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ELECTRICITY INFRASTRUCTURE: MORE BORDER CROSSINGS OR A BORDERLESS EUROPE?

GEORG ZACHMANN

Highlights

- Being able to transport electricity seamlessly across borders is essential for achieving three major European Union energy policy goals: (1) enabling competition between national energy companies, (2) cost-effective roll-out of renewables, and (3) security of supply. However, neither the market design nor the framework for infrastructure investment proposed by the European Commission is adequate for enabling free flows of electricity within the EU.
- We propose that first, vertical unbundling needs to be completed. Second, to ensure the reliable operation of the meshed European electricity system a European control centre should be established. Third, a truly European and binding network infrastructure planning process should be established. It should be transparent and open in order to ensure the synchronisation of investment. The outcome should be democratically legitimised. Finally, networks should be joint-funded by all benefiting parties, not just consumers that happen to live in the member state where a particular line is being built.
- Without a bold step the single energy market project risks falling short in the face of increased penetration of intermittent renewable sources and infrastructure planning that is focused on national cost minimisation.

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ELECTRICITY INFRASTRUCTURE: MORE BORDER CROSSINGS OR A BORDERLESS EUROPE?

GEORG ZACHMANN, FEBRUARY 2013

DECISIONS MADE IN THE SHORT-TERM about Europe's electricity system will be a crucial part of the transition to a low-carbon economy. A truly European electricity market is needed so that effective competition between national incumbents can take place, so that the intermittent supply of energy from renewable sources can be reliably averaged across wide geographic areas, and so that European Union member states can share back-up capacity and system-stabilising services. For this to happen, electricity must seamlessly be traded across national borders. If physical and administrative barriers to cross-border trade remain, the cost of electricity to the European economy will be increased, and security of supply will be undermined.

The European Commission is taking steps to remove the physical and administrative barriers to the European electricity market by putting in place technical rules that should enable the seamless trade in electricity between all member states, and by setting the framework for the provisioning of sufficient physical transmission capacity. Both the legal framework and the physical transmission capacity entail major technical and economic challenges, however. This Policy Contribution describes these challenges and the current approach to them. Notwithstanding these efforts, we argue that the vision needed for a truly European electricity market is lacking. A bolder blueprint is required to overcome the physical and administrative barriers to cross-border trade in electricity. We conclude by making such a proposal.

THE CURRENT CONTEXT: MANY COMPLICATING FACTORS

Electricity systems are made up of a great variety of interlinked generation, transmission and storage assets. The assets are partly complementary (power plants need to be connected to transmission lines), and partly substitutes (a power plant supplying local demand might be replaced by a transmission line that brings electricity from elsewhere). Furthermore, the different assets have different investment costs, variable costs, life-times and investment lead-times. This makes energy-system planning a complex task. Until the 1990s, vertically integrated monopolies were responsible for planning energy networks in most European countries, which had the advantage of enabling integrated planning. The vertically integrated monopolies were able to overcome the chicken-and-egg problem of synchronising the extension of transmission lines, power plants and storage facilities[1]. The liberalisation of electricity markets, however, brought the era of vertically integrated monopolies to an end. Liberalisation entailed a vertical unbundling of transmission and generation/storage assets. Additionally, the phase-in of the European single market made it possible for demand in one country to be met from energy assets in another country, creating complications for national planning.

Ensuring the efficient operation and extension of electricity transmission lines in a single liberalised market is a complex endeavour. Individual decisions have an impact on all other actors (the 'system nature' of the electricity sector), and a number of other issues must be contended with: the high degree of uncertainty, the diverging interests of stakeholders, strong incentives to strategically withhold private information[2], the diverging interests of individual countries, and complex funding structures of regulated monopolies. We discuss these issues briefly below.

The 'system nature' of the electricity sectors

The physical features of electricity require a high degree of interaction between all parts of the electricity-sector value chain. Changing one part of the system has immediate consequences for the

1. Some incumbents also incorporated the gas sector, and were thus able to integrate gas pipeline and storage system planning into electricity system planning.

2. For example, not announcing the privately planned decommissioning of power plants or lines is dishonestly signalling a greater need for complimentary investments in networks, and a lower need for investment in competing power plants.

entire system. Adding one transmission line might result in the overloading of another, and a new power plant might require network extensions hundreds of kilometres away.

Networks cannot be evaluated in isolation: many benefits of network extension can be equally well or better secured by changes at other levels of the value chain. Better coordination, demand response, energy efficiency and generation management can relieve congestion, increase reliability and mitigate market power.

The fact that electricity networks have to be seen as a part of a system implies a chicken-and-egg problem for generation, storage, transmission and load investments. A generation investment might only make sense if it is properly integrated into the transmission grid. However, as long as there is no generation, there is no need for transmission investment. This problem is amplified by the length of time it takes to build new energy assets, the strategic behaviour of the different stakeholders (Sauma and Oren, 2006) and the high capital cost of energy investment which risks being unrecoverable if extensions are ill-synchronised.

Uncertainty

The value of an energy investment is subject to major uncertainties. In the past two decades, the regulatory framework has evolved dramatically (liberalisation, unbundling, renewables support, emissions trading, nuclear phase-out and so on), and has certainly not yet reached a predictable steady-state. Future policy measures might change electricity pricing by making electricity cheaper at locations where it is plentiful and more expensive where it is rare, introduce new markets for capacity in order to provide a stable cash-flow for back-up power plants, increase the feed-in from renewable sources, or change the patterns of electricity demand by stipulating energy efficiency measures, demand response, electric heating and electric vehicles. All of these would have a major yet hard-to-predict influence on the need for new energy assets. This poses a significant problem for investments in transmission assets with their typical long lifetimes.

