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Flagship Report

A European Net Zero Industry in 2050:

The 5 blocks of Hard Energy Constraints

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As a premise to this analysis, it is important to fully understand the proper logic of "*Policy Making for EU Green Deal*", the particular "*Political economy constraints*" to create a large enough alliance to support EU policy, and the need to start to redefine everything – sometimes in new ways – in response to shocks as Pandemic, Global supply chains breaking, Russian invasion of Ukraine, USA tariffs' revolutions, etc.

It is also necessary to remind the readers that the EU energy transition has its own internal "*consistency constraints*" to properly reach an "*EU energy transition*". Because the result of EU policy should not be to have a policy, but to have policy results which have to be "*energy transition results*".

We identified five "*EU Energy Constraints*", that you can ignore only if you are not strongly interested into getting a significant EU energy transition.

1. Electrification is equivalent to "*energy efficiency first*": decarbonizing by reducing consumption. It is not a preference for electricity as such, only for its genuine efficiency performance.

2. But generating and delivering clean electricity requires a lot of investments, representing a gigantic economic effort, with pleasant surprises too.

3. Clean Electricity also implies to create a new integrated industry, with new supply chains upstream.

4. Clean electricity is absolutely unable to replace every other energy vector - it is why Clean Molecules are very welcome, wherever they fit.

5. Literally to end: Energy intensive industries too are very welcome. And, as they are mainly a transformation of large energy and material flows into other products, they are very welcome everywhere the EU and the EU countries can supply them.

Constraint 1

Electrification intrinsically means energy efficiency first: decarbonizing more easily by reducing our energy consumption

Looking at the various energy vectors from engineering eyes, electricity is very often the most efficient choice as supplier of any energy service, of course whenever feasible in practice. It is because for a given amount of energy (expressed mostly in kWh or MWh), electricity delivers far more energy services than any other energy vector. Two cases of very efficient usages are very popular these days: 1° electric vehicles for mobility (both for persons and goods); and 2° heat pumps, extracting heat from the landscape (even when it is freezing…; even for industrial heat).

Electrification really means "*decarbonizing by reducing energy consumption*". Take mobility *(transportation):* the energy efficiency of an electric mobility vehicle is roughly 3 times higher than an internal combustion motor. In 2019 (before Pandemic) EU fuel consumption by road transport was 3,365 TWh. 2/3 was for regular cars (gain factor 3 with electricity); and 1/3 for buses and trucks (gain factor 2.5). With full electrification, one gets the same final service of mobility with only 1,200 TWh of electric energy. The efficiency gain is of 64%.

For low temperature industrial heat (below 200°C) by using heat pumps, energy savings compared to fossil fuel heating are 2/3. Even better ratios at lower temperatures (40° - 50° for the output) can be achieved.

You immediately understand why Electrification will become a world competitive factor. In 2022 in China 28 % of the final energy use was supplied electrically, with industry being the largest consumer of electricity with 59 %. (= 16.52% of the Total Energy consumed). In Europe (whole of Europe, more than EU27), 22 % of the final energy use is electricity (roughly ¼ less than in China), while industry consumes 36 % of the electric energy (roughly 0.4 the Chinese score) = 7.92% of Total Energy consumed; more than 2 times less than in China. And China also prepares a full electrification of its new trucks from 2028 onwards. An electrified society is an energy efficient society and is ready for the future.

Constraint 2

Generating and Delivering clean electricity call both for a lot of investments beforehand

Firstly, consider that one has to finish the cleaning of existing EU electricity. It means roughly adding more clean energy sources to the ones already existing in the EU (going from 45% clean share to 100%).

Second, taking Electrification as favourite to clean existing fossil fuels consumption – for instance for mobility and for heating – will call for much more electricity generated, transported and distributed. Our EU starts with 23% of energy being electricity. For a jump to 50% clean

electricity in our final energy supply mix, one is starting with (45% clean share of 23% being electricity = 10.35% of clean electricity in our EU energy mix). To reach 50%, EU need x5 times more. However, thank to energy efficiency being x3, our effort will be reduced. To replace 27% fossil energy usage, one only needs 9% equivalent in electricity. Less than one more time our 10.35% clean electricity today!

Third, clean electricity is capital intensive. Wind and Solar are very well known to have (quasi) all costs at building. Nuclear less, but very significantly too. The latest EU assessment study finds 140bn euro of investment per year for 10 years, to reach 80 % renewables. However, consumers too have to invest (new cars + charging stations; Heat Pumps & new heating systems). It can seem a too enormous constraint; but remember that EU imported in the sole year 2024 for 376 bn Euro of fossil energy.

