TOWARDS A CIRCULAR ENERGY INFRASTRUCTURE

Final Report

Executive summary

Achieving the Dutch energy transition necessitates millions of tons of material. This extensive demand for material significantly impacts the environment throughout the supply chain, imposes substantial societal costs and heightens risks to security of supply. To ensure the feasibility and sustainability of the energy transition, a material transition is critically required.

Grid operators and market participants are committed to collaboratively advancing towards a circular energy infrastructure. The Dutch government's circular ambition is pivotal in this endeavor: a 50% reduction in primary ('new') raw material usage by 2030. The primary focus is on key network components: electricity cables, gas pipelines, transformers, and switchgear.

The energy infrastructure sector is well-positioned to take further steps towards circularity. Both grid operators and manufacturers are already engaging in circular initiatives. This has resulted in re-use programs, circular cables and enhanced insight through the application of material passports.

Transitioning from a linear to a circular mode of operation calls for a systemic change. This transition necessitates the adaptation of numerous agreements, work processes and cooperation methods to a new reality.
Four key transformations are essential:

- **From individual visions to a common language,** to work consistently towards circular ambitions;
- **From depreciating assets to maximizing the use of components**, to limit new asset procurement;
- **From focus on internal risks to supply chain risks**, to gain better insights into dependencies and manage them effectively, in accordance with regulations;
- **From prioritizing the lowest price to prioritizing material use, CO_2 emissions and environmental impact,** to drive improved sustainability performance on short and long term.

From these essential system changes, several recommendations emerge, forming the building blocks for a joint roadmap of clients (grid operators) and the market (producers and other partners) to achieve a circular energy infrastructure. These recommendations are as follows:

1. **Co-create circular solutions** through collaboration between producers, grid operators and other supply chain partners;
2. **Formulate joint procurement specifications** and category management across grid operators with corresponding objectives;
3. **Assign sufficient weight to circularity in tenders** and utilize a clear assessment framework based on the developed common language;
4. **Emphasize life extension** in technical principles and internal work processes (asset management) and implement a 'Reuse unless' policy;
5. **Jointly adapt current standards and norms** to enhance circularity;
6. **Develop a strategy to secure a supply chain approach** for circular materials and business models;
7. **Invest in supply chain information systems** to enhance transparency regarding material impact and supply chain dependencies.

To initiate the first steps, three sprints were conducted recently. Grid operators and market parties collectively sought circular solutions. The first sprint focused on the application of recycled and biobased plastics in cables. The second sprint explored the upgrading of power transformers. The third sprint examined the potential for emission-free and circular steel.

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FOREWORD

Together we share one earth

Together, we share one earth,
yet, we seem to be risking our only home now.
Fortunately, there are long-term life stories
of energy grids and assets
both above and underground:
a testament to value retention.

May we cherish them wholeheartedly
to turn the tide.

Energy is vital to our society, but it is not always and everywhere available by default. The networks are becoming overloaded due to increased demand and the strong growth in sustainable supply of energy from solar and wind sources. There are long waiting lists. The environmental impact of all the necessary raw materials for this expansion is also unacceptably high. Globally, the International Energy Agency predicts an exponential increase in material demand due to the energy transition. This exceeds the planetary boundaries within which we seek to ensure a safe and sustainable well-being for all life on Earth. Continuing our current practices poses significant risks to security of supply and affordability.

Grid operators, therefore, endorse the ambition from the National Circular Economy Program (NPCE) to use 50% less primary material by 2030 compared to 2014. This report was produced through close collaboration between the energy grid operators under the banner of Groene Netten, manufacturers, supply chain partners, and the industry association Fedet, supported by Invest-NL. The goal is to align supply and demand through focused market consultation and to stimulate circular uniform policy and innovation capacity.

Additionally, three promising supply chain dialogues ("Sprints") were set up to explore the application of recycled plastics in electricity cables, upgrading transformers to handle extra capacity, and commissioning of green and circular steel.