Different interests: stakeholders

Investment in transmission would be a lot easier if all major stakeholders had the same preferences. However, investor interests diverge and partly conflict (Sauma and Oren, 2009). Electricity generators in zones with low prices would like to be connected to higher price zones in order to export. Such connections would also be appreciated by the consumers in the zones with high prices. Meanwhile, generators in high price zones would prefer to prevent cheap imports, and consumers in low price zones do not want to compete with other customers for low-price electricity. The picture is even more complicated in zones with different seasonal price patterns. For example, storage operators prefer connections to zones with high price volatility because this allows them to buy at low prices and sell high. Consumers residing close to the storage capacity, however, are not fond of 'importing' higher volatility through a new line connecting to a zone with extreme price volatility.

Transmission system operators (TSOs) – the owners and operators of transmission infrastructure in one country[3] – also have complex preferences. They live from the regulated tariffs they charge to the users of their infrastructure. If regulators grant them the right to recover high rates of return on their transmission investments, they would prefer to overbuild the network ('gold plating'). Overbuilding the network means abundant capacity and peace of mind in terms of network operation. However, low regulated rates of return and the possibility to be reimbursed for costs resulting from managing an insufficient network might incentivise a TSO to delay investment. Additionally, TSOs might find that restricting cross-border flows is a cheap way to ensure national system security. Furthermore, if the TSO is still partly integrated with a generation company, the

'Many benefits of network extension can be equally well or better secured by changes at other levels of the value chain, such as better coordination, demand response, energy efficiency and generation management.'

3. Some TSOs operate in multiple countries (eg the Dutch TSO TenneT owns a central German TSO), others only in part of a country (eg the German TSO Amprion operates only in the western part of Germany).

incentives for the generation part of the business (eg enabling exports, preventing imports) might spillover to the preferences of the TSO (Supponen, 2011).

National energy regulators are typically biased towards short-term tariff reductions (Meeus *et al*, 2006). Hence, they often prefer tariff reductions over investment in transmission. Their task is to maximise the welfare of national network users, and, as such, they have no incentive to consider the positive cross-border spillovers of their decisions. Regulators risk being captured by some of the aforementioned interest groups (eg generators in importing zones).

Another group of stakeholders[4] is local residents, who often dislike new transmission lines in their backyards. A study commissioned by the European Commission has identified local opposition as one of the main obstacles to transmission system investment[5].

The issue of diverging stakeholder interest is amplified by the differing availability of information to different parties. The TSO has the best information on the cost of operating existing transmission lines and constructing new ones, while the generators/storage operators possess the best information on their own costs and extension plans. Consumers[6] have the best view of their future consumption. There is a risk that stakeholders might strategically withhold information or strategically react to the investment decisions of others (Sauma and Oren, 2007).

Different interest: countries

Conflicting interests are not restricted to individual stakeholders. Countries also have different preferences. Low-cost producers such as Norway might, for industrial and social policy purposes, want to restrain exports in order to restrict prices, while other countries strive to increase their exports. Transit countries know that if they build too many transmission lines, the price differentials between the country it imports from and the country to which it exports will decrease such that the total arbitrage rent (volume times buy price minus sell price) decreases. Thus, transit countries might want just enough international interconnection to maximise their rents. Due to the highly volatile national demand and supply position, the optimal transmission level for a country is difficult to establish analytically. Hence, national preferences with respect to individual projects are strongly driven by the advocating power of stakeholder groups.

On a political level, countries prefer to keep control of energy policy and are thus sceptical about increasing the levels of coordination and harmonisation. Hence, they retain the operation and extension of the transmission system as an issue at national level. As a consequence, the rules for incentivising transmission investments are different in the different EU member states[7]. National network extension plans are not regularly exchanged, and developments in the power plant park are not communicated to neighbouring TSOs. As a consequence, national energy strategies might be inconsistent – for example all Nordic countries plan to increase their energy exports – and internal network investments are ill-coordinated across borders.

Complex funding structures

Financing[8] new transmission investment is a challenge. Electricity networks are regional monopolies. So that this market power is not abused, TSOs are not free in setting the network tariff. In most EU countries, regulators try to ensure that the income of TSOs only slightly exceeds the operational and capital expenditure. To incentivise a TSO to construct new transmission infrastructure, the regulator allows the TSO to include all new assets in the 'regulated asset base' if they were part of the investment plan approved by the regulator. The regulator's approval is based on a more-or-less sophisticated cost-benefit analysis[9]. When the approved project is finalised, its capital cost

'National regulators are typically biased towards short-term tariff reductions. They often prefer these over investment in transmission. Their task is to maximise the welfare of national network users; as such, they have no incentive to consider the cross-border spillovers of their decisions.'

4. The interests of other stakeholder groups such as traders and power exchanges are not discussed here, although their business models (providing a national trading platform, arbitraging price-differential) are not always helped by more transmission investments.

5. Roland Berger (2011, p9): *"Project developers identify public opposition as a key problem"*.

6. This includes large industrial consumers as well as electricity suppliers that typically monitor the demand patterns of their final customers.

7. Hirschhausen *et al* (2012) provides a survey of the EU member states' transmission tariff structures. The UK, for example, has a sophisticated system that recovers different tariffs from network users in different locations, and provides signals for reducing system cost. Such sophisticated systems coexist with very simple approaches such as the Czech tariffs.

8. The complex question of the appropriate financial instruments for infrastructure investment (financing) is not discussed.

