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WORKING PAPER

**Reforming the EU internal electricity
market in the middle of a huge energy
crisis: an absolute short-term emergency
or preparation for the future?**

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Abstract

Having identified the basic characteristics of the current energy crisis and its particular shape in the European Union, three questions immediately arise. 1) If gas is at the 'core' of the EU mix of energy crises, why hastily reform the internal electricity market? Is the electricity market badly affecting the gas crisis, amplifying it or worsening its consequences? Are we short of sufficiently good emergency tools to immediately intervene against the detrimental effects of the EU gas crisis on the EU electricity market and vice versa? 2) If one assumes that most of the detrimental price effects of the gas crisis can be addressed with regular EU emergency tools, should we nevertheless revisit the EU electricity market to make it stronger vis-à-vis such a major energy shock? Would strengthening our internal EU electricity market against future energy shocks reinforce or weaken our well-established policy of securing an EU decarbonisation path to 2030 or 2050? 3) If strengthening and reforming our EU electricity market can help our EU electrification strategy and our general path to decarbonisation, can we already foresee other conditions and constraints which could slow down or block this securitisation of our energy future?

Keywords

Energy crisis; Electricity Market Reform; European Electricity Market Design; European Energy Security; European Energy Transition

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Introduction

What particularly differentiates the EU mix of energy crises from that of other leading economic regions is the key role played by the threat of a gas shortage entirely driven by Russia not feeding its network of gas pipes to meet EU demand [Ref. *IEA Outlook; Corbeau; Charbonnier; Tubiana*]. Fighting a war of aggression in Ukraine, Russia is both financing the war effort with energy exports and trying to leverage its energy dominance. This dominance regarding the EU was established before the current crisis as Russia was the EU's top supplier of oil, coal and gas. Oil has a substantial world market, and coal several regional ones. The difficulties and tensions involved in the current world energy crisis have many common features all over the world and some balancing forces are globalised, whereas the EU natural gas crisis is related to the existence of pipelines.

Continental gas pipe networks are strongly 'specific' assets. The only 'open' network for world gas exchange is that for LNG made of liquefaction and regasification units connected with fleets of specialised LNG ships. In practice, it takes years to expand this LNG market infrastructure. A lack of supply through a substantial gas pipe in a given region cannot be quickly or easily absorbed by existing LNG players [Ref. *IEA EU Gas crisis*]. If the EU cannot receive enough gas from new gas production somewhere in the world and cannot reduce its gas demand according to the Russian reduction of supply it can only try to -grab gas from the existing world short-term LNG market by offering a substantial premium to incentivise countries to re-route this gas to the EU. This game is mainly played against Asia, which is the biggest non-EU part of the world LNG market. The EU is rich enough to easily starve poorer countries like Bangladesh and Pakistan, where the gas shortage has subsequently been more dramatic. It is more difficult with stronger and richer countries like Korea, Japan and China. There it will depend on the exact short-term needs of these countries, on the economic effects triggered by the premium offered by the EU and on the concrete possibility of energy substitution to avoid needing very expensive gas to be re-routed to the EU.

Having identified the basic characteristics of the current energy crisis and its particular shape in the European Union, three questions immediately arise.

1) If gas is at the 'core' of the EU mix of energy crises, why hastily reform the internal electricity market? Is the electricity market badly affecting the gas crisis, amplifying it or worsening its consequences? Are we short of sufficiently good emergency tools to immediately intervene against the detrimental effects of the EU gas crisis on the EU electricity market and vice versa?

2) If one assumes that most of the detrimental price effects of the gas crisis can be addressed with regular EU emergency tools, should we nevertheless revisit the EU electricity market to make it stronger vis-à-vis such a major energy shock? Would strengthening our internal EU electricity market against future energy shocks reinforce or weaken our well-established policy of securing an EU decarbonisation path to 2030 or 2050?

3) If strengthening and reforming our EU electricity market can help our EU electrification strategy and our general path to decarbonisation, can we already foresee other conditions and constraints which could slow down or block this securitisation of our energy future?

I will now look more closely at these three questions.

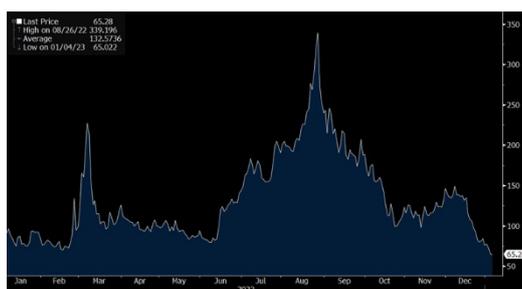
1. If gas is at the ‘core’ of the EU mix of energy crises, why hastily reform the internal electricity market?

Given the nature of the current energy crisis, which is a combination of crises affecting the three main fossil fuels (oil, coal and gas), and its particular European shape consisting of a threat of a gas shortage caused by Russia, it is legitimate to ask why a reform of the internal electricity market is so important on the EU energy policy agenda. The most candid answer to this question is because we need to protect our internal electricity market from the gas crisis, to stop the gas crisis destroying all the benefits of the EU energy transition which was initiated in the first decade of the 21st Century and has the electricity sector as its strongest tool and achievement (we all know the EU’s ‘20-20-20 in 2020’). Therefore, we first need to consider if the electricity market is badly affected by the gas crisis, if it amplifies it or worsens its consequences. Second, we also need to consider if in the EU we are short of proper emergency tools to immediately intervene against the detrimental effects of the EU gas crisis on the EU electricity market, or vice versa. Finally, we must understand how to balance emergency tools to deal with emergency phenomena and structural remedies to deal with the same emergency features?

