Powering Europe’s Tomorrow - A blueprint for 100% renewable and resilient infrastructure

CAN Europe's Top 5 recommendations for Europe's future grids and energy infrastructure

Introduction - a new approach for European infrastructure

With the climate crisis accelerating, its impacts are becoming more and more intense, especially for the most vulnerable in our societies. In response, it is imperative to deliver an energy infrastructure for the accelerated energy transition to a 100% renewable system, which is efficient, flexible, reliable, and affordable. European power grids are reaching high congestion levels: they have become a bottleneck for the deployment of renewable energy, even generating additional costs[1].

In anticipation of the European Commission’s forthcoming EU action plan on grids, CAN Europe places grids as a part of the wider energy infrastructure, and **presents principles to guide infrastructure decisions, addressing present challenges and anticipating next steps**.

Addressing the identified problems is ever more pressing as we move towards the implementation of the revised EU renewable energy target, which foresees a renewable energy share of at least 42.5% (and aiming for 45%) in the final energy mix by 2030. By that time, **more and more electricity will flow through both Europe’s transmission and distribution networks, resulting in the required direct and indirect electrification in transport, heating, industry**[2].

But the infrastructure needs for the transition to climate neutrality go well beyond grids. Problematically, electricity and gas networks are planned and managed separately, both on the EU and national levels. A misalignment can be seen especially at the distribution level. The initial model for grid development was not designed for distributed energy sources, the rise of energy sharing, prosumers, and demand-managing end consumers. The corresponding market rules are also largely specific to gas, heat, and power, each in isolation. There are many unanswered questions on how the

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[1] In Germany, congestion management costs show an increasing trend, at more than EUR 4 billion per year in 2022, which equals investing in about 4.51 GW of entirely new solar PV capacity. IEA (2023), Electricity Grids and Secure Energy Transitions, International Energy Agency, Paris.
https://www.iea.org/reports/electricity-grids-and-secure-energy-transitions

[2] Communication From The Commission To The European Parliament, The Council, The European Economic And Social Committee And The Committee Of The Regions. Powering a climate-neutral economy: An EU Strategy for Energy System Integration: Electricity demand is projected to increase significantly on a pathway towards climate neutrality, with the share of electricity in final energy consumption growing from 23% today to around 30% in 2030, and towards 50% by 2050. In comparison, that share has only increased by 5 percentage points over the last thirty years.
https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52020DC0299&from=EN

fossil gas and liquefied natural gas (LNG) infrastructure will be decommissioned, how future networks will transport and produce non-fossil gases (biogas, biomethane, renewable ammonia, renewable hydrogen), and of their linkages. A 'silo approach' will not deliver a climate-neutral economy.

A starting point for the discussion on electricity grids is **how to balance two needs: upgrading present electricity infrastructure, by making it smarter, digital, more efficient, and flexible, and building new infrastructure**, so as to facilitate the energy transition. This balance needs to be carefully analysed and crafted to avoid overexpansion, which could result in sunk costs, unnecessary use of space at land and sea, higher biodiversity impacts, and a risk of social conflicts with local communities. Instead, innovative nature conservation approaches should be promoted and citizens taken into the heart of the discussion. This paper presents our analysis of the developments and processes to be considered when developing grid infrastructure. We underscore where more efforts are imperative to achieve an inclusive, just and participatory transformation for climate neutrality by 2040.

Design principles for the infrastructure we want

We need a new, more holistic approach for the design, creation, replacement, and optimisation of how energy infrastructures in Europe are operated, which also looks across different levels. Electricity and gas distribution networks each have specific issues to be addressed. In electricity infrastructure, more attention is needed at the distribution-level, while transmission grids and cross-border interconnections will be the key enablers to transmit growing volumes of renewables-based electricity evenly across the entire EU as well as to and from offshore wind sites. For achieving climate neutrality in line with Paris Agreement goals, **crucial, interconnected and systemic changes** need to be taken into account, when thinking about electricity infrastructure development. This includes gas infrastructure adaptation/transformation across the levels, because they alter the system needs, production and consumption patterns, costs, as well as wider impacts. Newer innovative approaches also have to be harnessed[3].

We propose the following design principles:

1. **Enable and expedite a 100% renewable energy system**
2. **Plan for the phase-out of fossil-fuel infrastructure**
3. **Utilise the full potential of energy savings**
4. **Build a decentralised, flexible and digitalised energy system**
5. **Develop people-centred and nature-inclusive infrastructure**

Next, each key issue area is described in detail, accompanied with a set of political or policy actions, at the end of the paper.