9. According to Supponen (2011) *"The regulatory treatment of transmission investments varies widely. In some countries practically all projects proposed by the TSO are allowed to be passed on to the asset base. In other countries regulators or governments need to approve all investment projects before they are allowed to be financed via tariffs"*.

becomes part of the 'regulated asset base'. The TSO can now pass on the higher cost[10] to the network customers. In short, a national regulator approves – based on the welfare of national consumers – the investment plan of a national TSO that is then allowed to claim back the capital cost from national customers[11]. This model has proved workable in the national context. However, in the international or cross-border context it fails because both domestic and cross-border transmission lines cause significant spillovers onto neighbouring countries' networks that are not properly considered by national regulators and TSOs. The most straightforward problem is that the benefit of a new cross-border line might concentrate in one country, while its cost mainly accrues in another. The regulator in the latter country will not be inclined to approve a corresponding investment plan. The extreme version of this case is that a domestic line in one country to reduce congestion in a neighbouring country would never be approved by the first country's regulator. In addition, cross-border lines – even though they have a net benefit – might, for example, shift welfare from consumers to producers within a country. If regulators focus in their cost-benefit analysis only on consumer welfare, they might be inclined to oppose such projects. As a consequence, network development based on national cost-benefit analysis is not going to deliver an efficient European electricity network.

THE FAILINGS OF THE CURRENT APPROACH

The European Union's approach to overcome the obstacles to network investment in a liberalised single electricity market with high renewables penetration is twofold: the writing of market rules, and measures to support network development.

Market rules

The European Union is committed to establishing the single energy market by 2014[12]. To this end it has defined a "target model" for the integration of wholesale electricity markets[13].

The target model would overcome the fragmentation of European electricity markets by harmonising the rules governing the operation of cross-border infrastructure, and by making electricity tradeable across borders. The Agency of European Regulators (ACER) and the European Network of Transmission System Operators (ENTSO) are leading the process to prepare the necessary harmonised regulatory framework. The ultimate aim is a single European market with a single European electricity price. This would reduce the average cost of the system because it implies that only the cheapest available power plants would be running to meet demand. Price differentials between countries would in this model only be acceptable if no additional trans-

BOX 1: NATIONAL NETWORK OPERATION IN A SINGLE MARKET

The operation of national or sub-national electricity networks has significant spillover effects onto neighbouring systems. These interdependencies were highlighted by the 2006 blackout in Germany that spilled over as far as the Iberian Peninsula, and by the 2003 blackout in Italy caused by a failure in Switzerland. The tedious searches for the parties responsible for these major incidents are a clear indication of the complexity of the electricity system and its governance.

Different TSOs have drawn different conclusions from the blackouts and the increasing injection of only partly predictable wind and solar power: (1) the Dutch TenneT and the Belgian ELIA tried to improve their capability to deal with cross-border events by merging with German TSOs, (2) several TSOs are installing devices to limit cross-border flows[14], in order to retain control over their domestic systems, (3) groups of TSOs established two regional centres for coordinating electricity system operation[15]. Nevertheless, all systems are still operated nationally and collaboration is limited to ad-hoc initiatives. To prevent black-outs, the inadequacy of the cooperation arrangements for managing the real-time electricity system are currently resolved by imposing high security margins[16] and by accepting inefficient nationally-focused operational decisions[17]. This ultimately has an impact on the demand for transmission assets (for example, more phase-shifting transformers[18] and fewer cross-border lines).

10. Regulated rate of return times 'regulated asset base'.

11. In addition, single purpose lines to connect new users are often funded by the new generation, storage, or consumption unit that required the connection.

12. European Council Conclusions, 4 February 2011.

13. This was agreed by the Florence Forum, a platform for regulators, stakeholders and the Commission: http://ec.europa.eu/energy/gas_electricity/electricity/forum_electricity_florence_en.htm.

14. The Netherlands and Belgium have installed phase-shifting transformers that allow the loading of individual transmission lines to be controlled. The transformers can be used to avoid system-destabilising inflows of electricity from Germany (caused by unexpected wind-injections). Poland is also considering this.

15. Five major TSOs set up Coreso, a Regional Coordination Service Centre in 2008 in central western Europe, and eleven TSOs set up the 'TSO Security Cooperation' in central eastern Europe. The Commission is helping by funding research on enabling the international exchange of electricity operation data.

16. That is, TSOs reduce the transmission capacity available for commercial transactions in order to have enough flexibility in case of unexpected events.

17. A hypothetical, though not unrealistic, example might be a German nuclear power plant close to the Dutch border (NPP Emsland) being switched-off because of high wind penetration in the North Sea at the same time that the less-than-100km away Dutch

mission capacity is available to bring cheap power (eg produced by wind turbines) from one country to another where it could replace expensive generation (eg produced by gas turbines).

The envisaged changes to the market framework might, however, be insufficient. First, network congestion within countries will be dealt with differently from network congestion between countries. This discrimination is necessary to be able to consider countries as single price zones. For example, the price of electricity in the port city Hamburg is the same as in Freiburg in southern Germany even when the 600km transmission line between both cities is congested because of an abundance of power from coastal wind turbines. At the same time, the price in Freiburg might be different from the price in Colmar, 30 kilometres away in France, even when the transmission line between Freiburg and Colmar[19] is not congested. Such a disregard of physical infrastructure, implied by the imposition of country-based price zones, induces an overly conservative calculation of cross-border transmission capacities. The end result is higher-than-necessary price differentials between the zones/countries.