1.1 Is the electricity market badly affected by the gas crisis, amplifying it or worsening its consequences?

Yes, the electricity market is affected by the gas crisis. Electricity is not a primary energy resource. It is an energy vector which works by transforming primary energy resources into flows of electricity. At the time the EU internal electricity market was created about 25 years ago, gas was the most promising primary energy resource for electricity generation (“Dash for Gas”). And gas generators, CCGTs, were seen as powerful ‘game changers’ of the entire EU electricity landscape. In some countries, for example Italy, gas is still today the main source for electricity generation. Overall, in the EU internal market, gas is a very powerful resource needed for power generation. Particularly in winter, when in most places electricity demand is the highest, ‘flexible’ generation units like CCGTs are needed to meet our daily consumption peaks.

Figure 1. The wholesale price of gas in the reference Dutch market “TTF” (January 2022-January 2023)



Therefore, the EU wholesale electricity market transmits the very high gas prices it meets in the wholesale gas market. Furthermore, in a certain sense, electricity generation concentrates the gas price shock because electricity generation needs approximately two MWh of gas to generate one MWh of electricity. When the price of a MWh of gas increases by 100 euros (a new normal in year 2022) the price of CCGT electricity output increases by 200 euros per MWh. It is, of course, necessary to verify whether sellers of gas on the gas wholesale market and sellers of CCGT output on the electricity wholesale market abuse the new market situation. However, this is dealt with by the existing market surveillance authorities, which were created after the 2007-08 financial crisis. Therefore, unless it is contradicted by market surveillance, CCGT generators, in their electricity bids, only transmit the true costs created by the rising wholesale price of gas [Ref ACER-CEER; Commission de Régulation CRE France].

However, the existing pricing in the wholesale electricity market also amplifies the effects of the rising cost of gas on the wholesale gas market. How? The wholesale electricity market gives the price corresponding to the highest accepted bid to all the winning sellers. Since mid-2021 the highest bidder is very frequently a CCGT. If the demand cannot be met without any CCGT output, all the sellers get the same 'gas cost-based' price while not all of them are buying gas to generate electricity. This wholesale pricing rule is called '*marginal pricing*.' The unit producing at the margin of the market equilibrium sets the price for all sellers.

What is the rationale for this pricing rule? The first rationale is '*short term efficiency*' i.e. economising the variable generation cost. Under the pressure of this rule, each generator will bid the variable cost incurred when generating (not the fixed cost incurred when not generating) and not much more in order to be sure to be selected by the market to serve demand. The second rationale is '*long term survival*' i.e. also reimbursing the fixed generation cost. This fixed generation cost is reimbursed to many generators when another type of generator with higher variable costs is called on by the market to generate, and in this way creates a reimbursement of the fixed cost not covered at lower levels of market demand. This extra money to reimburse the fixed cost is usually called an 'infra-marginal rent.' When the size of the entire generating fleet has been well conceived and the proportions of the different generation technologies correctly anticipated into this fleet, these infra-marginal rents are able to cover the fixed costs of most of the generators and give them a regular profit [Ref. Green].

However, when an unanticipated 'supply shock' pushes up the variable cost of a technology absolutely needed by the market to cover demand, the formerly normal 'infra-marginal rent' received by the non-marginal generators turns into a 'windfall profit.' [Ref. Natalia Fabra; Pollitt; Grubb; Maurer & v.a.]. This is what the EU wholesale electricity market has been facing since the second semester of 2021. Non-gas generators, be they nuclear, hydro, wind, solar or even coal (despite the carbon price applied to coal generation in the EU), can benefit from 'windfall profits.' This worsens the consequences of the wholesale gas price shock by creating another supplementary price shock in the wholesale electricity market, a shock not coming from the genuine gas cost but adding another wave of price shock to it.

1.2 Is the EU short of proper emergency tools to immediately intervene against the detrimental effects of the EU gas crisis on the EU electricity market, or against electricity market mechanisms which worsen these detrimental effects?

Public opinion and the public authorities legitimately look for ways and tools which can either block the transmission of a genuinely higher gas cost or the creation of windfall profits in the wholesale electricity market. If the main aim is to smoothen the gas price shock and slow down the inflationary wave it creates and the corresponding loss of purchasing power, the simplest way is to isolate the retail electricity market from the wholesale trend with some re-regulation of retail pricing. This isolation can be relative, and the smoothening of the price shock is only obtained by delaying the reimbursement of the wholesale increase over a longer period. The French government did this in autumn 2021. It asked the gas suppliers to smoothen their tariffs over a longer period. The Danish authorities have been said to be thinking of transforming the price shock into a multi-year consumer debt. Several years ago the Spanish government created an enormous national consumer debt by blocking the recovery of renewable support schemes via retail tariffs.