[3] Next-generation district energy networks, for instance, integrate thermal, power and mobility, with storages, as described by Revesz et al. (2020) https://doi.org/10.1016/j.energy.2020.117389

1. Enable and expedite a 100% renewable energy system

The Paris Agreement's objective to limit temperature rise to 1.5°C requires the renewables share in final energy consumption to be at least 50% by 2030 and a 100% renewable energy system by 2040, according to the Paris Agreement-compatible energy scenario (PAC) by CAN Europe[4]. But even to reach the EU-agreed target level of 42.5% in 2030 alone, renewable energy shares "will need to grow continuously by an average of 2.2 % each year from 2022-2030, which is three times the growth during the period 2005-2022" according to the European Environment Agency (EEA)[5]. So, it will be crucial to upgrade the capacity of the electricity networks, and digitalise them, always based on real needs, to create the new "electrical space"[6], assisted by new clean energy investments, and to avoid further queues to connect renewables.

Grid development, grid "smartening", digitalisation, and especially investments in new grids are time-consuming and require careful coordination. In 2040, in a fully renewables based energy system, the 'traditional baseload' will shift entirely, and no longer will consist of large-scale power plants that use fossil fuels or nuclear reactors, as they would rather cause grid congestion. If there is still 'a baseload', its nature will shift, and it will mean harnessing variable renewable electricity fully, coupled with electrolysers. As indicated by the Commission, investments in energy infrastructure typically have an economic life of 20 to 60 years. This means that forward-looking planning and implementation needs to be happening already, also with an outlook to 2030 and 2050 targets.

A high level of renewables-based electrification is mandatory to reach decarbonisation and a 100% renewable energy system. This means *at least* doubling the current electrification in the EU energy system with renewables by 2030. The Paris Agreement Compatible Scenario (PAC) indicates that in order to achieve the 1.5 C target, recommended levels of electrification across sectors, while switching all electricity production to renewables, needs to reach 43.8% in final energy consumption already by 2030, and 73.5% in 2040, across the 27 EU Member States[7]. The current electrification level across the EU is equal to 23% only[8], and there must be a coordinated effort to double this result in less than 7 years with renewables. As a gain, efficiency of the energy system increases significantly. Therefore, **the planning and development processes concerning grids must increase renewables-based electrification as a key objective**.

One key identified bottleneck for building the required infrastructure for a 100% renewable energy system is the permitting of grid development projects, which is not efficient and needs to speed up, while ensuring the protection of the environment. It is also not clear if all electricity distribution companies have the necessary incentives to aim for climate-optimal solutions. There is an urgent

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[4] PAC 2.0 scenario for the EU27 member-states. https://www.pac-scenarios.eu/

[5] EEA (2023) Trends and Projections in Europe 2023. European Environmental Agency. EEA Report 07/2023. https://www.eea.europa.eu/publications/trends-and-projections-in-europe-2023

[6] E.g. wind and solar across the whole country, as a different spatial allocation instead of highly centralised energy resources.

[7] PAC 2.0 scenario for EU27, with data visualisation. https://v32p1.pathwaysexplorer.climact.com/pathways?visualisation=0&region=EU27&source=modelsource&scenario=EU27%3A+Preliminary+%28CE%29+Net+Zero+2040+100%25RE+%28in+progress%29

[8] As also described by Eurelectric https://www.eurelectric.org/policy-areas/electrification in their Power Barometer 2023: https://powerbarometer.eurelectric.org/

need for substantial improvements in human and skill capacity in authorities, reducing unnecessary administrative burdens, and ensuring full alignment with nature conservation goals and meaningful public engagement[9]. Permitting processes for storage facilities also need to be improved[10]. It will also be important to explore, identify and address other relevant bottlenecks.

2. Plan for the phase-out of fossil-fuel infrastructure

Planning of all new energy infrastructure must be aligned with EU-wide fossil fuel phase-out dates and climate goals: coal no later than 2030, fossil gas no later than 2035, oil by 2040, as well as phasing out nuclear facilities. We need to gradually phase out all fossil fuels and replace them. Subsidies to fossil generation must be immediately stopped, and phase-out plans prepared in dialogue with stakeholders[11][12]. Transmission, distribution and storage infrastructure planning and investment decisions must avoid false solutions (like using hydrogen and renewable methane in the individual heating and transport sector). **Because nuclear power plants struggle with a fully flexible system**, are costly, vulnerable to geostrategic influencing, have unresolved waste issues, and prolonging Europe's ageing fleet risks puts in jeopardy the safety and health of society and nature[13], we propose to gradually phase them out by 2040 across the EU.