Second, the harmonisation of rules relevant for cross-border trade[20] is organised as a bottom-up agreement between system operators based on general framework guidelines. These rules will be codified in the form of twelve 'network codes' that deal with technical issues such as the allocation of cross-border transmission capacity or the requirements for generators. Due to the complexity of the electricity sector and the widely differing preferences of stakeholders, a compromise risks providing no more than fairly general direction. In addition, the short timeframe for drafting the network codes – only 12 month are foreseen in order to complete the process in time for the 2014 deadline – could give undue influence to the TSOs that have a significant information advantage with respect to technical issues, and which are responsible for drafting the codes. It is, for example, conceivable that TSOs will shift costly responsibilities for system stability onto network users. The tight political deadline might force ACER and the European institutions (Council, Parliament and Commission), that have to adopt the codes through comitology, to favour speed over thoroughness. Only when the network codes are implemented we will learn how widely they might be interpreted. Consequently, this approach might lead to a wide range of rules in the participating national systems, which is unlikely to bring about workable interfaces at all borders for all dimensions of electricity trade.

Third, a more general point. According to the target model, the single electricity market will only provide harmonised signals for the operation of existing assets (including generation, transmission, storage and demand-side response). National markets/regulations will remain pivotal for investment in new assets. Nationally implemented markets for capacity and ancillary services favour the construction of certain technologies in certain countries. In 2010, about 40 percent of newly installed power plants in the EU were either wind or solar (Jäger-Waldau *et al*, 2011). These types of plants are largely built based on national support schemes and are thus exempted from the single electricity market. If the share of nationally organised electricity sector segments (renewables, capacity mechanisms, ancillary services) continues to increase at the current pace, a 'deep single market' that also drives optimal investment decisions will be unachievable.

Consequently, the target model – even if fully implemented – is unlikely to deliver a fully-fledged single market in which it is irrelevant for the remuneration of a supplier whether it is sited in the same or a different country to its customer.

Building the network

The establishment of sufficient energy infrastructure is the second part of the EU's vision for a single energy market. The Commission has estimated that €142 billion will have to be spent on electricity grids up to 2020[21]. There are diverse motives for extending and reinforcing the transmission network. Additional power lines might help the integration of renewables and produce implicit environmental benefits by, for example, allowing well-connected wind-turbines to replace generation from polluting conventional power plants[22]. Other reinforcements increase the reliability and operational flexibility of the transmission system or reduce congestion, dispatch costs

gas-fired plant Harculo needs to be switched on. As operational data is not disclosed, it is impossible to assess the frequency and economic cost of corresponding incidents.

18. See footnote 14.

19. There is a high-voltage link between Muhlbach (France, close to Colmar) and Eichstetten (Germany, close to Freiburg).

20. Rules not directly relevant for cross-border trade remain within the remit of national system operators.

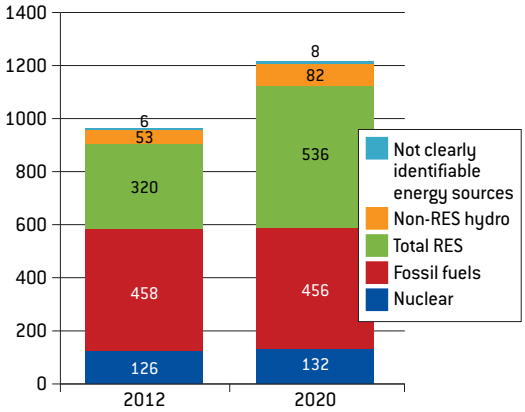
21. European Commission (2010a).

22. According to Benatia, D., N. Johnstone, and I. Hašcic (2013) the additional cost of meeting the renewables targets in the EU by 2020 in a grid shortage scenario could be US$ 37.8 billion compared to the baseline. By contrast, a grid expansion scenario might save some US$ 29.7 billion compared to the baseline.

and losses. Furthermore, network investment that allows more electricity to be transmitted to certain areas can substitute investment in generation or storage in import-constrained areas ('load pockets'). Finally, a substantial benefit of transmission reinforcement is its mitigating effect on local market power, exercised by generators in load pockets (Awad *et al*, 2006). The diversity of the motivations makes it difficult to establish the total investment needed for the most cost-effective network development. However, there is a need to increase transmission investment in Europe for three reasons[23].

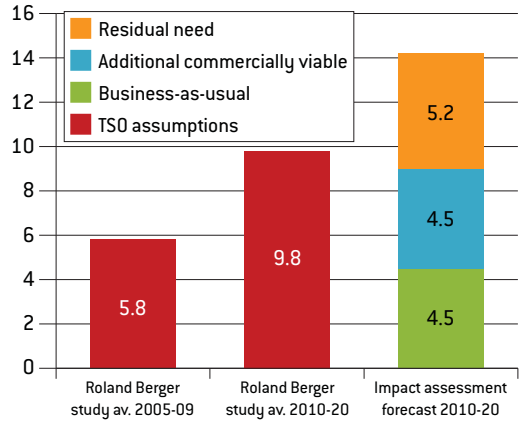
First, investment has dropped to a historic low in the past decade, resulting in some modernisation backlog. Second, the massive deployment of renewables (see Figure 1) will require additional investment in order to adapt the network to the changing location of electricity generation, and to allow for the wide geographic averaging of electricity injections from intermittent sources[24]. And third, in order to develop the single market, sufficient electricity flows across borders need to be enabled.

Figure 1: Changes in the European fuel mix assumed in the transmission system planning



Source: ENTSO-E (2012).

Figure 2: Annual electricity transmission investment (past, forecast and need in €bns)



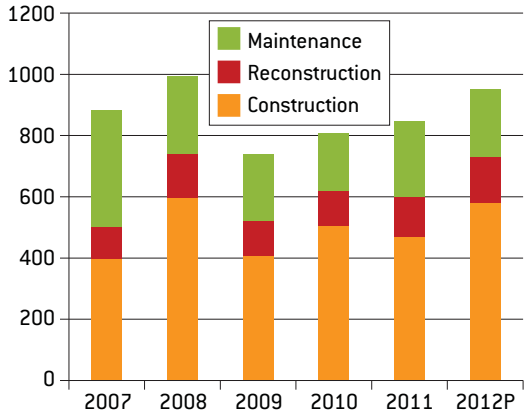
Source: Roland Berger (2011), European Commission (2010a).