Fourth, the electricity networks too have to be updated for capacity, and for batteries and storage. In France only, the transmission grid found 100bn Euro investments needs till 2040, and the distribution grid another 100 bn Euro… 200 bn Euro within 15 years, 13 bn Euro a year for France. The EU assessment study found a need of 85 bn Euro for grids per year for 10 years and 8 bn Euro in storage. We should not forget that normal grid components have a proven lifetime of over 60 years.

Fifth, high fixed costs do not have only adverse heavy consequences. These assets are naturally protected from further price spikes and other similar crisis occurring after the investment. These assets can also benefit from "*Learning curves – Economies of scale*" reducing their burden overtime. The most well-known is PV panel, with over 90% cost reduction in 1980-2012, and again 98%% reduction in 2004-2023. Other significant costs reductions have been seen for wind, or for batteries. Even the new nuclear tech (the *Small Modular Reactors*, SMRs) claims effects of this kind. The Canadian Ontario Power promised, in March 2025, to build its fourth SMR one third cheaper than the first.

Constraint 3

Clean Electricity also requires new supply chains upstream and/or circularity

Firstly, Clean Electricity requires its own mineral chain upstream: copper, lithium, cobalt, neodymium, or gallium (a semiconductor, like silicon), etc.… We all know that China dominates parts of this global upstream supply, and works to seduce other big suppliers, like Indonesia or Chile. While, in the EU, Portugal is our N1 for lithium, and the world N8. Nuclear too is well known for claiming uranium upstream.

Second, a "*Circular Economy*" can greatly reduce our needs of imports and of foreign suppliers and can promise to work very well with most of our needed "*green upstream supply*". Recycling might deliver up to 85%-90 % of our EU basic needs, with EU mining and EU privileged foreign

partnerships delivering the 10%-15% rest. Recycling nuclear waste too is a promising field for our future.

Third, there is another very big step in our supply chain needs: the manufacturing of components and systems, for generation, grids and storage, plus at the users' sites (EV charging, heat pumps, industrial electro heat). Some are also concentrated in China, as PV panels, and batteries. But, in other parts, as grids, wind turbines, network equipment, industrial applications, European industry fortunately has a very significant role.

Fourth, how much "*industry reshoring in the EU*" is doable? For example, for PV panels and batteries? A terrible question there is the bankruptcy of NorthVolt (in March 2025): was it an unfortunate accident, or a strong warning? Can the EU strategy calmly separate the "*mature PV and batteries*" items (calmly staying imported) from the "*advanced or disruptive*" ones where an organized EU industrialization might still pay?

It is important to stress that import of the above is totally different from the fossil fuel age: once imported, the materials can be reused/recycled and the systems have a very long lifetime substituting the continuous flow of gas, petroleum and to a smaller extend coal.

Constraint 4

Clean Molecules are very welcome: where they fit

Firstly, Electrification is welcome mainly to decarbonize our energy demand for a given energy service by reducing the energy consumption. Therefore, everywhere electricity cannot enter and do the job, all clean molecules are very welcome as bio-molecules, E-molecule. The latter being based on so-called green hydrogen, i.e. hydrogen produced from water using green electricity (for a more detailed overview read the chemistry review by Ronnie in our longer paper 2025).

Second, Clean Molecules have their own strong operational points. 1° *Their operational readiness*: the equipment to use them mostly is already in place, with existing supply chains, and proper users know how. 2° *Their operational easiness*: storability, dispatchability. 3° *Their operational eeffectiveness*: in specialized usages (as aviation, or long-distance shipping), or in chemical reactions to produce materials (plastics, fertilisers, medicines, steel, etc.).

Third, where are their limits, their frontier, then? When a lot of electricity is needed to produce them. Typical you find there Green H2, when considered as a dedicated storage for the electricity system itself. Remember that the whole chain [*Production of Green H_2 by electrolysis of fresh water supplied by renewable electricity)* going to *(Produce electricity from thermal plants fed by Green H_2)*] is only 40% efficient. When using other e-molecules derived from green hydrogen or accounting for the large losses transporting the hydrogen molecules, this chain consumes 2.5 more electricity for each unit of the same final result, being again electricity. We

should not forget all investments needed in this specific value chain, often in countries that lack an industrial basis.