Fossil gas and LNG infrastructure needs to stop expanding and start planning for decommissioning. According to ACER, gas grid operators are not planning enough to prepare the energy transition and a recent report on Germany for example, shows that 90% of the existing gas network could become redundant by 2045.

The planning of gas networks has to be done in an integrated manner between all energy vectors (electricity, gas, heat and hydrogen), together with public authorities, to provide clear incentives for

[9] RGI Position Paper regarding upcoming Commission Guidance for Streamlining Environmental Assessments of Projects of Common Interest (PCIs) for Energy Infrastructure under the new Regulation for trans-European energy infrastructures (TEN-E)
https://renewables-grid.eu/fileadmin/user_upload/Files_RGI/RGI_Publications/Position_Papers/RGI_Position_on_Streamlining_Guidance.pdf

[10] For related discussion on storages.
https://ease-storage.eu/news/repowereu-rules-on-accelerated-permitting-apply-to-all-energy-storage/

[11] CAN Europe. https://caneurope.org/content/uploads/2023/03/Fossil-Fuels-Subsidies-Report.pdf

[12] For heating, we should stop subsidies for the installation of fossil-fuel based heating systems in buildings and this public financing should be rather redirected to improve energy efficiency, building renovations and move district heating systems to renewables. For heating, separate strategies are required, providing clear objectives for heating decarbonisation. Such objectives could take many forms: a date by which all heating needs be decarbonised, an ambitious target rate for deep renovations encompassing work on envelope and the installations of renewable heating and cooling technologies per year, an obligation to install renewable technologies or connect to (renewable) district heating networks when replacing a boiler, etc. District heating, a collective heating solution, requires more planning, infrastructure investment and coordination than individual solutions such as heat pumps and solar thermal panels. So encourage and scale up the implementation of local and regional heating and cooling plans, ensure financial and advisory support to the municipalities and citizens to decarbonise their heating systems, need it and should start in the shortest term and be crafted on the national strategies and reflected in NECPs.

[13] Discussed also by EEB. https://eeb.org/investing-in-nuclear-energy-is-bad-for-the-climate-ngos-say/

decommissioning and to significantly reduce gas network utilisation, as gas users disconnect from the gas grid to switch to other heating sources, such as electrification for instance. The decommissioning of gas grids has to be assessed by independent regulatory authorities to truly estimate the actual gas flows i.e. the reduction in gas demand and risks of unused gas infrastructure. Such an assessment should also look into renewable hydrogen needs that require repurposing of existing gas pipelines. It is a priority to make sure that the costs of accelerated depreciation periods of networks are not put on the shoulders of end-consumers. There are also multiple uncertainties around using gas networks and LNG terminals for hydrogen[14].

No new gas capacities should be eligible for public subsidies, and subsidies for existing gas plants should not delay gas phase-outs. Where fossil gas turbines and cogeneration are used as one of the flexibility options up until the Paris Agreement-aligned gas phase out by 2035, alternative flexibility options have to apply first, new gas capacities should not be eligible for public subsidies, and subsidies for existing gas plants should not cause a delay in the gas phase-out.

Today, almost all hydrogen comes from fossil fuels, and **there is a significant risk that the European hydrogen sector fails to shift completely to renewable hydrogen**. The first question to be addressed is to define a clear framework limiting hydrogen use only to hard to abate and hard to electrify sectors. This goes hand in hand with assessing the need for additional renewable energy generation capacity to cover hydrogen demand needs (additionality principle)[15]. Non-renewable hydrogen can easily become "a diversion", which justifies continued investments in fossil fuels, and maintains legacy or even builds new infrastructure that should instead be decommissioned urgently[16]. With this strict criteria in mind, those processes that cannot be directly electrified, will convert to sustainable fuels, such as renewables-based ammonia (marine and aviation) or renewable hydrogen (e.g. steel industry).

CAN Europe is against the build-out of new fossil gas power plants and other gas infrastructure presented as "hydrogen ready". Until 2030 renewable hydrogen demand will be much smaller than the 20 million tonnes (10 million domestic and 10 million imports, equivalent to approx 600-700 Twh) projected by REPower EU[17]. Renewable hydrogen expansion will ramp up significantly only after 2030 for use in key priority sectors (storage, hard to electrify sectors such as steel).

