, 2008).

5.4. Infrastructure and research and R&D

Infrastructure is supplied publicly for all relevant technologies where private parties are expected to use it for low-emission systems. Core is the international HVDC supergrid, making electricity into a normal product. Its east–west connections link time zones and north–south connections link wind and solar to storage systems and to final use. This supergrid supports more stably linked transmission grids. Funding research is for long-term possibly relevant subjects, with also climate reasons in setting up programming. R&D is limited to technologies with high-risk but high long-term potential, where private investment may be lacking. For interesting combinations of public infrastructure and long-term technologies, full public supply is possible, as in the first decade of the Internet. Mazzucato (2013a) advocates even broader public provision.

5.5. International agreement

The prime international agreement in the Institutionalist strategy relates to an equal design and level of the high-rising emission tax. Because of its greater political and administrative feasibility, MacKay, Cramton, Ockenfels, & Stoft (2015) prefer this type of agreement over binding caps. The main differences with Planning & Control are as follows:

- No national emission targets per year; a global reference volume suffices for setting the emission price path.
- No universal global agreement is required but only a start with core countries, open for others to join this Climate Club on the same conditions (Nordhaus, 2015) and similarly (Brenton, 2013; Falkner 2015a, 2015b).
- BTA on high fossil energy products covers their upstream emissions only, *not* including the induced cost of a hypothetical emission tax abroad. This is easily in line with WTO rules (Tamiotti, 2011).
- The deposit type emission tax incentivizes exporting countries to join the Climate Club, avoiding the emission tax by levying the same tax on its exports itself (see Dong, Ishikawa, & Hagiwara, 2015).

6. Discussion: comparing instrumentations

Customary evaluation criteria for instrument mixes include effectiveness, efficiency as cost-effectiveness, and several feasibility aspects (see the survey by Görlach, 2013). They are difficult to specify and quantify for long-term transformations and are certainly not fit for overall weighted optimality analysis. Also governance considerations can hardly be quantified. Hence mostly qualitative criteria remain, regarding effectiveness, efficiency, feasibility aspects, and governance.

6.1. Climate effectiveness

Climate effectiveness is assumed to be reachable with both instrumentations. It will not come about automatically, even if assuming political willingness for operational implementation. Uncertainties abound. How will emission reducing technologies develop? Are there unforeseen bottlenecks? Will fossils be produced ever more cheaply, as through improved IT and super-fracking? The speeds of emission reduction may differ. In Planning & Control, currently available options are implemented. However, technology-specific measures with positive primary effects may have limited long-term overall effects due to rebound mechanisms (see Font Vivanco, Kemp, & van der Voet, 2015; Font Vivanco & van der Voet, 2014), to be controlled by additional measures. Incentives for deep innovation are limited. The Institutionalist strategy might start more slowly, but may lead to more fundamental technology and behaviour changes towards zero emissions, also reducing rebound effects.

The notion that Planning & Control will deliver more ‘certain’ results seems unjustified, given the problems of consistent design, policy implementation, administrative implementation, and control in large numbers of mutually interfering regulations (see Hood, 2011, pp. 42–45 on negative interactions). Making Fleet Standards effective, for example, has proved difficult, with actual fleet reductions substantially lower than on-paper Fleet Standard reductions (see Mock et al., 2014) and with even more limited overall reductions. The incentivizing Institutionalist route might better guide the known unknowns and unknown unknowns most relevant for the long term, in substantially broader domains than can be covered in Planning & Control.

6.2. Efficiency

Long-term efficiency can be approached only qualitatively and is substantially dependent on technology dynamics and behavioural changes, occurring mostly independent from climate policy. Activating the ingenuity of larger sectors of society seems more likely in the incentivizing Institutionalist approach, leading to lower costs and hence higher efficiency. Some – by necessity soft – modelling exercises support this view. In general climate policy modelling, technology-specific instrumentation tends to involve substantially higher costs (see Deetman, Hof, & Van Vuuren, 2015). For the transport sector, models of different set-ups show cost a factor 2 higher for standards as compared to financial instruments (see Anderson, Parry, Sallee, & Fischer, 2011). Long-term dynamics, not covered in such modelling, may well have an overriding effect on costs of emission reduction. The ultimate shift to electric drives may well be delayed by forced efficiency improvements in combustion drives creating a lock-in.