Another simple, but hard, way is to prohibit any increase in the retail rate, making suppliers bear the wholesale shock on their own. Surprisingly, this was what was done in Britain at the beginning of the current wholesale price shock.

If the main aim is to control the increase in 'infra-marginal rents' and take back the 'windfall profits,' other tools can be used to intervene. A few wholesale electricity markets outside the EU previously used mundane tools to limit the 'infra-marginal rents' when the marginal bidders deviated from the ordinary cost trend (*Ref. ACER final assessment & RAP-Michael Hogan*). Some properly designed 'clawback mechanisms' let the wholesale market marginal pricing produce its 'short-term efficiency' outcome but blocked the corresponding excessive 'infra-marginal rents' by confiscating this revenue in the wholesale market.

Another way is to let the wholesale market do what it usually does and classically taxing 'ex post' the excess profits made by electricity-related companies (producers, pure traders or suppliers) by defining a reference 'normal profit' which will stay safe from the increased taxation. Even the new Rishi Sunak UK government has employed this extra-taxation scheme.

Other ways are also used. Some are simply practices which do not claim to be models, while of course they are because any way to actually control 'infra-marginal rents' and 'windfall profits' is genuinely a crisis-handling model. For more than a decade the public authorities in France have organised regulated access to nuclear electricity, which means a regulated price for some nuclear power. In 2022, 120 TWh of France's nuclear output were sold at 42-46 euros per MWh. This was more than 40% of the country's nuclear output. If you estimate that the average spot market price was maybe 200 euros more per MWh, 24 billion euros of infra-marginal rents were not cashed in. Furthermore, most of the professional renewable entities in France have long-term contracts with public authorities and the French regulator estimates that 30 billion euros of infra-marginal rents will be restituted to the public treasury by the renewable industry in 2022-23.

Other ways are more sophisticated, like the so-called 'Iberian Model.' It combines changes in the wholesale and retail markets. In the wholesale market, the price of gas used to generate electricity is halved by regulation. Therefore, the marginal electricity market price is also halved, as are the corresponding 'infra-marginal' rents. In the retail market, a charge is added to the wholesale supply price to compensate CCGT generators for the second half of the gas cost that was not taken into account at the wholesale level. This two-level manoeuvre is said to have decreased the Spanish wholesale supply cost to retailers by 15% to 20% [*Ref. Collado at Esade*].

Some others are quite straightforward, simple and effective. One is to let the gas and electricity markets do what they do but transfer to consumers enough revenue to compensate all or the worst effects of the price increase. This is known in the EU as the 'German Model.' In this way 100 to 200 billion euros can be transferred to consumers (professionals or households) [*Ref. Pototschnig Consumer protection*]. Another one is to cap the price of gas in its wholesale market. [*Ref Pototschnig-Conti; Neuhoff*]

We have seen seven different ways in which transmission of the gas price shock, or worsening of it, by electricity market mechanisms can be smoothed or blocked. What is striking, in an atmosphere in which the European authorities are so easily accused of insensitivity or rigidity, is that six of these ways have quickly been cleared by the European authorities (*Ref. European Commission Tackling Prices October 2022*) while the 'German Model' was needing some more EU review. It is therefore mainly a national responsibility to choose, calibrate and implement emergency measures to mitigate perceived and prioritised national emergency phenomena.

1.3 As the EU is not short of emergency tools to deal with a genuine gas shock or an electricity shock, how to balance the use of emergency tools to deal with emergency phenomena and the use of structural remedies (as in a market design reform)?

What is the best way to deal with emergency phenomena? With emergency tools or with structural remedies?

The answer to this legitimate question can be very pragmatic. It will take a minimum of a year (if we are lucky) to agree at the EU level on a draft electricity market structural reform, and two years more to have this new EU frame transposed into national law. This takes us to the end of 2025, with a new EU Parliament having been elected in spring 2024 and a new Commission formed in autumn 2024 – not a very effective way to address a gas or electricity shock supposed to calm down from 2025.

A more analytical answer looks at the characteristics of the aims and tools, and wonders if they match. Let's assume that the aim is to deal with a gas price shock which is expected to decrease from winter 2025-26 (as a warm beginning of January 2023 also suggested), and to protect some categories of consumers from its direct (gas price) and indirect (electricity infra-marginal rent) redistributive effects. Using emergency redistributive tools seems best, a priori, as it permits national authorities to better define their own particular national aims and better control for the adequacy of the national outcomes. The variety of emergency tools available gives the EU countries many alternative national choices, which a single uniform EU mechanism can hardly match or beat.

Furthermore, changes made to the electricity market framework are rarely unidimensional. Reducing by reform the price of a commodity when we face a direct shortage (as with gas) or an indirect shortage (as at peak electricity demand) does not cure the roots of the problem but feeds them. Any structural reform of the electricity market has to take this into consideration. More generally, the core rationale for a market structure cannot be to avoid passing to consumers the total cost of supply, including a normal profit. Voluntarily unbalanced retail pricing schemes, if they are massive, have strong long-term effects on the structure and evolution of the electricity sector. The typical long-term effect is termed 'low equilibrium': low quality of service, low security of supply, low investments etc., all of which are the opposite to what the EU wants. The EU electricity sector has strong primary goals of high-quality service, high security of supply, high investment, high electrification of energy consumption and fast and deep decarbonisation of electricity generation. All these primary goals call for keeping the daily electrical energy market safe from over-high price regulation and keeping its two legs working (short-term efficiency in the ranking of assets generating at each moment; and long-term financing of fixed costs neglected in the marginal bidding of each generator, via the receipt of infra-marginal rents).

