

MAINTAINING MOMENTUM IN THE ENERGY TRANSITION

The Co-Benefits Framework: Investing Where Climate, Affordability, and Security Reinforce One Another

Synthesis report based on NTNU Energy Transition Week workshops, held in
Trondheim in March 2026

BRIEF

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This synthesis report summarizes two high-level workshops held as part of NTNU Energy Transition Week 2026, organized by the NTNU Energy Transition Initiative, with a particular focus on the European energy transition. The report argues that maintaining momentum in the energy transition now requires a co-benefits framework that connects climate action with affordability, security, resilience, strategic dependence, and public legitimacy. It classifies transition measures into four groups: synergistic, conditional, trade-off, and unresolved measures. The main conclusion is that the strongest transition strategy is not to accelerate all measures equally, but to prioritize measures whose benefits reinforce one another, carefully design conditional measures, manage trade-offs explicitly, and keep unresolved options open without overclaiming them.

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Key Messages

The next phase of the energy transition should prioritize measures that reduce emissions, strengthen security, improve affordability, and build public legitimacy at the same time. In a more unstable geopolitical environment, measures that solve only one problem are no longer enough.

I. INTRODUCTION

A. WHY CO-BENEFITS MATTER NOW

Maintaining momentum in the energy transition has become more difficult because energy policy is now shaped by several pressures at once. The transition remains essential for reducing greenhouse gas emissions, but it is increasingly tied to energy security, affordability, industrial competitiveness, defense preparedness, supply-chain exposure, and public legitimacy. Recent geopolitical instability, attacks on energy infrastructure, volatile fossil-fuel prices, cyber threats, and concentrated clean-technology supply chains show that the transition can no longer be treated as a narrow technical shift from fossil fuels to low-emission energy.

This creates a more demanding policy question. It is not enough to ask whether a measure supports decarbonization. A useful transition measure should also be assessed by whether it lowers exposure to external shocks, keeps energy affordable, strengthens resilience, reduces strategic dependence, and maintains legitimacy among citizens, industries, and local communities. Some measures clearly support these goals simultaneously. Others are useful only under specific design, governance, and market conditions. Some improve security while creating climate or affordability risks. Others remain promising but uncertain.

The purpose of this report is to turn these distinctions into a practical classification of transition measures: which ones offer clear co-benefits, which require careful design, which involve trade-offs, and which remain uncertain. This report builds on two NTNU Energy Transition Week 2026 workshops: the first on drivers of a resilient and secure energy transition, and the second on co-benefits among climate, affordability, and security [1], [2].

B. THE CO-BENEFITS ASSESSMENT

The co-benefits assessment asks whether each measure strengthens climate action, affordability, and security together, or whether its value depends on design, involves trade-offs, or remains uncertain.

The report categorizes the measures discussed during the two workshops into four categories:

- 1) **Synergistic Measures:** measures that reduce emissions, improve affordability, and strengthen security or resilience at the same time.
- 2) **Conditional Measures:** measures that can support several goals, but only if they are well designed, integrated, governed, financed, and accepted.
- 3) **Trade-off Measures:** measures that improve one objective while weakening another, especially security measures that may conflict with climate or affordability.
- 4) **Unresolved Measures:** measures with potential future value, but where cost, maturity, market demand, or system role remains unclear and/or uncertain.

The central argument is that the strongest transition strategy is not to accelerate every measure equally. Instead, prioritize measures that advance several objectives, redesign conditional measures so their benefits are realized, manage trade-offs explicitly, and keep uncertain options open without overclaiming them.

In the remainder of this report, Sections II–V present the aforementioned classes of measures. Table I also summarizes the directional assessment of the main measures and shows how they are classified under the co-benefits assessment. This report is an editorial synthesis of themes raised in two NTNU Energy Transition Week workshops. The categories and directional assessments were developed after the workshops; they do not represent a vote or consensus among participants. The assessments are qualitative and may change with geography, time horizon, system boundary, financing and distributional effects.

II. SYNERGISTIC MEASURES: DELIVERING MULTIPLE BENEFITS ACROSS THE ENERGY SYSTEM

These measures should be prioritized because they deliver multiple benefits (i.e., reducing emissions, improving affordability, and strengthening security or resilience) rather than advancing one objective at another's expense.