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[14] As described by Fraunhofer institute reports: https://www.isi.fraunhofer.de/content/dam/isi/dokumente/cce/2022/Report_Conversion_of_LNG_Terminals_for_Liquid_Hydrogen_or_Ammonia.pdf and https://www.iee.fraunhofer.de/content/dam/iee/energiesystemtechnik/en/documents/Studies-Reports/FINAL_FraunhoferIEE_ShortStudy_H2_Blending_EU_ECF_Jan22.pdf

[15] As per IRENA, globally, 99% of hydrogen was produced from fossil fuels, which emphasises the importance of scaling-up renewable electrification rapidly. In 2021, of global H2, nearly 47% was from natural gas, 27% from coal, 22% from oil (as a by-product) and only around 4% produced with electrolysis. As electricity had a global average renewable share of about 33%, it can be estimated that only around 1% of global hydrogen stemmed from renewable energy. https://www.irena.org/Energy-Transition/Technology/Hydrogen

[16] Even the LNG sector thinks so, as suggested in this study: https://doi.org/10.1016/j.ijhydene.2021.10.206

[17] Bruegel (2023) Renewable Hydrogen in Germany, Poland, and Portugal. Bruegel, Instrat, ZERO, Germanwatch. https://www.euki.de/wp-content/uploads/2023/09/Renewable-Hydrogen-in-Germany-Poland-Portugal_2023.pdf

3. Utilise the full potential of energy savings

The Paris Agreement's objective to limit temperature rise to 1.5°C requires at least 20% energy savings by 2030[18]. Even to achieve the EU agreed 2030 energy efficiency target as a minimum, a substantial acceleration in energy savings is necessary for both primary and final energy consumption. Compared with the average annual reductions of the last ten years, reaching the primary energy consumption target for 2030 would require multiplying the annual reductions by three, and for final energy consumption by nine, in each year for the rest of the 2020s[19]. Strong action until 2030 will be needed to reduce energy consumption in the coming years[20].

Unfortunately, network losses in transmission and distribution constitute a significant amount of wasted energy[21]. Energy savings within the transmission and distribution of electricity are needed to reach the Paris Agreement goals and can generate many benefits for climate and society. Energy savings also help ensure the balancing of supply and demand within electricity grids, making them more stable, by reducing electricity peak demand, lowering the need for additional fossil fuels. Policy makers need to ensure that the full energy savings potential through the reduction of network losses is leveraged.

In light of the pressures to expand large-scale transmission grids, cost-efficient energy efficiency measures need to be better considered[22]. The "Energy Efficiency First" principle aims to prioritise energy efficiency and avoid energy waste. Concerning grids, this principle points to prioritising energy savings over investments in energy infrastructure, optimising existing energy infrastructure, and consequently minimising energy losses. Its application is enshrined in the 2023 Energy Efficiency Directive. It must be applied regarding decisions on energy infrastructure, including on network planning and network development.

However there is a need to have a more holistic approach to European grid planning, including making sure that assumptions used in infrastructure and investment planning take into account the need to reduce absolute energy demand in line with the Paris Agreement goals. The EU action plan on "Digitalising the energy system"[23] lays out that EUR 584 billion of investment in the electricity grid will be required between 2020 and 2030, in particular, in the distribution grid. In comparison,

[18] https://caneurope.org/position-on-energy-efficiency-directive-recast/#:~:text=CAN%20Europe%20believes%20that%20binding,to%20set%20national%20indicative%20contributions.

[19] EEA (2023) Trends and Projections in Europe 2023. European Environmental Agency. EEA Report 07/2023. https://www.eea.europa.eu/publications/trends-and-projections-in-europe-2023

[20] The value of demand reduction has also been identified by the European Scientific Advisory Board for Climate Change (2023), as a key lever for Europe to meet +1.5 C compatible energy and climate pathways.

[21] CEER (2020). https://www.ceer.eu/documents/104400/-/-/fd4178b4-ed00-6d06-5f4b-8b87d630b060

[22] In the EU, demand response through digital solutions and increased storage can reduce curtailment of solar photovoltaics (PV) and wind power from 7% to 1.6% in 2040, and avoid 30 million tonnes of carbon dioxide emissions in 2040, as per IEA (2017).

[23] COM(2022) 552. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX%3A52022DC0552

globally, demand-side responses could avoid USD 270 billion of investments in new electricity infrastructure[24].

The value of demand-reduction is best understood in light of the high estimated costs of required grid modernisation and any new transmission capacity to minimise the costs of the transition, stemming from grids. Although more grid capacity will be needed, without taking into account the need for energy demand reduction, calls for “more grids” alone do not result in economically, socially or environmentally optimal solutions. Placing also more emphasis on the distribution system level than before, with demand side flexibility and digital solutions, help lower transmission system expansion[25]. A better balance between distribution and transmission grids is needed, with DSO/TSO coordination, which should enable a better use of the existing power grid, while expanding the capacity of grids to incorporate renewables.