According to the Commission[25], about €45 billion of investment in electricity transmission infrastructure in Europe is planned between 2011 and 2020. According to the Commission figures, this amounts to only half of the 'commercially viable' (€90 billion) potential investment, and about a third of the 'total investment need' (€142 billion – see above)[26]. The assessed total investment need exceeds the Transmission System Operator (TSO) investment forecast, of €98 billion between 2010 and 2020, compiled by consultants Roland Berger (2011) for the European Commission (Figure 2)[27]. Consequently, the Commission's assumptions imply a significant gap.

While the TSO forecast and the European Commission proposal both foresee significant growth in transmission investment, there has been no noticeable increase. For example, current investment in Germany is at the same level as in 2007-09 (Figure 3)[28] and net transfer capacities with neighbouring countries have not increased.

By contrast, transmission investment is on the rise in the United States and China. In China, in 2009 alone, 2078 km of ultra-high voltage transmission lines were added and state investment in the power transmission system was €38.5 billion

Figure 3: Transmission investment in Germany in €millions



Source: Bundesnetzagentur (2012).

23. For a more detailed discussion see Zachmann (2010).

24. According to the ENTSO-E Ten-year network development plan 2012, RES integration is the major concern for grid development.

25. European Commission (2010a)

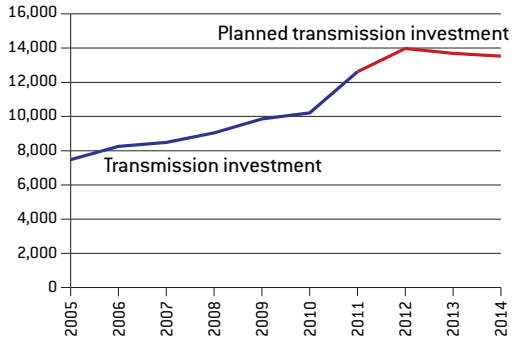
26. The underlying estimation is based on transmission investment estimates by ENTSO-E, as well as assumptions about the offshore grid and smart-meter deployment cost.

27. The quality of the Roland Berger figures cannot be evaluated as the methodology has not been disclosed.

28. Note that the figures for 2012 are planned volumes that are likely to be revised downward. In 2011 the value for construction had to be revised from €530 million to €470 million.

(Cheung, 2011). In the US, the recent increase in transmission investment is predicted to continue from, currently, about €7 billion per year to €10.5 billion per year (see Figure 4). Even though investment volume is an imperfect proxy for transmission system improvements, Europe appears to be falling behind on this critical issue, even though it is considered crucial for achieving all three energy policy goals: security, competitiveness and sustainability[29].

Figure 4: Transmission development in the US, transmission investments in IOUs, US$ bns



Source: Edison Electric Institute.

Infrastructure development is, of course, not primarily about the kilometres built and the money invested, but about the substantive improvement of the network's capabilities. Hence planning and funding the right projects is crucial.

Currently, network extension in most EU countries is based on decentralised planning. TSOs forecast future power plant fleets and electricity demand in their areas. They deduce from these forecasts the likely need for new lines. National TSOs differ in the degree to which they coordinate with power plant and storage facility investors, administration, regulators, consumers and foreign TSOs. Since 2010, TSOs share some of this information with the European Network of Transmission System Operators for Electricity (ENTSO-E) which uses these inputs to build a 10-Year Network Development Plan. This European plan was the first common European network modelling exercise based on massive data gathering and a structured consultation process. Hence it is a big step towards more transparent and more common network planning. The European plan identifies extensions, which affect transfer capabilities between individual TSOs, needed in addition to what the TSOs are planning for themselves. Supponen (2011) has noted *"ACER has to give an opinion on the ten year network development plan and to verify that the national plans are coherent with the European ten year plan. If they are not, ACER shall make recommendations to amend either the national plan or the ten year plan. ENTSO-E and the ACER shall monitor the implementation of these plans"*.

Currently, the European plan is a non-binding proposal by ENTSO-E to the individual TSOs. In addition, no stakeholder is legally accountable if the information it transmitted to ENTSO-E, on which the European plan is based, proves wrong ex post. Hence, the plan cannot ensure synchronisation of the different stakeholders' investment decisions[30]. The lack of accountability for the accuracy of submitted information may allow individual stakeholders to distort or hide information in order to influence the overall European plan. The evolution of the status of the individual projects in the 2010 plan reported in the 2012 TYNDP indicates that about half of the projects are delayed. According to this report only 52 percent of the projects proceed as planned, 28 percent are postponed because of delays in the authorisation process, 6 percent are delayed because generators rescheduled their plans and 13 percent are delayed for other reasons.

The non-binding nature also casts a degree of doubt over the credibility of the European plan as it may allow individual TSOs to delay investments in certain lines they are not particularly interested in[31]. This uncertainty may discourage generators from coming forward with investments, the profitability of which depends on the realisation of certain lines. Finally, the technical planning and the resulting selection of projects is not transparent. The model and major assumptions are not disclosed. Consequently, challenging the set-up proposed by ENTSO-E is virtually impossible.