Energy efficiency and demand reduction are the clearest examples. In this context, demand reduction

refers to lower energy use achieved through efficiency improvements while maintaining the same level of energy services, rather than through sufficiency measures that reduce service levels. Using less energy usually lowers emissions, although the effect depends on the energy source displaced. It also reduces household and industrial exposure to volatile fuel prices, eases pressure on grids and generation capacity, and limits the infrastructure that must be financed, imported, defended, and maintained. Building renovation and insulation are particularly strong because they combine lower energy demand with lower bills, reduced fuel poverty, and greater public support. One workshop discussion pointed to revolving funds, which use repayments from completed projects to finance new ones, as a way to overcome upfront-cost barriers. More efficient transport systems can create similar co-benefits by reducing energy demand, emissions, and exposure to fuel-price shocks.

Demand-side flexibility can also deliver robust co-benefits when it helps the whole system, not just individual consumers. Flexible heating and cooling, smart appliances, electric-vehicle charging, and industrial demand response can shift electricity use away from peak hours. This makes better use of renewable electricity and reduces pressure on the grid. When many small actions are coordinated, they can add up to a valuable system resource. The result is a cheaper and more resilient energy system, with less need to build extra capacity for rare **peak events**.

Skills, energy literacy, and human capital are also robust co-benefits, although they do not deliver megawatts directly. A more complex, digitalized, and security-sensitive energy system needs people who can plan it, operate it, repair it, regulate it, and explain it clearly. This makes operator competence, repair capacity, public literacy, and next-generation skills part of the system's resilience.

III. CONDITIONAL MEASURES: WHEN BENEFITS DEPEND ON DESIGN

Many transition measures can create strong co-benefits, but not automatically. Their value depends on how they are integrated into the system, who owns

them, how they are regulated and financed, whether they are secure, and whether the public accepts them.

A. THE ELECTRICITY BACKBONE

The electricity backbone of the transition includes a wider set of connected measures: renewable generation, electrification, grid expansion and smarter operation, storage & flexibility resources, local energy systems, interconnectors, and resilience capabilities such as islanding and restoration. Together, these measures reduce dependence on fossil fuels and make it possible to decarbonize buildings, transport, and industry. They can also strengthen security by replacing continuous fossil-fuel imports with electricity produced from domestic or allied low-carbon sources.

However, their co-benefits depend on design. **Renewable generation without grid capacity** can create curtailment, congestion, and local opposition. **Electrification without affordable electricity** and grid access can become politically fragile. **Grids** that are expanded **without resilience** standards may increase dependence on vulnerable infrastructure. **Interconnectors** can reduce overall system costs and improve balancing, although their distributional effects may vary. In Norway, greater integration with continental European electricity markets has been associated with higher prices in southern price zones. They also create cross-border dependencies. **Batteries and short-duration storage** provide strong system value for balancing, ramping, frequency response, and data-center-related load swings, but they do not solve all seasonal or multi-week adequacy challenges.

The electricity backbone must be built to support decarbonization while simultaneously strengthening energy security and resilience. This means designing for restoration, islanding, black-start capability, redundancy where justified, repairability, cyber-secure control systems, and the ability to operate through external disruptions or internal failures.

B. DIGITAL, INDUSTRIAL, AND SUPPLY-CHAIN CONDITIONS

Digitalization and AI can support various parts of the energy system, such as decision support, efficient grid/asset utilization, forecasting, surveillance, and restoration. They can also improve overall system efficiency. However, these benefits come with new

dependencies on data, algorithms, software, compute infrastructure, and external technology providers. AI used in industrial systems must therefore be treated differently from general-purpose AI applications. Critical systems also need trusted data, validated models, manual fallback, trained operators, clear criteria for human takeover, and operational technology security.

Critical minerals and clean-technology supply chains are also conditional. Diversifying suppliers, recycling materials, reusing components, and working with trusted partners can make the transition more resilient. However, bringing more production closer to home can also raise costs, slow deployment, and create environmental conflicts around mining and processing. The strongest approach is therefore not full self-sufficiency. It is a diversified dependence: keeping global trade open while building trusted partnerships, backup options, and stronger circular value chains.