Truly future-proof networks are technically advanced with a minimal footprint on materials and energy use. We warmly invite you to join us: every step counts to make this crucial energy infrastructure more sustainable.

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Background: no energy transition without material transition

To realize the Dutch energy transition, millions of tons of material are needed. This large material demand leads to significant environmental impact in the supply chain, social impact, high costs and increasing risks to security of supply. To ensure the feasibility and sustainability of the energy transition, a material transition is critically required.

In 2020, regional grid operators (Stedin, Enexis, Liander) alone purchased about 50 million kilos of material.[1] Since then, the demand for medium-voltage cables has doubled or even tripled. The same trend is visible at TenneT as the national grid operator, particularly due to the growth of offshore wind farms.

This growth will continue towards 2030 and 2050. From the perspective of grid operators, the quantities of electricity cables (high, medium, and low voltage) are particularly significant: +50 to +70% by 2050. The number of transformer stations also increases significantly due to this growth in capacity.

The material demand consists primarily of aluminum (e.g., as a conductor in cables) and copper (in both cables and transformers), steel (e.g., in transformers and high-pressure gas pipes), high-grade plastics, rubber, and transformer oil.

The material demand of the Dutch energy transition is a significant part of the global production, both for copper (0.25 – 0.65%) and aluminum (0.10 – 0.24%)[2]. For illustration: the Netherlands is responsible for 0.5% of global energy consumption and hosts about 0.2% of the world's population.

Handling our raw material demand more consciously is essential for four reasons:

- **Minimizing the environmental impact** of the energy transition to reduce the impact in the supply chain and limit the amount of waste in the rollout of the network;
- **Minimizing the social impact** of the energy transition to reduce forced labor and human rights violations in the supply chain;
- **Limiting risks** associated with the timely, cost-efficient, and adequate availability of materials for strengthening the energy network;
- **Reducing the costs** of network expansion to limit unnecessarily high societal costs.

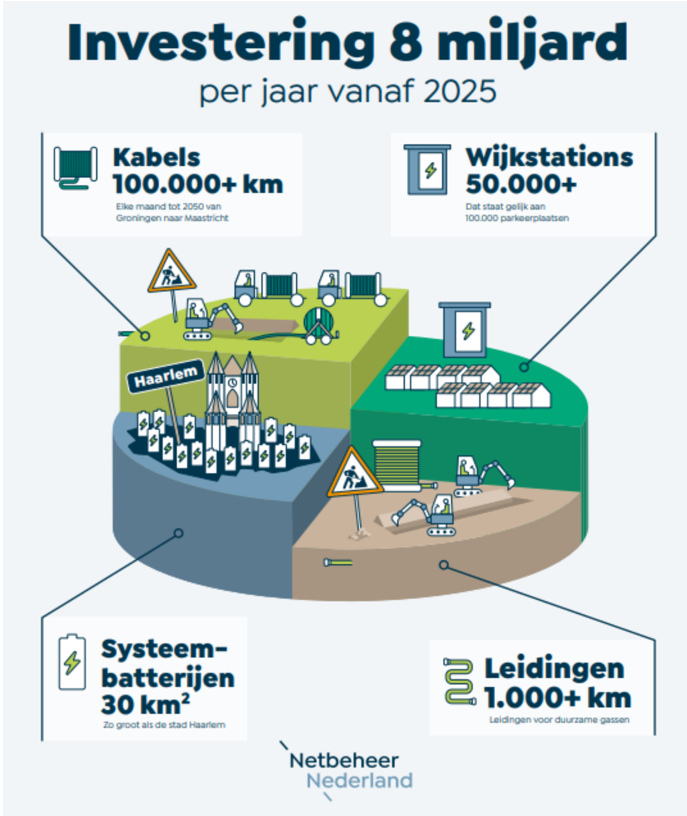

Figure 1 | Required infrastructure for a sustainable energy system in the Netherlands

Volume growth of the electricity system

In the coming decades, the required network capacity will grow significantly because of the energy transition in the Netherlands. The goals for this growth have been established in the Climate Agreement up to 2030. For the period up to 2050, four 'corner flag scenarios' with extremes have been developed from the Integrated Infrastructure Exploration 2030-2050 (II3050).