In buildings, renewable energy deployment should be coupled with energy savings measures, improving performance and comfort for occupants while reducing energy costs, using renewable heating and cooling solutions for heating and cooling demands[26]. There are many examples of how energy end-use and supply can be integrated with one another. Aligning mandatory local heating and cooling plans as per 2023 Energy Efficiency Directive with infrastructure planning could help further integrating planning efforts on different levels. Attending to the distribution-level aligns with the values of efficiency and sufficiency.

4. Build a decentralised, flexible and digitalised energy system

The transition to a 100% renewable energy system will require an **increased emphasis on the role of electricity distribution grids.** Distribution system operators (DSOs) have to be equipped with the necessary tools to bring about a transparent, digitalised, and decentralised grid which optimises local generation and consumption. The future distribution grid will interlink households, offices, public buildings and industry with decentralised photovoltaics, battery storage, and heat pumps, aided by the upgrading and expansion of the existing grid and supportive, non-infrastructure solutions. DSOs will be responsible for harnessing flexibility, by helping prosumers become active participants in the energy system, using smart metres, digitalised data flows, demand-side response, onsite renewables and storage, and dynamic contracts. For this transformation to take place, DSOs and TSOs have to cooperate more by sharing real-time grid data, planning the future energy system together, and sharing sources of flexibility to ensure congestion at the transmission level can be solved by resources at the distribution level. In several EU countries, the regulatory environment has to be further developed to achieve this.

The current challenge for every European government is to adapt the planning, upgrading, renovation, and management of the distribution grid to this target model. All member-states should have mandatory, transparent and standardised network development plans at distribution grid level. **As part of this effort, DSO Network Development Plans need to be aligned with 2050 horizon**

[24] IEA (2017), Digitalization and Energy, Paris: IEA, p. 17-18. https://iea.blob.core.windows.net/assets/b1e6600c-4e40-4d9c-809d-1d1724c763d5/DigitalizationandEnergy3.pdf

[25] Of note how future Renewables Acceleration Areas (RAAs) in the EU are planned to give priority to artificial and built surfaces, such as rooftops and transport infrastructure.

[26] CAN Europe. https://caneurope.org/position-on-energy-efficiency-directive-recast/

projections for electricity supply and demand, scenarios, and deviations. Placing increasing responsibility on DSOs, who by nature are more disaggregated and operate differently than TSOs, requires much greater cooperation between parties and changes in their mandates.

The necessary revolution in the approach to distribution grids is also very much dependent on political will and national starting points, such as the age and technical condition of grids, unbundling of transmission and generation, the level of country's digitalisation, tariff composition, deciding what financial resources are allocated to grid improvement, and the current bottlenecks related to RES deployment. Some positive improvements will stem from the current revision of the EU-wide electricity market rules[27], but the **majority of work and decision making needs to be delivered by governments and DSOs nationally**. In order to support this effort, a dedicated **Distribution Grid Task Force** on EU Level should be established to oversee and investigate the following topics and require legally responsible parties (national regulatory agencies, TSOs, DSOs, governments) to implement solutions: grid expansion, renovation, and capacity needs, improvements of permitting procedures, distributed production of renewable gases, and grid management.

At the transmission level, power system flexibility must fully help integrate variable renewable energy, so the demand matches the supply at all times, and to avoid unnecessary overexpansion. Demand-side flexibility, efficiency and cable pooling[28] enhance the capacity of the grid and optimise existing infrastructure. The incorporation of short-duration, long-duration, and seasonal storages into grid planning will give system operators the ability to provide renewable energy consistently, even through periods with low or no wind and solar power generation[29]. Demand-side flexibility and storage are not adequately captured in transmission-level planning, and the system operators **(TSOs) are not yet aligned or incentivised to operate grids according to a shifting paradigm.** Network development plans and strategies do not always reflect the climate neutrality target and intermediate targets, such as the EU 2030 renewable energy target. This has crucial implications for grid planning.