Funding for most projects in the European plan will have to come from regulated tariffs. For projects with international spillovers this raises the issue of cost allocation. To date, only if the benefits of a project are very high, do the corresponding TSOs and regulators find ways to agree on cost-sharing. In all other cases, the absence of a commonly accepted cost-benefit analysis prevents quick agreement on multilateral projects. A workable

29. The European Commission (2010a) impact assessment even claims that increasing infrastructure investments would have a measurable impact on EU GDP.

30. This lack of enforceability also holds true for most national plans.

31. Delays that essentially represent a lack of interest of the TSO in a certain line can easily be justified on the basis that finance is lacking, authorisation is delayed or that there is local opposition.

compromise on rules to allocate investment costs incurred in one country to benefiting network users in another is not in sight.

For some cross-border projects – such as the sea cables between Norway and the Netherlands – a second funding scheme has been tested. Investors might seek the right to use a transmission line exclusively for some time. They then can earn money by selling line capacity to traders or by using it themselves to transport electricity from a low-price area to a high-price area. This is known as the merchant interconnector approach. This approach suffers from the drawback that the optimal investment for an individual company is less than the socially optimal investment – if the interconnector is too big, the price difference between the zones collapses and there is no more money to be made through arbitrage. Hence, profit-maximising merchant investors have systematically under-built network extensions. Furthermore, such an approach is not well suited for complex networks.

In order to nevertheless deliver the necessary infrastructure, the European Commission proposed an Infrastructure Package[32] in the autumn of 2011. On 27 November 2012 an informal agreement on the package between the European Parliament, the European Council and the European Commission was reached[33]. The proposal defines a small number of trans-European priority corridors on which European action for energy infrastructure should primarily focus. The Commission will identify 'projects of common interest' that are necessary to implement the corridors[34].

To fund these projects of common interest, the regulation provides rules for possible cross-border allocation of construction costs and determines the conditions for eligibility of these projects for EU financial assistance. EU funding for this regulation is to be negotiated in the context of the Connecting Europe Facility financing instrument. The Commission has proposed that €9.1 billion be allocated to energy infrastructure in the next multi-annual financial framework (2014-2020). On 8 February 2013 the European Council agreed to reduce the amount to €5.1 billion[35]. Furthermore, the focus on a limited number of projects risks ignoring the system nature of the meshed energy network. Consequently, the emphasis might be on building more border crossings rather than investing in the most efficient marginal improvements. In addition, in order to satisfy private or public interests (eg for low or high prices), only lines with limited impact might be brought forward. Finally, despite detailed criteria, the ultimate choice of projects to be granted the 'common interest' status might not be driven by efficiency motives, but by the requirement to disburse the scarce EU budget money 'fairly'.

Consequently, the infrastructure package is unlikely to be a major breakthrough in the development of infrastructure for the single European electricity market.

A PROPOSAL

The European Commission's proposal is supposed to deliver more cross-border electricity transmission. It is an extension of the current system of national-welfare centred regulations, a system which does not target the optimisation of the EU electricity network, and as such is inconsistent with a truly single market. However, the integrated first-best solution – a single European system operator, regulated by a single regulator, which develops the network in coordination with generators and consumers – appears politically infeasible. To overcome this, we propose a bold blueprint for a European system to fund and incentivise infrastructure development. The approach is fourfold: (1) implement vertical unbundling; (2) add a European system-management layer; (3) establish a stringent planning process; and (4) phase-in European cost-sharing.

Implement vertical unbundling

Léautier and Thelen (2009) find that vertical separation is one key-requirement (the other being a well-designed incentive scheme) for reducing network congestion. It is important that transmission system operators should not be concerned with the interests of affiliated generators. The legal basis for this has already been adopted in the third EU energy sector liberalisation package of 2009. Implementation of the unbundling requirements should have been done by 3 March 2012. The European Commission acknowledges that in most

32. European Commission (2011c).

33. See http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/trans/133926.pdf.

34. The Commission will adopt the first Union-wide list of projects of common interest on the basis of the regional lists by 31 July 2013.

35. The initial European Commission proposal for energy in the Connecting Europe Facility amounted to €9.1 billion. The Van Rompuy proposal foresaw only €8.3 billion and the Cypriot presidency proposed €7.1 billion on 29 October 2012.

member states the unbundling provisions are not yet fully transposed[36].

Add a European system management layer

National system operation has major spillovers onto neighbouring countries, but also affects network investment incentives. Uncoordinated system operation increases the incentives for national operators to close their borders in order to ensure system stability. The straightforward way of escaping this dilemma is to add a European system management layer, in other words, centralising and monitoring electricity system information in real-time. This would enable throughput of electricity through national and international lines to be safely increased without any major investments in infrastructure. This would neither require TSOs to merge or to be expropriated, nor would it substantively infringe on national sovereignty over the security of national electricity systems. A European control centre would complement national operation centres and help them to better exchange information on the status of the system, on expected changes and on planned modifications. The ultimate aim should be to transfer the day-to-day responsibility for the safe operation of the system to the European control centre.

To further increase efficiency, electricity prices should be allowed to differ between all network points across and within countries. That is, electricity in Hamburg might be cheaper than in Munich on the wholesale market if there is a lot of wind in the North Sea, while the sun is not shining on Bavarian solar panels[37]. This would provide the correct incentives for switching off coal-fired power plants in the north and switching on gas turbines in the south in order not to overcharge the network. In addition, investors in generation (or load) will base their location decisions on these locational price signals. This will reduce congestion over time, by creating an incentive for generation/load to move to net electricity deficit/surplus areas.

Establish a stringent planning process

Current approaches to network planning suffer from a number of shortcomings: they essentially reflect the interests of TSOs, which make planning decisions without full information about cross-border impacts; the plans are non-binding, meaning stakeholders are not obliged to comply, and so do not provide the necessary synchronisation of investments in the energy system; the planning process is non-transparent as far as the modelling is concerned; and the planning process is 'technocratic' in the sense that it does not *a priori* take the concerns of residents into account. Some of these issues have been addressed effectively in other countries (see Box 2 for one example).