In all scenarios, a large increase in network capacity is needed, although the degree of growth varies per scenario. For grid operators, the most significant growth is in transformer stations and cables.

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Joint ambition: towards a circular energy infrastructure

Grid operators and the market aim to work together towards a circular energy infrastructure. The focus is on key network components: electricity cables, gas pipelines, transformers and switchgear. Based on the Dutch government's circular ambition to use 50% less primary raw materials by 2030, we aim to improve the feasibility and sustainability of the energy transition.

Implementing this ambition builds on circular principles already being applied. However, this is a formidable task given the increasing material demand needed for the energy transition. To guide our efforts, we have developed a vision for circular energy infrastructure. From this vision, we undertake joint actions detailed in Chapter 5.

Administrative commitment

In February 2023, the collaborating grid operators committed administratively within Groene Netten. They collectively endorsed the ambition from the National Circular Economy Program (NPCE) to work towards 50% less primary raw material use by 2030 (baseline: 2014, measurement per kg). This ambition forms the basis for this trajectory.

The way of working regarding the electricity and gas grids show that circular working is already the standard in some areas. Therefore, there is a strong foundation for the future. The circular strengths of the energy infrastructure sector include:

- **Lifespan:** very long lifespan of assets: > 40 years, sometimes even 100+ years in use
- **Product requirements:** reliable and robust design
- **Market characteristics:** decades-long strong relationships between grid operators and many Dutch and international manufacturers

National and European ambitions

Nationally, there are high ambitions in the circular economy field. By 2030, primary raw material use must be reduced by 50% (baseline 2014); by 2050, the ambition is for the economy to be 'fully circular'. This ambition was previously endorsed by many parties in the Raw Materials Agreement (2017)[3] and reaffirmed in the recent National Circular Economy Program (2023)[4].

These national circular economy ambitions complement national climate goals. For 2030, a 55% CO_2 reduction has been agreed. European sustainability laws are bundled in the Green Deal, including a Circular Economy Action Plan[5]. The most concrete elaboration of this is the EcoDesign regulation, creating European design guidelines for circular design.

The energy infrastructure sector: a solid circular foundation

The energy infrastructure sector has a solid foundation for taking further steps towards circularity. The topic has been a strategic (CSR) theme for about 10 years, translating into internal operations and tenders. Various parties are already proactive, both grid operators and manufacturers. This has led to the following successes, among others:

- **Re-use programs for network components** at Alliander, Enexis, Stedin, Gasunie and TenneT, mainly for transformer stations and switchgear. This results in both significant material and cost savings. For example, the re-deployment of existing assets accounted for 2% of the total procurement volume for grid operator Alliander in 2022 (approx. €10 million).
- **Internal circular KPIs for control and reporting** at all major grid operators are in place, focusing on reducing primary material and increasing component recyclability.
- **Material passports** requested from market parties as a data source for the KPIs.
- **Circular procurement** by weighing circular principles in tenders, such as the Fair Meter and Circular Cable with recycled plastics. (see frame)

- **The Groene Netten collaboration** (Green Grids active since 2015), from which a joint material passport has been introduced, the Coalition Leadership on Circularity has been established, and material exchange between grid operators with regard to reuse has been shaped.
- Various **circular innovations** from manufacturers, including in the field of lifespan extension, re-deployment, and smarter design. These innovations often contribute not only to sustainability but also to the feasibility and timeliness of implementation.
- Increasingly available **sustainability data** from products provided by market parties.

However, these successes often stand alone. Circular solutions are still too much within individual organizations. Collaboration and structural embedding are the main challenges.