6.3. Feasibility aspects

Feasibility of an effective climate policy includes political, technical-implementational, and economic aspects, and ultimate legitimacy consequences. *Political feasibility* involves a willingness and a capacity element. Willingness for an effective climate policy is assumed here, but of course does not emerge just naturally: it is politics. The capacity element is more diverse. More specific regulations in Planning & Control tend to have more specific opponents, and require a larger number of policy decisions, competing with other issues, including non-climate ones. Tackling the diesel emission fraud detected by the Commission in 2013 was put on hold as economic recovery was given priority (Brunsden & Oliver, 2015). Also, large-scale subsidies create opposition. Such mechanisms are part of difficult to predict *regime resistance* (see Geels, 2014), delaying effectiveness. Total Fleet Standards seem procedurally far away as car producers have received long-term stability assurance for quantitatively insufficient reductions. Later implementation would require extreme yearly emission reductions by 2040, hardly possible economically. Greening the tax structure (Andersen & Ekins, 2009) by the generic Institutionalist yearly rising comprehensive emission tax will raise broader but less forceful opposition, reduced by making the tax budgetary neutral through compensating reductions in other taxes. The high CO_2 emission tax in Norway and Sweden, and the annually rising emission tax in British Columbia and the Price Floor Tax in the UK did not meet with strong opposition. Overall, single large decisions such as the introduction of the Institutionalist high emission tax or the Planning & Control extremely stringent Fleet Standards will need the momentum of the right moment, for which they must be fully prepared, with strategy-dependent justifications. For some specific measures, now Planning & Control has an advantage, while overall implementation seems more feasible in Institutionalism.

Legal and administrative feasibility seem not to pose a serious long-term problem. Legal issues are not to be expected, as both strategies can remain within the confines of provincial arrangements in China, federal rules in the US, and the Lisbon Treaty in the EU. The administrative aspects of well-designed renewables subsidies and Fleet Standards seem manageable, as are the emission standards in electricity production. Current issues such as Dieselgate may largely be avoided by setting up more realistic measurements and controls. Implementing technology-specific regulations in industry will require the most extensive apparatus and sensitive tactics, but in a well-established environmental policy tradition already present in most countries. The implementation of the upstream emission tax is also an established routine, fully comparable to centuries-old excises like on alcohol.

Economic feasibility relates mostly to the required speed of transformation: It takes time for new technologies to grow to relevant levels. In the energy domain, novel technologies tend to lose momentum as soon as they approach relevant volumes (Kramer & Haigh, 2009). The Hirooka Rule states that successful new technology systems need around 35 years to come to full speed of introduction (Hirooka 2006). That period is, however, substantially dependent on the scope of the change and the strength of the incentive, where the Institutionalist approach may have the best long-term cards. Conversely, closing down a coal-fired power station ends its emissions directly in Planning & Control. But market mechanisms and regulatory surroundings like the ETS may reduce the net effect later. Most institutional changes need longer time to implement, then working slowly but continuously and broader. In the longer term, Institutionalism might have the best cards working through normal economic mechanisms. In the US, low-cost fracking natural gas drove out coal very fast without much to do around it.

Legitimacy of the political system is a final feasibility aspect. Planning & Control may generate short-term enthusiasm among climate environmentalists and beneficiaries of subsidies. Individuals prefer subsidies including tax deductions over taxes (Brannlund & Persson, 2012). But any subsidy given requires raising the same amount of tax, including those hidden in prices, like consumers of electricity paying for feed-in-tariffs, creating opposition. Long-term policy will have to deal with lack of support for continuously constraining instruments, with unavoidable implementation scandals, and with additional taxes (in the broadest sense) to fund subsidies. The generic emission tax creating diffuse 'normal' market mechanisms has less of a legitimacy issue, being part of continuous economic transitions mostly induced by other factors. They allow for decentralized participatory processes, contributing to legitimacy (see Borrás & Ejrnæs, 2011). There seems to be a clear advantage for Institutionalism here.

6.4. Governance considerations

Governance considerations constitute the ultimate difference between the two strategies, at a somewhat higher integration level. The Planning & Control strategy for climate policy instrumentation results from a planning and control governance view. The community sense of jointly doing what is collectively deemed best is part of its ideological attractiveness. The Institutionalist strategy focuses on incentives and option creation. It concentrates on decentralized independence and the role of civil society in guiding cultural and socio-economic development. Climate policy instrumentation inevitably involves such strategic governance choices, to be made in a reasoned and explicit way.

7. Conclusions on instrumentation strategies

- Just adding 'enough' instruments will lead to incoherent instrumentation.
- Strategic design starts with views on public governance linked to two main strategies, directly relevant for climate policy instrumentation: Planning & Control and Institutionalist.
- Efficiency considerations around simplicity come second: limit the number of instruments, while covering all emissions as equally as possible. It helps reduce the public and private cost of regulation and reduces political vulnerability.
- How efficiency considerations guiding instrumentation development work out depends substantially on the governance choice first made.
- The differences in efficiency and feasibility between the two instrumentations are limited, with some advantage for Institutionalism.
- Further clarification of especially feasibility issues is a substantial research task remaining, in relation to more detailed instrumentation designs.
- Instrumentation might be adapted to differences between countries.
- There may be some options to combine elements from both strategies.
- The final policy conclusion is that a strategic governance choice is required for climate policy instrumentation: either go for really effective control measures or develop adequate institutions.

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