Long-duration and seasonal storage remain important challenges in high-renewable systems. **Product storage and flexible industrial supply chains** may offer an alternative by storing energy-intensive products rather than energy itself. This is promising because it could support both flexibility and supply-chain resilience, but practical deployment depends on labor, logistics, storage costs, and industrial coordination.

Stable policy, market design and access to finance are among the essential conditions for realizing these co-benefits. Instruments such as contracts for difference and de-risking mechanisms can help make technically sound measures investable.

Social value, community benefits and meaningful participation are also important conditions for realizing co-benefits. Workshop examples included community ownership, local employment, and opportunities to influence decisions. These illustrate how involving communities and sharing benefits can help connect system objectives with local priorities and strengthen public legitimacy.

IV. TRADE-OFFS: WHEN OBJECTIVES PULL IN DIFFERENT DIRECTIONS

The co-benefits assessment does not remove trade-offs. It makes them visible. Some measures may be necessary for preparedness or security, but they should not be presented as climate-affordability-security co-benefits.

Fossil backup and liquid-fuel preparedness are the clearest examples. Liquid fuels may remain necessary for defense, emergency response, host-nation support, and hard-to-electrify functions. This can strengthen short-term preparedness, but it conflicts with climate goals and creates lock-in risks if treated as a long-term substitute for low-carbon resilience.

Spare capacity, stockpiles, redundancy, and hardening of critical assets also involve trade-offs. They improve resilience and repair capability, but they raise costs and may require additional materials, land, and infrastructure. By contrast, broad reshoring or the pursuit of full strategic autonomy can reduce dependence on hostile or concentrated suppliers, but they may increase costs, slow deployment, and create environmental or social conflicts.

AI infrastructure, electricity demand, and digital sovereignty also involve trade-offs. Domestic computing capacity can support digital sovereignty, while the example from Tydal illustrated potential local benefits through employment, rural development, and waste-heat use. However, large AI loads can increase system costs, compete with other industries for grid capacity, increase electricity demand, and create cyber, ownership, and operational dependencies. Their climate effect depends on the electricity source, whether new low-carbon generation is additional, and whether AI demand displaces other electrification. Measures such as operational transparency, flexible load profiles, battery support, and useful waste-heat recovery can mitigate these effects.

Managed fossil decline and **stranded-asset risk** also belong in the trade-off discussion. A disorderly transition can create stranded fossil assets, stranded clean-energy assets, or underinvestment on both sides if

investors face high uncertainty. The policy challenge is to avoid new fossil lock-in while maintaining enough preparedness for severe disruption.

Affordability also involves trade-offs over time and between groups. Workshop discussions highlighted that households may be unable to finance efficiency improvements even when these offer savings over their lifetime. A similar financing challenge was discussed

for developing economies, where higher borrowing costs can hinder investment in clean-energy technologies with low operating costs but substantial upfront expenditure. Benefits can accrue over periods longer than electoral cycles, making sustained policy support important. Co-benefit assessments should distinguish upfront costs from longer-term savings and identify who pays and who benefits.

MEASURE FAMILY	AFFORDABILITY	SECURITY	CLIMATE	CLASSIFICATION
Energy efficiency and demand reduction	++	++	++	Synergistic measure
Building renovation and insulation	++	++	++	Synergistic measure
Demand-side flexibility	+	+	+	Synergistic measure
Skills, energy literacy, and human capital	+	+	+	Synergistic measure
Renewable electricity deployment	+/-	+	++	Conditional measure
Electrification of buildings, transport, and industry	+/-	+	++	Conditional measure
Grid expansion and smarter operation	+/-	+	++	Conditional measure
Grid resilience-by-design, islanding, and restoration	+/-	++	+	Conditional measure
Local energy systems and microgrids	+/-	++	+	Conditional measure
Short-duration batteries and storage	+/-	++	+	Conditional measure
Interconnectors and cross-border integration	+	+/-	+	Conditional measure
Digitalization and AI for system operation	+/-	+/-	+	Conditional measure
Clean-tech supply chains & strategic European capacity	+/-	++	+	Conditional measure
Long-duration storage and flexible supply chains	+/-	+	+	Conditional measure
Emergency fossil backup and liquid-fuel preparedness	+/-	+	--	Trade-off measure
Targeted spare capacity, redundancy, and stockpiles	--	++	+/-	Trade-off measure
AI infrastructure, electricity demand & digital sovereignty	--	+/-	+/-	Trade-off measure
Hydrogen and green gases	?	+/-	+	Unresolved measure
Carbon capture and storage	?	+/-	+	Unresolved measure
Nuclear power	?	+	+	Unresolved measure