Circular KPIs of grid operators

Many grid operators measure their circular performance – often on circular procurement – according to KPIs. The material passport is the basis for gaining insight into the quantities of primary ('new'), recycled, and recyclable material. In developing the KPIs and requesting material passports, mainly a 'baseline measurement' has been done so far, with the next steps for improving performance still to be taken.

Grid operator	Focus of KPI	Scope
Enexis	Reduction of primary material (including biobased and recycled material)	Cables, gas pipelines, distribution transformers
Alliander	Average of reduction of primary material and theoretical recyclability	Cables, gas pipelines, distribution and power transformers, smart meters
Gasunie	Average of reduction of primary material and theoretical recyclability	Gas pipelines (including its use in the transition to hydrogen and other sustainable gases)
TenneT	Reduction of primary material through circular design, procurement for high-quality reuse, avoided waste in closed loop, and lifespan extension	Cables, stations, transformers and other primary and tertiary (architectural) assets

A joint vision

To take further steps towards a circular energy infrastructure, a joint vision has been developed. This vision forms the basis for all efforts on circular grids in the coming years. The focus is on the four largest ('primary') asset groups within the **electricity and gas infrastructure: electricity cables, gas pipes, transformers and switchgear.**

Vision circular energy infrastructure: 50% less primary material by 2030

(Compared to 2014)

Grid operators in the Netherlands have succeeded, in close collaboration with suppliers and other supply chain partners, in improving annually from a holistic perspective (including CO_2 reduction) in building a circular energy network where all components circulate in a closed loop close to their own area and are deployable with optimal lifespan.

The material need as a risk is mitigated by the following efforts:
- **Ensuring optimal material use in design with a reduction in primary material where possible**
- **Lifespan extension by making optimal use of assets and preventing premature aging**
- **Re-deployment and refurbishing of assets and components is the standard**
- **High-quality recycling returns raw materials to production, and nothing is incinerated or landfilled**

As a result of these efforts, new opportunities arise in the Netherlands for start-ups and scale-ups based on (new) circular business models.

From this vision, different types of action perspectives arise. For grid operators, the emphasis is on two areas:

- **Lifespan extension** (repair, re-deployment) of existing assets, focusing on re-deployment of transformers and condition management of connections through monitoring;
- **Circular procurement** of the newly needed capacity, focusing primarily on cables, which form more than 75% of the total procurement volume of the grid operators Alliander, Stedin and Enexis (based on mass).

For producers and suppliers, the emphasis is on two other areas:

- **Product and material innovation** to reduce the amount of primary material in newly delivered products and increase the share of recycled or biobased material;
- **Supply chain collaboration** to achieve the highest possible processing of residual material after return

The higher on the R-ladder, the more sustainable

By focusing on a circular energy infrastructure, we aim at various levels on the 'R-ladder' – the national framework for determining the degree of circularity. A measure higher on the R-ladder contributes more strongly to realizing circular ambitions.

Shifting to "higher on the R-ladder" means shifting from primarily purchasing more re-cycled material (R8) to repurposing parts (R7) and extending the lifespan through repair (R4). There are also opportunities in smarter design, shared use and monitoring of components (R2) to reduce material demand – and thereby environmental impact, costs and supply risks.

Repurposing parts and repairing or renovating existing assets means less new procurement is needed. In many cases, the costs of this are significantly lower than the costs of a new asset, which also leads to a net cost saving for the grid operator. Hereby, reducing overall societal costs as well.

Note | The 'refuse' of additional capacity (R0 - Refuse on the R-ladder) is most impactful in many instances but for this study out of scope. This theme includes, for example, large-scale energy saving at companies and households, cable pooling (sharing capacity) and better matching of supply and demand which lowers energy peaks. Many parallel projects are currently ongoing on this matter, to significantly contribute to reducing the extra material demand and lower grid congestion needed for a sustainable energy system.