In the EU, the daily electrical energy market plays another fundamental role which also has to be carefully considered. This daily exchange platform is the core of the European internal electricity market because it is the mechanism that daily allocates the use of transmission grid interconnections to sellers of electrical energy. This daily functioning of the EU internal electricity market among countries is fully automatized. Delivery of electrical energy between countries is executed according to market equilibriums realised in the various power exchanges. This automation of European cross-border delivery is a key feature and a strong benefit from the Europeanisation of electricity trade. It would be irresponsible to break or breach this remarkable 'electricity system first aid' tool. For example, in the December 2022 cold snap France got up to 20% of all its electricity consumption from neighbouring countries, and 15 TWh net from Germany in the whole year 2022, without any drama, threat or diplomatic crisis thanks to this common mechanism known, practised and trusted by the hundreds of companies working in the European electricity industry.

2. Should the EU electricity market be made stronger vis-à-vis major energy shocks? Would this strengthening reinforce or weaken our well-established policy of securing an EU decarbonisation path to 2030 or 2050?

Even if emergency tools are able to deal with unwanted consequences of the current gas price shock or of the infra-marginal electricity rent shock, public opinion and public authorities can still ask if structural reforms could better prepare the EU electricity market for future energy shocks. Can the EU internal electricity market be made more resilient to price shocks? A very frank answer is yes. Therefore, a second question arises: would this voluntary reform of the EU internal market reinforce or weaken the other key priorities in the EU energy policy: accelerated decarbonisation and swift electrification of many fossil fuel uses?

2.1 Can the EU internal electricity market be made more resilient to price shocks?

What hurts public opinion, and therefore public authorities, is facing a sharp price increase for an energy considered domestic, being electricity. The political economy of electricity retailing has been known for decades. Households consider they have a strong right to react to price shocks, to lower electricity price increases and use this habit to lobby public authorities. Furthermore, electricity has become an essential vector of energy use in the domestic area, and being excluded from certain electricity uses by a lack of revenue becomes strong exclusion from ordinary social life. In Europe, energy poverty (let us define it arbitrarily as using 10% or more of income to buy energy) is still a mass phenomenon, with some countries having more than 10% or 20% of the population concerned before the current crisis.

However, to be frank, the concerns of these two populations of households (the price-shock averse and the energy poor) are not with the wholesale electricity market but with the retail market. First, it is the responsibility of public authorities to organise affordable electricity provision to the poor and the vulnerable. Second, it is also the responsibility of public authorities to organise hedging by suppliers against large wholesale price shocks in order to protect their customers from these shocks. This means creating insurance against price accidents. When some years ago the Spanish government decided to source household default electricity supply directly on the spot wholesale market, it was a national regulatory decision not an intrinsic EU market design rule. However, it is also true that long-term electricity hedging markets are not strong and liquid, but an obligation on suppliers to hedge can greatly facilitate the take-off of such markets. It is again a regulatory decision, a retail market rule, even if it changes a component in the chain of wholesale markets.

Public authorities can also go further and reinforce the inner stability of wholesale pricing at different horizons by signing more long-term wholesale contracts with generators. These contracts, known as 'contracts for differences' (*CfDs*), operate as automatic 'clawback mechanisms' for infra-marginal rents when a given marginal technology undergoes a supply price shock. Similar to these contracts for differences are 'power purchasing agreements,' (*PPAs*) which are long-term private commercial contracts directly tying a generator with a given professional consumer or a small group of professional consumers. This long-term private contracting might be made stronger and more stable by public authorities organising or helping to organise a secondary market for *PPAs*. eHowever, the detailed features of private contracting can resist the building of a secondary market. A success there would make possible to mitigate some of the risks involved in private bilateral contracting.

2.2 Would such a reform of the EU internal electricity market reinforce or weaken the other key EU energy policy priorities: accelerated decarbonisation and swift electrification of many fossil fuel uses?

Any reform of the EU internal market will have consequences, and justifying a reform only by its official aim(s) does not reveal what these possible consequences can be. Given the various interactions between the numerous components of the electrical system and between the various areas of the chain of electricity markets, we may even involuntarily miss certain reactions and feedback loops. Nevertheless, I address below some of the most obvious interactions.

Strongly protecting consumers from wholesale price variations clashes with the need to increase the flexibility of demand in a strongly renewable-based system in order to avoid multiplying demand peaks when the supply of renewables is low and the lack of demand when this supply is high. One option proposed is to build flexible protection for consumers, particularly those who are not poor or vulnerable. In such a flexible protection frame, the monthly bill will be protected with a cap while proactive consumers could easily decrease their bills well under this cap by responding to flexibility incentives [Ref *Battle & Schittekatte; Pototschnig Protecting Consumers; Meeus et v.a.*]. Of course, this flexible consumer behaviour could be made much easier with greater digitalisation of homes and consuming devices [Ref. *Sioshansi; Glachant & Rossetto in EEEP*]. New suppliers can enter this market segment by constructing ad hoc flexible contracts dedicated to particular uses (e.g. heating and cooling, or electric mobility) [Ref *Elia; RAP Power System*]. In the UK and Australia a few advanced suppliers are already offering such advanced contracts to ‘prosumers’ and ‘flexsumers’ (consumers who have invested in digitalised assets that are controllable). In the UK, the most advanced supplier has even designed new energy-efficient houses fully equipped with assets generating and storing electricity, and many digital controllers. This already guarantees the price of a full electricity supply over the years.