Harmonising national network planning rules is administratively difficult and would take many years. To avoid this, the European approach is to use the ten-year network development plan (TYNDP) to ensure the consistency of the results of national planning with European objectives. To achieve this, ACER must provide opinions on the consistency of the individual national ten-year plans with the TYNDP. However, the consistency of national plans with European objectives cannot be enforced by ACER or any EU institution (Commission, Parliament and Council) – Regulation 714/2009 explicitly refers to the *"non-binding Community-wide ten-year network development plan"*. Hence, to safeguard consistency of individual national network plans and to ensure that they contribute to provide the infrastructure for a functioning single market the role of the TYNDP needs to be upgraded. This could be enacted by obliging national regulators to only approve projects proposed by European planning unless they can prove that deviations are beneficial.

The boosted role of the TYNDP that this would entail would need to be underpinned by resolving the issues of conflicting interests and information asymmetry. Two approaches to this are conceivable: first, relying on thorough cross-checking of ENTSO-E proposals by the regulator, or, second, shifting the entire planning process to an independent body.

In the first case, ACER should be requested and authorised to thoroughly check that the TYNDP maximises the welfare of current and future European citizens and that national plans are consistent with the TYNDP. This implies that ACER would not only rely on the modelling results that TSOs

36. European Commission opinions on the national certification of TSOs (see http://ec.europa.eu/energy/gas_electricity/interpretative_notes/certification_en.htm) reveal that most TSOs did not fulfill at least some unbundling requirements.

37. In contrast to 'zonal' approaches that allow prices to differ between predefined zones, nodal pricing has three advantages: (1) there is no risk of having to redefine price zones and all contracts that are based on them when the network layout changes; (2) all dispatch operations are fully transparent and based on one single algorithm; and (3) it is likely that for political/administrative reasons suboptimal national zones would be preferred over 'optimal' zones.

use to justify their plans, but would have tools of its own for impartial evaluations. ACER should not resort to consulting proprietary models that are not fully disclosed and that have to be repeatedly procured. Instead, ACER – or another public body – should invest in the capabilities to build, manage and use a European open-source energy model. Based on a substantial upfront investment in a suitable model, ACER would structure a process in which all relevant stakeholders can support ACER by updating the assumptions and the modelling. Individual stakeholders will still have better information on their parts of the electricity system. TSOs will know the network better than any independent network modeller, generators will have a clearer view of their individual plans, large consumers (including distribution system operators) will have more information on their future load, and residents will best be able to evaluate the acceptability of proposed lines. Thereby, ACER's power to approve the TYNDP based on its own modelling results would shift the burden of proof to the stakeholders (including ENTSO-E) in case they disagree with ACER's conclusions. This would give the stakeholders an incentive to disclose private information. In addition, the open-source nature of the model would allow inconsistencies to be identified, and improvements to be proposed. Of course, state-of-the-art could only be ensured by continued investment in the model's capabilities[38].

In the second case, resolving the issues of conflicting interests and information asymmetry in network planning could also be achieved by building on the significant effort that ENTSO-E has made in developing the TYNDPs. Using the TYNDP expertise would require that its governance structure be made independent from the interests of TSOs. Hence, a dedicated TYNDP governance structure should be developed that is representative of all electricity sector stakeholders (in a membership committee). An executive board that is independent from industry interest should have full operational control. Finally, the by-laws of the institution governing the TYNDP would need to ensure that the model used for planning is made fully transparent and open source.

Irrespective of the model chosen ('cross-checking' or 'independent planning') it is essential to make both stakeholders' inputs and the final plan binding in order to improve the synchronisation of investment. That is, stakeholders which, for strategic or other reasons, deviate *ex post* from their predictions (eg building a power plant or consuming electricity at a certain point of the network) will be liable to claims for damages from other stakeholders.

Finally, planning will not be able to make all stakeholders equally happy. And certain choices that do not affect overall welfare might have substantial redistributive effects. To rectify the distributional consequences, an ultimate political decision by the European Parliament on the entire plan could open a negotiation process around selecting alternatives and agreeing compensation. This need for democratic approval ensures that all stakeholders have an interest in ensuring a maximum degree of balance of interest in the earlier stages. In fact, transparent planning, early stakeholder involvement and democratic legitimisation are well suited for minimising as much as possible local opposition to new lines.

The delivery of the plan would then be left to the TSOs or any other investor willing to deliver individual lines according to the regulated conditions. In case of multiple interests, the national regulator might choose the best value offer.

Phase in European cost-benefit sharing

A critical element in the discussions about EU electricity networks is cost and benefit sharing. Different stakeholders have diverging interests, and it sounds unnatural to require stakeholders to pay for a transmission line that actually reduces their profits. On the other hand, stakeholders that are the major beneficiaries of a new line should not be able to pass all the cost onto society.

'Critical to the discussions about EU electricity networks is cost and benefit sharing. It sounds wrong to require stakeholders to pay for transmission lines that reduce their profits. However, stakeholders that benefit from a new line should not be able to pass all the cost onto society.'

38. *"The extension of current planning methods to a fully integrated network planning for transmission (onshore and offshore), distribution, storage and electricity highways for a potentially longer timeframe will be needed. CO2 infrastructure, that does not currently exist, will be required and planning should be started soon,"* (Energy Roadmap 2050).