Interconnections between countries are a means to stabilise grids, enhance security of supply, reduce the role of fossil gas peaking plants in the short term, and storage needs in the long-term. In a 100% renewable energy future, as shown by the PAC Scenario, increased cross-border exchange of electricity is vital, as it helps preventing shortages or curtailment[30]. The fundamental assumption of the European Internal Electricity Market regarding **cross-border trade and solidarity among Member States needs to be built upon. Currently the progress towards 70% benchmark for interconnection capacity is not on track[31].** Cross-border capacity must be more proactively used by Member States. This requires a big change in the underlying mindset as many Member States today

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[27] Ongoing Electricity Market Reform discussions contain positive measures such as: flexibility connection agreements, dedicated measurement devices, revised tariff methodologies, TSO/DSO performance targets on efficiency, and better oversight over network development plants

[28] Multiple generation units on a single grid connection.

[29] Also called a Dunkelflaute.

[30] In this modelling exercise, the swift expansion of the net transmission capacities of cross-border electricity grids is taken over from the TYNDP 2018 Global Climate Ambition 2040 scenario.

[31] By 2026, all Member States are tasked to increase their interconnection capacity to 70%. As shown by ACER some Member States have reached their targets in 2022, but many others fall short. ACER also points out that the 70% target will become increasingly difficult and costly to reach.

still operate individually, adhering to the energy sovereignty paradigm, with a belief that exchanging energy with neighbours is a threat to national energy security.

Sector coupling and Energy System Integration[32] can increase flexibility and reduce energy usage. Coupling renewables-based electrification in the power sector, with the heating, cooling and transport needs, supports decarbonisation across sectors and can harness cross-sector flexibility. Electric vehicles, for example, charged with renewable electricity, serve both as means to decarbonise mobility, as well as storage capacity to unlock flexibility for the power sector. Supporting the interconnection of flexible EVs, heat pumps, other cooling and heating in buildings, and through district heating and cooling networks optimises the energy system, allows for efficient energy use and reduces energy demand. Additionally, sector coupling reduces the costs of decarbonisation and stabilises the energy system[33]. In order to reap those benefits, Member States should urgently introduce supporting regulatory frameworks, coupled with proper preparation of the infrastructure (metering, digitalisation, adapting the distribution grid).

5. Develop people-centred and nature-inclusive infrastructure

Shifting to a 100% renewable energy system is essential, and it must and can safeguard biodiversity, involve communities in decisions, and uphold the highest environmental and social standards at every phase. Rolling out new and repurposing old infrastructure must be socially just to ensure people do not just benefit but also support the necessary changes. How to distribute the costs and benefits of the future energy system and how to engage local communities and wider civil society in decisions are important considerations.

First of all, it is important to underscore that citizens and local communities will benefit in multiple ways from the transition to 100% renewable energy, including lower energy prices, local job creation, and the active participation in energy production, ownership, and consumption[34].

But the required investments in our energy infrastructure obviously also come with a cost and it is of utmost importance that these costs are addressed fairly. At the moment, the cost of moving into the prosumer model[35] is passed to consumers, via bills. It is essential to consider different parts of the society with different needs and abilities to adopt flexibility when developing policies in order not to risk deepening energy poverty. Costs of improving the distribution grids need to be optimised. State responsibility is to keep energy affordable through structural change (not with emergency measures, ill-suited to this task). Political elements in this puzzle, like restricting connections for politically favoured projects, conflicts of interests or refusing connection to prosumers without clear explanation, need to be eliminated. Moreover, specific needs of energy communities should be

[32] See EU Strategy for Energy System Integration: https://energy.ec.europa.eu/topics/energy-systems-integration/eu-strategy-energy-system-integration_en

[33] Clean Energy Wire (2018) Factsheet: Sector coupling. 25 Apr. https://www.cleanenergywire.org/factsheets/sector-coupling-shaping-integrated-renewable-power-system

[34] CAN Europe. https://caneurope.org/demand-side-flexibility-blog/

[35] Also “DSO-centric model”, as suggested by the industry.

considered[36] and specific measures need to be taken such as providing priority grid access and setting grid access quotas with targets adapted to the specific context.

A more flexible, more complex energy system requires training, re-skilling and specialised personnel, about the development of more decentralised energy infrastructures. The DSOs should learn how to talk to people in an understandable way, and make their processes and procedures customer-friendly. Distribution and transmission companies can inform local communities about required systems or behavioural change, how investment patterns impact local property, adopt efficient and meaningful consultation strategies, and environmental and social governance (ESG) criteria to enhance supplier relations. These can also help minimise the wider biodiversity impacts of transitions and help achieve nature conservation and restoration goals, which should adhere to the highest environmental and social standards, as a basis for all infrastructural development, throughout every phase.