Signing many long-term contracts with generators transfers to the public authorities a substantial amount of the responsibility for ‘generation adequacy’ (the size and location of generation assets, the type of technology and its detailed characteristics) and generation operation (via incentives to deliver energy embedded in the long-term contracts). One might question whether these authorities are actually organised enough to be able to assess these responsibilities, whether they are ready to manage them according to the changing needs of the electrical system and the chain of electricity markets and also whether they duly follow the successive waves of innovation challenging the electricity industry and electricity consumers. As deep decarbonisation and widespread electrification both call for genuinely radical innovation, on the EU path to 2030 and 2050 it is key to keep nurturing and welcoming many waves of innovation [Ref. *IRENA Outlook; IRENA Sector Coupling*]. Of course, planning action and investments, and accordingly selecting technology options, is something well known in the electricity industry and that grid operators have practised for decades. However, planning accelerated decarbonisation and swift electrification of many fossil fuel uses is not something anyone in the public authorities can fully master yet [Ref. *Glachant & v.a. Report Electrification*]. It requires continually adequate changes in interaction with numerous other required changes. We all remember how the appearance of ‘smart grids’ challenged industry practice and the regulatory frame. The jump needed today is several orders of magnitude bigger. The EU needs to jump towards a ‘wholly smart electrical system’ and a ‘smart chain’ of markets [REF. *Schittekatte & Pototschnig*].

However, the public authorities can also use a third transformation of the chain of electricity markets to better secure the aims of decarbonisation and electrification. It is the ‘capacity market.’ This was conceived to bring complementary revenue to traditional assets unable to cover all their fixed costs with their energy sales because of the growing influence of renewables on their gross revenue in the daily energy market. This can now be expanded to financing new innovative assets with a high system value which does not fully materialise in their energy sales. This could be particularly useful for certain classes of storage or of flexibility assets [Ref. *Glachant Euractiv; RTE report; Glachant & v.a .Handbook Elec Markets*].

In conclusion, there is not a severe frontal clash between strengthening the EU internal market against energy shocks and pursuing the main aims of accelerated decarbonisation and fast electrification, even though several adaptations will be needed and trial and error is inevitable. The deep transformation that the existing EU electricity market design can undergo without risking breaking or derailing has, as we have seen, three pillars: long-term contracts for retail price hedging; long-term contracts for energy delivery; and long-term contracts for capacity building. It is certainly not a kind of “free laissez-faire market” (which has never existed for electricity). It no longer gives the leading governance of the entire chain of markets to the short-term energy and reserve markets. We are entering a new step in the public-private organisation of the electricity industry: an era of “hybrid electricity markets”, both in the US and the EU. (Ref. *Gruespecht & Joskow; F. Roques; Joskow; Joskow & v.a.*).

3. Will a reform of the EU internal electricity market suffice to deliver EU energy security, decarbonisation and electrification?

It is good news that strengthening the EU internal electricity market against energy shocks does not clash with the main European energy policy aims of deep decarbonisation and fast electrification. If it is well conceived and well executed this EU market reform can also facilitate the pursuit of other main policy aims. Why?

After the current crisis that started in autumn 2021 and which might last until 2025, players and citizens may wonder when the world will start to stabilise again, what can be expected in the coming years, and which new investments and new changes of behaviour and practice are sound.

Electrification requires users of fossil energy to invest in new devices only fed with electricity. These actual consumers and potential investors may ask themselves whether the necessary electricity supply will always be guaranteed, at what price and what will happen at peaks when there are shocks? Strengthening the electricity markets might be the answer to these questions for many users which are the proper electrification decision-makers (who may install heat pumps or buy electric vehicles).

Similarly, investors in new generation or new supply assets might wonder if there is any real business to be done or if any move, change or novelty will be adversely frozen by administrative by-laws, price controls or profit caps. Long-term contracts for energy delivery or for capacity building can mitigate these adverse professional expectations by securing the revenue to feed new business models. Then, moving ahead, proactive consumers and innovative investors will lower the use of fossil energy and our collective dependence on it, and increase the adaptability, reactivity and flexibility of the energy system. This promises reinforcement of positive effects on both sides, a real win-win.

However, we need to stop and wonder if a reform of the EU internal electricity market would suffice to deliver EU energy security, decarbonisation and electrification. Regrettably, this is not the case. Let us be frank again: this market reform, this entry into an era of ‘hybrid electricity markets,’ is a condition for success but only a necessary condition, not a sufficient one. Why?

Let us consider four other conditions for success to make this point clearer. 1) Success of the decarbonisation and electrification aims faces other direct constraints, such as adequacy of grids and infrastructure. 2) These aims also face indirect constraints, such as the allocation of decision rights between the EU level and the Member States. This success equally faces other types of constraints, both external to the energy area and not, such as 3) the EU Central Bank monetary policy and Member States' public budget financing, and 4) the existing international industry trading and manufacturing chains.