Symbol interpretation: ++ strong positive effect + positive effect +/- mixed or conditional effect
 - negative effect -- strong negative effect ? uncertain

Table I. Directional classification of selected transition measures by co-benefit effect.

Note: These qualitative classifications reflect editorial judgment based on workshop discussions rather than a workshop vote or consensus, and may vary by context and time horizon.

V. UNCERTAINTIES: PROMISING MEASURES THAT SHOULD NOT BE OVERCLAIMED

Some measures may become important, but their future role remains uncertain. These should be developed as strategic options rather than treated as guaranteed pillars of the transition.

Hydrogen and green gases may be useful for hard-to-abate sectors, selected industrial processes, synthetic fuels, and possibly long-duration flexibility. However, their costs, infrastructure needs, and market demand remain uncertain. One example from the workshops concerned early-stage projects for large-scale hydrogen production in Norway and transport to Germany. The projects were stopped because potential buyers were not willing or able to pay the premium for low-carbon hydrogen. **Carbon capture and storage** may be important for high-concentration industrial emissions and some carbon-removal pathways. Its role depends on cost, market development, and the availability of direct reductions through electrification, efficiency, or process change.

Nuclear power may provide firm low-carbon electricity in some systems, but it is highly context-dependent because of cost, lead time, politics, regulation, and system fit.

VI. POLICY IMPLICATIONS

First, demand-side measures should receive greater attention in transition strategy alongside supply- and infrastructure-side measures. Efficiency, demand reduction, building renovation, demand flexibility, and energy literacy can reduce the system's scale, cost, and vulnerability.

Second, infrastructure should be planned as security infrastructure. Grids, storage, interconnectors, local systems, data centers, digital systems, and supply chains should be assessed not only for cost and emissions, but also for resilience, reparability, cyber trust, restoration, and strategic dependence.

Third, policy should make design-dependent measures conditional. It is not enough to assume that renewables, electrification, AI for system operation, or supply-chain measures automatically support all objectives. Policy should specify the conditions required to achieve those co-benefits.

Fourth, treat affordability and legitimacy as resilience conditions. Projects that are technically sound may still fail if costs are unfairly distributed, local benefits are invisible, or communities experience the transition as imposed.

Fifth, develop uncertain measures selectively, without distracting from synergistic measures. Hydrogen, CCS, and nuclear may become important but should not delay efficiency, demand reduction, grid resilience, and flexibility.

VII. CONCLUSION

Across the two workshops, a recurring theme was that transition measures do not automatically strengthen security and affordability. This report therefore applies a more disciplined co-benefit logic. Some measures reduce system stress and should be prioritized. Some can create major benefits, but only if well designed and governed. Some are necessary for preparedness but involve real trade-offs. Others remain promising but uncertain.

The most useful transition measures are those that remain valuable under uncertainty because their benefits stack across climate, affordability, security, resilience, and legitimacy. Energy-transition policy should therefore prioritize robust co-benefits, improve the design of conditional measures, manage trade-offs explicitly, and treat uncertain measures as options rather than guarantees.

REFERENCES

- [1] NTNU Energy Transition Initiative, "[Workshop on Drivers for a Resilient and Secure Energy Transition](#)," Trondheim, Norway, Mar. 16, 2026.
- [2] NTNU Energy Transition Initiative, "[Maintaining Momentum in the Energy Transition: Co-Benefits between Climate, Affordability, and Security](#)," Trondheim, Norway, Mar. 17, 2026.