Another area, in which the social dimension needs stronger consideration in future is the decommissioning of gas infrastructure. With electrification progressing, the utilisation rate of gas grids will decline. This means ever fewer consumers that are still connected to gas grids, e.g. to heat their homes, will have to pay for the costs to maintain the network, which opens questions about how this transition can be made socially fair and how cities and regions cope with this arising challenge. Fossil gas infrastructure will need to be decommissioned i.e. gas pipes either will need to be taken out of the network (not utilised anymore), to be repurposed for hydrogen use or dismantled. However, gas grid operators are failing to prepare for such changes, and related implications. It is a priority to make sure that stranded assets are avoided and that the costs of accelerated depreciation periods of networks are not put on the shoulders of end-consumers.

Efforts to accelerate permitting procedures for electricity infrastructure must also promote meaningful and innovative public engagement[37]. Consultative dialogue has to consider multiple issues openly and widely with community engagement, inclusion, respect for rights, and issues of due compensation (also community payments). Public consultations have to be conducted early in advance and in a meaningful way with full, clear, and transparent information, entail good-quality environmental sensitivity analyses and follow due obligations to map for biodiversity and wildlife sensitivity, migratory routes, ecosystems needs, and consider all environmental impacts. Early involvement of the public can significantly reduce planning and implementation of new infrastructure in the long run by addressing concerns at the very start. Sites that do not harm high-biodiversity areas should be prioritised on land and at Europe's sea basins.

Nature-protection must guide land and maritime spatial planning, in interaction with energy system planning, and their underlying modelling. Active information exchange and data collection on biodiversity impacts minimises risks. Integrated approaches, such as nature-positive infrastructures must be actualised and advanced, as new, best practices[38]. The use of existing

[36] Renewable energy (RES) communities, as an example of citizen-driven initiatives and ownership structures, are a good example of legitimacy for electricity infrastructure enhancements. In becoming infrastructure owners, local benefits are tangible. More work remains in leveraging awareness of this model, as part of far more decentralised infrastructure development.

[37] More on public engagement for energy infrastructure. https://userstcp.org/public-engagement-for-energy-infrastructure-task/?mc_cid=6962e2343b&mc_eid=fb1146d9c5

[38] Best practices database by the RGI. https://renewables-grid.eu/activities/best-practices/database.html

infrastructure efficiently or innovatively minimises environmental pressure[39]. For instance, most recent analyses revealed that none of Member States' maritime strategies are on course to meet EU climate and nature goals[40][41].

Awareness-raising campaigns are necessary for design improvements and ideal outcomes, and also assist in promoting the benefits of active energy consumption. Because new power lines and substations can cause temporary or permanent disruption to livelihoods and ecosystems, early consultation processes and transparent planning are key, especially for transmission grids onshore and offshore. Information can be shared to address and alleviate concerns (e.g. perceptions of public health risks like fear of radiation) across many different types of user groups. Early consultation and involvement in the planning process of local communities and experts can help avoid and mitigate potential impacts. How corridors, where power lines pass through the landscape, are managed can have minimise impacts on the surrounding ecosystem by for example encouraging the growth of endemic plant species. Green electricity corridor management should be widely implemented, however the basis for its success remains careful grid planning.

Conclusion

The future energy system will be fully renewable, considerably more decentralised (based on distributed energy resources), flexible and digitalised, and people-centred.

As the EU rolls out a grids action plan, we present in this paper principles to address grids strategically, to deal with present and avoid any future bottlenecks, to inform infrastructure decisions, as guidance to assist the EU and the EU Member States in national-level actions, to build a future-proof energy system of tomorrow[42]. European infrastructure planning must prioritise renewables-based electricity infrastructure that achieves national climate and energy targets, assuming a more ambitious, systems-based and integrated perspective, which also phases out all fossil fuels, as a transformative vision for Europe.

Citizens must be empowered and understand the key role of grids and energy infrastructure overall to achieve a successful energy transition. In moving towards a 100% renewable energy system, all related decisions should be assessed on a resilience basis, against environmental/biodiversity criteria and climate goals, and with a forward-looking view.