It is therefore equally true to say that a) the existing energy crisis does not change all the fundamentals in the European energy policy, and that b) the existing energy crisis requires more effort, more attention and more coordination from the public and private energy-policy decision-makers.

3.1 The success of the decarbonisation and electrification aims faces other direct constraints, such as adequacy of grids and infrastructure

The behaviour of electricity generators, suppliers and consumers and their investments are only half, or a third, of the entire EU electricity industry's present and future. When decarbonisation and electrification trends displace the frontier to wind farms, PV panels, heat pumps and electric vehicles, the reality of electricity flows must still deal with the reality of grids and system operation. The four countries leading the EU's offshore expansion are targeting 65 GW in their northern seas in 2030 (more than France's existing nuclear fleet) and 300 GW in 2050 (2.2 times France's total generation set). Where are the transmission lines to move all of this? Will the corresponding enormous power flows only be canalised among these northern sea countries or will they also feed many other EU countries, but with which lines, interconnections or corridors? How to convince citizens in the Benelux that power lines are constructed that pass the country to supply power to Italy, Austria,...? How to finance the grid in the Northsea and beyond?

The same can be said of offshore wind, solar PV and distribution grids. For example, the European vision of the solar future expressed in 'RePowerEU' in May 2022 is 320 GW of PV by 2025 and 600 GW by 2030 [Ref. *European Commission RePowerEU; Agora EnergieWende*]. Are there distribution grids ready to connect and to manage accordingly? One can also consider heat pumps and electric vehicles in the future. The EU would like to double its number of heat pumps to 10 million in 2027. Are the distribution grids ready for this? The Dutch distribution grids are already quite congested and the Belgian are starting to be. And what would 'being ready' mean? In the past, flow constraints in distribution grids were considered a given and grids had to be adapted to overcome them: 'Fix and forget.' Today, research shows that investments in distribution grids can vary by 40-50% if the users of the grid behave differently and become proactive. How can the users be incentivised to adapt and react to the reality of grid constraints, peaks, congestion and investment costs? By creating new markets, local markets, new grid usage rules or new connection agreements, or by giving grid managers new grid congestion management rights? [Ref. *Poudineh & Brandstät; Nouicer & v.a.; Nouicer & v.a.*].

This reasoning could be extended to other assets and investments needed by the grids and to operate them such as large storage and balancing reserves to deliver security and resilience of electricity systems by 2030 and 2050, as is explained and exemplified in two TSO reports: in France by RTE [Ref. *RTE Report*] and in Belgium by Elia [Ref. *Elia*].

3.2 The success of the European energy transition aims also faces indirect constraints, like the allocation of decision rights between the EU level and the Member States.

We have seen that a sensible reform of the EU internal electricity market is likely to have three pillars: long-term contracts for price hedging; long-term contracts for energy delivery; and long-term contracts for capacity building. Another key condition, the fourth, for the success of Europe's energy transition aims is related to grids and infrastructure adequacy. Frankness and realism immediately show that in each of these four key areas the Member States and not the EU have the core decision-making rights. The EU mainly intervenes in the transmission grid operating codes, flows between countries and the rules on trade and delivery between countries. There are the numerous European grid codes, and the coordination of power exchanges and transmission system operators through 'market coupling.' It is somewhat paradoxical that this future reform of the internal electricity market would reinforce so deeply the role of public authorities in each country but would not consider at all how to better coordinate the new European cobweb of long term contracts. Regarding the elementary micro-economics of collective action, one might say that the EU as a whole will face a consistent 'moral hazard' issue. Each country will directly combine the way it wants its four key areas of decision-making; but many core results will be European-collective and only appear at the EU level: dependence on imported fossil fuels, sensitivity to fossil price shocks, sharing of new decarbonised assets through interconnection and market coupling, and resilience against new types of energy shocks created by worsening climate change, etc.

Certainly, we already have some tools addressing some similar issues: the studies made by ENTSOE (the 10-year network development plan, the adequacy study); the financing granted to Projects of Common Interest through the EU network policy; and the National Energy & Climate Plans (and the corresponding regulation of Energy Union governance). However, all these tools suffer from two main limits: they were conceived to work within the former internal electricity market framework; and they are all quite deeply entrenched in their respective silos. A new system of European governance has to be carefully thought through and practically implemented to reach the level of coordination that the EU will need to successfully accelerate its decarbonisation and deepen its electrification. The challenges that European industry and the European economy will face in the new world geopolitics in the three decades up to 2050 do not allow us to make many mistakes or lack cohesion.

3.3 Other hard constraints external to the energy area such as the EU Central Bank's monetary policy and the Member States' public budget financing

Unfortunately, the success of Europe's energy policy aims also faces hard constraints external to the energy area, which means that one cannot expect much benevolence and leniency. Among these are the EU Central Bank's monetary policy and the Member States' public budget financing.