BOX 2: THE CALIFORNIAN EXPERIENCE

The United States' transmission systems are operated through a wide spectrum of regional schemes – some have sophisticated wholesale markets and independent system operators (ISOs), while others possess neither. However, motivations for transmission investment are largely the same as those in Europe: deployment of intermittent renewables (47 GW of wind in 2010), historic investment backlog and regional integration within the US. However, the way the investment needs have been addressed, and the levels of success in addressing them, differs markedly in the US, which has been more successful. In the period 2007-11 a total of 16,000 km of new lines were installed[39] and the volume of investment shows an increasing trend (Figure 4).

California ISO (CAISO) is one example of a successful US model. CAISO is responsible for the operation and extension of a large portion of the California grid but the grid hardware itself is owned by the transmission owners (TOs)[40].

Funding: CAISO collects a regulator-approved transmission charge from all consumers connected to the CAISO grid. It retains a grid management charge, and redistributes revenues from the transmission access charge to participating TOs. The tariffs of TOs joining the CAISO grid are transitioned into a grid-wide transmission charge over a 10-year period. CAISO revenues are determined by the regulator.

Operating: CAISO optimises the entire electricity system centrally by setting higher prices in import-constrained parts of the network and lower prices in export-constrained parts.

Planning: CAISO has developed a formalised 23-month transmission planning process, TEAM, which attempts to incorporate five main principles into their planning studies: benefit framework, full network representation, market prices, explicit uncertainty analysis and interactions with other resources. TEAM includes a cost-benefit analysis of investment proposals which uses flexible weighting of the different welfare components, allowing for the assessment of a proposal from the perspectives of different stakeholder groups (Wu *et al*, 2006). The result is a project submission window in which transmission element proposals (both economically driven and policy-driven) are evaluated, and project sponsors are selected to construct and own the approved elements.

The process has been very successful in incentivising the construction of approved transmission lines. An impressive 87 percent of the transmission lines approved in 2005 had been completed by 2009[41]. Since 1999, transmission investment has increased by 84 percent. A ratepayer organisation claims that this 'success' essentially represents excess transmission being funded through increasing tariffs (since 1999 load has only grown by 9 percent in that time)[42]. The organisation asserts that reasonable, and perhaps economic, alternatives (some non-infrastructure) are not being considered. Indeed, the US Department of Energy has begun to look at non-transmission alternatives. From a European perspective the possibility of the oversupply of transmission, and the developing discussion about how to encourage non-transmission alternatives, are a testament to the success of models like CAISO that allow the discourse to be elevated a higher level.

Hence, all easily attributable cost should be levied on the responsible party. If new generation requires grid reinforcements, the reinforcements should be largely paid for by the generator. In this way, the investor has the right incentives to trade-off high locational prices in one place (eg close to consumption centres), with cheap network access in another place (eg in a zone where an old power plant has recently been shut down), and good access to resources in a third place (eg for a wind turbine, a zone with high constant wind)[43].

For all remaining network extension the question is how to share the cost[44] between network users in different regions. Having all line extensions in Sweden being equally financed by Bulgarian network users seems difficult. Having a Belgian line that is required to accommodate loop-flows caused by inner-German imbalances being paid for only by Belgian network users is not reasonable either.

Based on the assumption that the outlined network development plan delivers an efficient

39. Staff Database and US Electric Transmission Projects © 2012 The C Three Group, LLC.

40. In contrast, European TSOs own the grids that they operate.

41. 2009 ISO/RTO Metrics Report.

42. http://www.ucan.org/files/CAISOplanningreport.pdf.

43. As the grid enforcements required by a new generator might also benefit society, not all cost should be levied on this investor. Olmos and Perez-Arriaga (2009) have, for example, developed a model for optimal network charges.

44. It would be sensible to harmonise the allocation of network cost to different types of network users (consumer, generator, storage) across countries. According to Billette de Villemeur and Pineau (2012), trade between different regimes can increase inefficiency. For example, if in some countries only consumers have to pay the the entire network cost while in another all costs are borne by the generators, more generators will move to the first country and more (industrial) consumers to the second country. Hence, more electricity will have to flow between countries and congestion is likely to increase.

proposal, and that new generators have to pay deep connection charges, we suggest that some redistribution is unavoidable. The reason is that, so far, even the most sophisticated cost-benefit analysis models have been unable to identify the individual long-term net benefit in an uncertain environment. For all infrastructure (eg rail and road) there is some socialisation of the costs of individual projects within the different regions of a country. Hence, we propose that consumers in all nodes that are predicted to receive more imports through a line extension should be obliged to pay a certain share (eg half) of the line extension through their network charges, while the rest of the cost is socialised to all consumers[45]. Such a cost-distribution scheme will involve some intra-European redistribution from the (infrastructure-wise) well-developed countries to the laggards. However, such a scheme would perform this redistribution in a much more efficient way than ad-hoc disbursements by the Connecting Europe Facility to politically chosen projects, because it would provide the infrastructure that is really needed.

CONCLUSION

Implementation of this proposal will deliver the infrastructure needed to achieve the European energy policy targets in the field of electricity. It will increase the reliability of the network, enable a truly borderless European electricity market, and facilitate the integration of renewables. If the EU decides to wait for the results of the non-binding plan to materialise in the 2020s, valuable time will have been lost. All approaches involving throwing money at the problem to achieve flagship projects will fail to resolve the complex underlying issues. After three energy sector packages and 20 years of work, the EU possesses many of the key institutions and laws necessary for achieving the single electricity market. In the past, the benefits of a more coordinated system have not been great enough to outweigh the significant political and transaction costs required to achieve such a system. However, recent developments (unbundling, renewables, more trade) have substantially increased the value of greater coordination. Thus, it is the right time for the EU to take a bold step towards a borderless electricity infrastructure.

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