To advance these principles, a set of political and policy actions at the EU level are called forth:

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[39] Despite the spatial needs for grids, overall, the PAC scenario 2.0 by CAN Europe suggests lower spatial needs than the TYNDP Distributed Energy scenario. For data, explore the RGI/RLI tool: https://rgi.rl-institut.de/

[40] WWF 26 June 2023. https://www.wwf.eu/?7932966/The-EU-is-not-on-track-for-a-sustainable-blue-future

[41] In 2014, the EU adopted the Maritime Spatial Planning (MSP) Directive, which provides goals and requirements for human activities to take place in an efficient, safe and sustainable way. Under the MSP Directive, coastal EU Member States were required to publish national maritime spatial plans, aligned with the Directive's objectives, by 31 March 2021. See Directive 2014/89/EU of the European Parliament and of the Council of 23 July 2014 establishing a framework for maritime spatial planning. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32014L0089

[42] CAN Europe (2023) Energy System of Tomorrow. February 2023. https://caneurope.org/content/uploads/2023/02/ELECTRICITY-MARKET-DESIGN-BRIEFING-ENERGY-SYSTEM-OF-TOMORROW-6.pdf

Political/policy actions at the EU level

1. Enable and expedite a 100% renewable energy system

- Challenge the role of gas and other fossil fuel infrastructures in the Ten Year Network Development Plan (TYNDP) and the eventual selection of PCIs (Projects of Common Interest)/PMIs (Projects of Mutual Interest). Ensure that the scenarios underpinning the TYNDP meet science based climate ambition and are based on a 100% renewable energy system by 2040.
- Create an independent planning body for hydrogen, ENNOH (European Network of Hydrogen Operators), as future hydrogen networks should not be planned by gas TSOs (ENTSOG) only. Call for ENNOH to be established under the gas package.
- Call for independent assessments of hydrogen demand in priority sectors (for instance by ACER)

2. Plan for the phase-out of fossil-fuel infrastructure

- Quantify hydrogen demand and identify needs for localised infrastructure. The planning and modelling of hydrogen infrastructure projects needs to be led by an independent and science-based body. Conflict of interest as seen in the EU's current infrastructure planning process (TEN-E) with the gas transmission industry in the lead (ENTSO-G together with ENTSO-E), has led to increased gas consumption projections and continued eligibility of fossil gas projects for EU funding
- Eliminate conflict of interest (described above) throughout all the relevant pieces of legislation or processes (e.g. TEN-E, Decarbonised Gas and Hydrogen Package, Clean Hydrogen Alliance etc.).
- Create an EU framework for the decommissioning of fossil gas infrastructure.

3. Utilise the full potential of energy savings:

- Incorporate a holistic approach to European grid planning with regards to energy savings. Ensure absolute demand reduction in line with the Paris Agreement goal as main drivers for assumptions on how to frame cross-border infrastructure and pan-European network development plans.

4. Build a decentralised, flexible and digital energy system

- Finalise Electricity Market Design Reform, and make sure the provisions related to new framework for flexibility can guarantee quick ramp-up of Demand Side Response and Storage, while incentivising Members States to start assessing and addressing their flexibility needs.[43]
- Assess implementation of previous market reforms in the Member States properly (introduced as part of Clean Energy Package in 2019), especially flexibility and the system integration dimensions. The key findings should be taken onboard by national decision makers, including DSOs and TSOs.

[43] See CAN Europe expectations towards the reform: https://caneurope.org/electricity-market-design-emd-trilogues/

- Revise the EU strategy on energy system integration (2020), aimed at optimising and modernising the EU energy system to advance the transition.
- Ensure an ambitious and robust implementation of national heating and cooling plans.
- Ensure the currently revised Gas Package facilitates the uptake of renewable gases and customer empowerment.
- Establish a Distribution Grid Task Force on EU Level to oversee and investigate the bottlenecks and Member States' progress in addressing them.

5. Develop people-centred and nature-inclusive infrastructure

- Ensure transparency of costs to invest and operate new infrastructures are provided, and explained in the context of wider economic benefits of the transition to society.
- Incorporate strong environmental measures, including an ecosystem-based approach, and assessments into Offshore Network Development Plans (ONDPs) and national maritime spatial plans, informed by the EC Directive 2014/89/EU for Maritime Spatial Planning (MSP).
- Encourage active sharing of best nature-positive practices at land and at sea as well as promote R&D and innovation on locally adapted, nature-positive infrastructural solutions.
- To ensure an effective science-based development process it is of utmost importance to collect and share environmental data continuously to guide responsive and adaptive decision-making. The development of a centralised collection system based on common protocols should be considered. Enable/require cross-border collaboration to ensure environmentally sensitive and efficient grid planning. Large-scale compensation, mitigation, and restoration measures should be implemented beyond national borders.
- Ensure the upcoming guidance (April 2024) on the establishment of renewable acceleration areas includes recommendations for the dedicated infrastructure areas (art 15e of the RED 3) and development of sensitivity maps for member states to ensure a coherent approach.

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