Fourth, to conclude. Clean Molecules have real strong points and are legitimately "policy *appealing*", particularly the biofuels. It is why much more research and applied work is needed to identify and to test their "*legitimate niches*"; plus, the "*legitimate compromises*" that various countries can do to prioritize them and to benefit from their various strong points.

Constraint 5

Energy intensive industry is very welcome: when and where EU can supply them?

Firstly, it is unfortunate, but obvious, the most socially painful of the five points. Ronnie and I have lived the retreat of coal in Belgium and North of France, and we do strongly feel today's threats on basic steel, chemistry and aluminium.

Let's however, think about it as rational researchers, and not only reacting as witnesses, who see the pain in their neighbourhood. Simplifying this issue, these industries can be said transforming energy into something else: either steel, aluminium, cement, pulp & paper, glass, etc.; or commanding chemical processes like fertilisers, plastics, high value chemicals. Simplifying: energy intensive industries are "cheap energy" industries.

Second, energy intensive industries actually consume more than ½ of the total of EU industry consumption. Should EU for ever keep all currently existing energy intensive plants in Europe because we have had abundant, affordable and resilient energy supply in the past? Frankly: how to simply keep them alive for ever, if our EU energy supply in the future is limited and expensive compared to other countries?

Third, it can therefore be horribly shocking for many of you; but, can EU rethink rationally, at different horizons [as: 2035 (+10) _ 2045 (+20) _ 2055 (+30]) the different industrial decisions regarding investment for upgrading, retrofitting, rebuilding, reshoring, re-locating, etc. etc. … A typical example: what could be gained from new CCS- CCU infrastructures, and from related public CfDs protecting their industrial users?

Fourth, our parents and us (Ronnie and Jean-Michel) have learnt from the end of coal, that it has been less painful and less destructive where it has been actively prepared; including with training, skilling, re-skilling of Human Resources. Look at China: there too it is painful to prepare post-coal industry, and to promote clean electricity as a motor of new industry investments and location.

Conclusion

We are reminding you of several constraints emerging from energy realities and their associate reasoning. We very well know that it is up to the citizens and the decision-makers to choose and to act. And that nobody else can or will do. But, as a fact too, this will not change these basic constraints.

Electrification is impossible to replace as N1 core of our European decarbonization because it reduces energy consumption by a factor 2 to 3, which is properly gigantic. Sure, that electrification is slow and demanding, because it requires enormous investments, to only continue to do tomorrow something similar to what we have always done, for decades. It looks as not creating "*more*" than decarbonizing. Except… preserving and guaranteeing the world rank of our EU, and of our citizens, in a very hazardously fractured geopolitical landscape.

Of course, Clean Molecules are extremely welcome, and our EU Energy Transition cannot happen without them. But their more precise areas, roles, techs, priorities must be better known and assessed than they are at present. Therefore, to our eyes, the energy Intensive Industries might become a very painful part of our EU Energy Transition. Difficult for the 20 years to come. Our EU and EU countries start today with existing plants, which might each be upgraded, or not, with new investments, reshoring, reskilling of their Human Resources, or not. Political capital, economic or social support might lack, here or there, for this or that period, to address this or that industry, district or facility. But it is altogether a too big issue for us, the Europeans, to keep it too long under the carpet.

As deeply and very realistically explained by the Draghi's report in September 2024, our EU's best protection in today's threatening world is our EU keeping changing, investing and innovating.

Maybe we must give a list of questions that can be raised and should be answered and judged by the jury – which is each of you, the readers.

1. ***Are you really putting electrification first at the centre?***
2. ***Are you willing to enable the industry that brings the systems of electrification to the market?***
3. ***Are you willing to push the education and long-life training in that direction?***
4. ***Are you willing to accept that societal change is going to be part of the transition (human investments made by less wealthy people)?***
5. ***Are you willing to move industry in order match electrification first, ignoring national borders?***
6. ***Are you aware of the change in value chains electrification first brings (fuel station, car maintenance, …)?***

7. ***Are you ready to set aside "legacy assets" often in hands of public owners (some gas grids for instance) or large companies (refineries, fuelling stations)***
8. ***Are you ready to go for real recycling: keeping every atom that entered Europe here or integrate it in new, high value export products?***
9. ***Are you going to accept the visible impact of "electrification first", while stressing the environmental advantages (acoustic noise, local pollution)?***
10. ***Are you accepting that large investments are made in the electric energy system, while we still must pay a lot for import fossil fuels (but decreasingly)?***

You know that the jury is out: you know that you are the jury.

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