- a. EU monetary policy should have stayed outside our review. This is particularly because the European Central Bank's leaders are openly addressing climate change, and have put it in their general policy framework, which is remarkable; but the current inflationary wave has created a much more urgent priority for them. The ECB is no longer willing to sustain the 'easy money' policy that it has adopted for a long time, and a tightening of monetary and financial policy is the new normal. This may even last for a long time, as the ECB is not willing to have a very rapid and very brutal tightening of policy but rather prefers a significant but softer and longer hardening. It is not obvious that this softer tone will not depress the willingness to invest of companies and households [Ref. *Patrick Artus*]. How will the EU then accelerate its investments in both decarbonisation and electrification? The size and speed of investment flows are not the only concern here. Most decarbonisation investments are capital intensive with low variable costs (such as in wind, solar, storage assets and building refurbishments).

The total cost of these actions is then strongly impacted by rises in interest rates. Even if interest rates stay under the current inflation trend, the total cost of many decarbonisation actions is jumping today and will push up the European price for decarbonisation.

- b. The second part of this monetary and financial lock is the Member States' public budget financing. In 2021 the Member States enjoyed €750 billion funds more at the EU level, as the post-Covid extraordinary recovery instrument joining the ordinary European budget of €1,000 billion for 2021-27, but things have tightened since. More than €700 billion was spent in 2021-22 by EU governments only to feed current energy and fossil fuel consumption [Ref. *Sgaravatti-Tagliapetra-Zachmann November 2022*], and this crisis is expected to last through 2023 and 2024. The cost of the Commission's *RePowerEU* plan if implemented by the Member States was evaluated in May at €300bn. The cost of addressing the lack of Russian gas in 2023 has been put by the IEA at €100bn [Ref. *IEA EU Gas 2022*]. While the prospects for growth in the EU are seen as very slim if not negative, where will governments find the financing to accelerate decarbonisation and electrification? Of course, the macroeconomics of such energy transition investments and expenses are good for economic growth, as was demonstrated in 2020 by Stiglitz and Stern [Ref. *Hepburn, Stiglitz and Stern*], but where can the initial financing be found? Furthermore, financing the acceleration of the energy transition at the Member State level not only competes with more redistributive expenses that governments might prefer in an atmosphere of energy crisis but it might also have to compete with other types of macroeconomic stimuli. The new understanding of 'green macro-economics' is less rosy than was thought in 2019-2020 [Ref. *Pisani-Ferry 2022 & 2023*]. Many decarbonisation and electrification actions are investments today to obtain the same amount of services as yesterday. These investments do not increase industry productivity or consumption satisfaction. They 'only' reduce an externality: climate change. This means that the effort to invest *de facto* reduces the available amount of 'market wealth' that can be redistributed. It is literally an effort. The new 'sobriety' wording gives some of that meaning. When starting this effort, we have to be sober with appropriable wealth and promises of consumption. This is a difficulty not yet factored in the 'fair and green growth' policy that the EU has made popular since 2019. Of course, citizens and decision-makers will find ways of absorbing this new approach and giving it a sense, for example as a duty to build a sustainable future for future generations or as pride in constructing or reconstructing sustainable industry and a sustainable economy in the EU, with all the geopolitical turmoil that we face until 2050. All of this is doable, sensible and positive but it has to be done. The sooner the better.

3.4 One more constraint: existing international industrial trade or manufacturing chains.

It is more and more understood in the EU that the former worldwide global economy is fragmenting, and that new geopolitics/geo-economics have come or are coming with a still undefined shape and new set of rules but a clearly different direction to 20 years ago at the birth of this century. It is pointless to wonder why but we need to ask ourselves what the possible consequences for the success of the core European energy transition aims are.

The very first obvious consequence concerns European energy security. For 10 years (2004-2014) José Manuel Barroso was President of the European Commission and was unconvinced that Russia and its leaders could be fully trusted. An immense majority of other European leaders, businessmen and presumably public opinion thought the opposite. As Jean Monnet ('Founding Father of Europe') used to say, doing business appeases tensions and if you do not become friends you might at least become partners respecting a few basic rules for a peaceful neighbourhood. This actually worked so well between France, Benelux and their former enemies Germany and Italy; but finally not with the remaining core of the USSR: Russia. Therefore, the EU and Russia are divorcing.

As Russia was our first supplier of oil, coal and gas, this divorce is economically and financially bloody. Together, as the EU, we have not decided to replace our dependence on Russia with exactly the same dependence on other countries. We will instead try to accelerate our independence from fossil fuels by accelerating decarbonisation and electrification. Our decarbonisation has for the moment several pillars, the biggest being the renewables exploited in the EU (hydro, wind, solar, geothermal, biomass, biogas, etc.) and another being low carbon like nuclear or fossil fuels with CCS. In addition, our electrification (for example with heat pumps and electric vehicles) is conceived as expanding our decarbonisation beyond today's uses of electricity. We also know that electricity will not be a universal vector for all energy uses, and we are preparing a green low-carbon hydrogen sector (with methanol and ammonia) for heavy transport as a part of maritime and air traffic plus parts of industrial processes [REF. Ronnie Belmans; Jones FSR report 2021]. How much clean H₂ (methanol, ammonia) the EU will import and from where remains an open question.

A less obvious but equally important factor is other industrial chains, notably ones centred on manufacturing. Will the EU keep quietly importing solar panels, wind turbines or key components of wind turbines, heat pumps, etc. from remote foreign countries? If we really want to accelerate our decarbonisation and strengthen it as a component of our energy security, shouldn't we build an entire European manufacturing chain for wind turbines, solar PV, heat pumps, storage, etc.? We have already realised that we need to Europeanise the manufacturing of electrical batteries for our coming wave of electric vehicles. What else should we see similarly?

As "green manufacturing chains" are fed at their roots by many "green critical materials" like lithium, cobalt, rare earths, etc. [Ref. IEA May 2021], how should the EU organise the basic supply of these key strategic components? Are we going to open mining activities for those materials in Europe? There is enough lithium for batteries in Europe, but to get a permit...; one rather imports to avoid public opposition.

The European Union is discovering what dependence is in a de-globalising world and what alternative options are doable, with their pluses and minuses. We have to build a minimum base of European sovereignty to be sure to be able to achieve our core strategic aims. It is doubtful that we can do it separately in each of our 27 countries. We will do it in some kind of European sovereign cooperation: to be explored, tested and then duly implemented.

General conclusion

Europe is facing one of the worst world energy crises in 50 years. The particular core of this crisis in the EU is Russia's weaponisation of its gas dominance over Europe in order to get political results in its aggression against Ukraine. As this result is impossible to concede on the EU side, the EU has to prepare for full energy independence from Russia as our first supplier of gas with no easy and complete substitute before 2025 or 2026.

However, the electricity market is also adding another shock to the gas price shock by practising marginal pricing allowing all generators not using gas as a primary resource to get the marginal price required by gas generators, the CCGTs.

There exist numerous ways of addressing these two shocks: by reducing the impact on consumers; by separating wholesale prices from retail prices; or by stopping non-gas generators benefitting from marginal pricing, either with 'in the market clawbacks' or 'outside the market windfall profit taxation'; by capping price of gas. The European authorities have not forbidden these various alternative emergency tools and they let the national authorities choose what best fits their own national case.

A priori, emergency tools are more suitable to deal with national emergency priorities. However, it makes sense to look at a reform of the EU internal electricity market to strengthen it against future energy shocks. Three main pillars appear significantly able to strengthen the EU electricity market.

They are: long-term contracts for price hedging; long-term contracts for energy delivery; and long-term contracts for capacity building. These three new pillars do not weaken our EU global strategy of accelerated decarbonisation and fast electrification. There is no fundamental conflict at stake here, only adjustments and care.

It has to be noticed that these three components of the reform do not touch the core of the existing EU coupling of national electricity markets, which are the short-term markets for energy and for reserves. The future EU electricity market design could therefore have five market pillars: the three types of long-term contracts and the existing two types of short-term markets. It also has to be noticed that I avoided to really address the issue of deeper decentralization (typically pushed by prosumers and flexsumers) and the creation of other new markets, very local by characteristics of their products, nature of their trade agreements, and governance.

However, this new configuration combining long term contracts and short term central markets is not a surprise discovered during the European crisis. Leading electricity researchers at MIT arrived at the same conclusion in their study of the main consequences of the push for decarbonisation in the US sector. Both in the US and in the EU we are entering a new era of 'electricity hybrid markets' combining private and public dimensions. What the EU adds to this general finding is a need to build strongly independent European energy security when accelerating the decarbonisation push and the electrification pull.

Nevertheless, reforming the EU internal electricity market around a five-pillar architecture cannot guarantee the success of the core European aims. The EU also needs a much stronger policy with both transmission grids and distribution grids, and several other types of infrastructure such as storage and flexibility assets. Without these new infrastructures, the European policy of higher RES targets cannot be fully implemented both on time and with the expected effect of market price softening. However, it is the Member States and not the EU authorities which hold the key decision-making rights in these key areas (long-term contracts for hedging, energy and capacity; transmission and distribution grids plus other infrastructure). It is unlikely that the existing coordination tools at the EU level can easily deliver both increased energy security and an accelerated energy transition [REF. *Tubiana & v.a. 2022*]. New governance tools have to be found and implemented soon because the current EU crisis is a very serious one threatening even our European industrial and economic future. We have seen that uncoordinated national rushes to fill gas storages can push market stress and prices too far. We have not seen yet a solid planning of options and a robust study of a minimum set of European infrastructures needed to reach our ambitious EU targets for 2030 and 2050. And, at these horizons, we also have to assume a fully European electric mobility...

Unfortunately, other conditions for success are not guaranteed. The European Central Bank is tightening its monetary and financial policy while many investments that the EU needs to multiply are fixed-cost assets very sensitive to the interest rate. Furthermore, the national finances of the Member States are deteriorating due to their enormous budgetary support for the consumption of energy and fossil fuels. The coming years do not promise any growth in fiscal revenue. And the 'green macroeconomics' of progressive recovery through public expenses and investments has not an easy hand against direct redistribution of revenue to the vulnerable, the losers and many other plaintiffs. It is likely that, after such a crisis, the general European aim of a "*Just Transition*" will have to be seriously reviewed to keep legitimacy and credibility.

However, the EU has no other way forward to address the many industrial, economic and social challenges it will inevitably face during the 30 years to 2050. The EU literally has a war to win against itself: either it wins it and reinvents a bright future for itself; or it lets the other major world powers decide what the EU is allowed to become.

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