R-ladder: levels of circularity

For products, circularity has three main levels in order of priority: smarter design by applying no or less material or by intensifying use.

Extending usage by re-deploying, repairing, or renovating products, and making material useful by high-quality recycling. The R-ladder states: the higher on the ladder, the more sustainable.

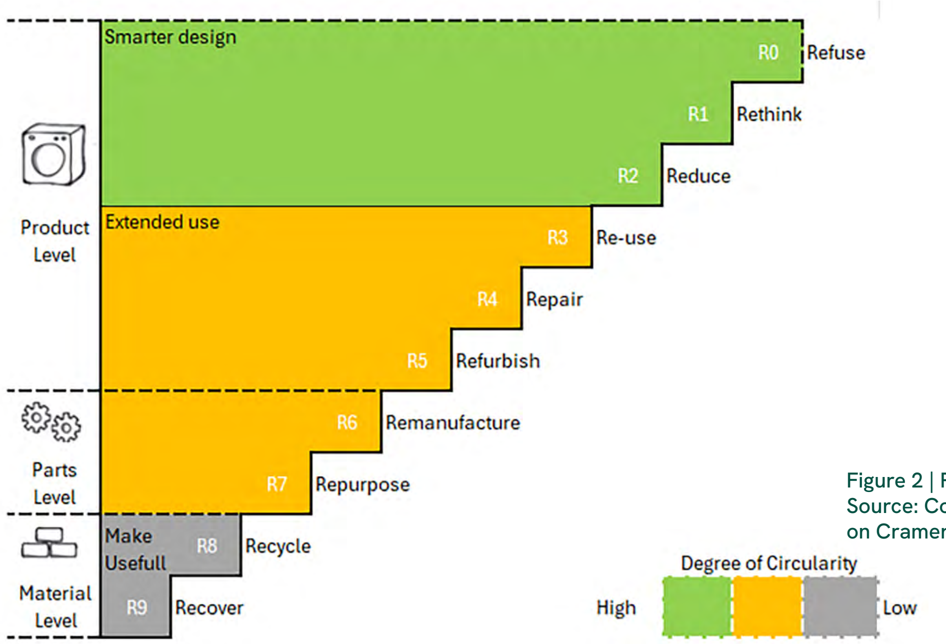

Figure 2 | R-ladder
Source: Copper8 based on Cramer et al. (2012)

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System change: shift of perspectives

If we want to realize a circular energy infrastructure and create long-term value, the existing way of working must change from linear to circular. The ambitions for this have been expressed. The translation to work processes is an important next step. There are four significant changes that need to addressed both by grid operators and by producers as well as supply chain partners involved.

The current working method is largely still based on the linear economy, assuming that raw material is available indefinitely in a free trade market and that the impact throughout the supply chain is invisible. In a circular economy, we take the limited availability of raw materials on earth as starting point. After all, undeniably, the earth has finite resources and we are conscious of limits to growth and increasing scarcity. Minimizing environmental and social impact of material use in the supply chain is also of major importance.

The transition from a linear to a circular way of working requires a system change. This means a change of virtually all agreements, work processes and ways of cooperation as they have been over the past decades. Especially when we combine this change with the great 'production pressure' due to the expansion needed for energy grids to facilitate the energy transition, significant challenges arise.

From an analysis with insights from various supply chain parties – see Appendix I – the four most important changes needed have been identified to take the next steps in this system change:

1. From individual visions to common language
2. From depreciating assets to maximizing the use of components
3. From internal risks to supply chain risks
4. From steering on the lowest price to steering on material use, CO_2 emissions, and environmental impact

1. From individual visions to common language

Currently, grid operators each have their own vision and strategy on circular economy. As a result, definitions and KPIs differ as well as control mechanisms within each organization. An example is that almost all organizations request material passports, but this is done in different ways without a clear underlying purpose.

Content-wise, the various definitions largely overlap. However, there is a difference in the recyclability (end-of-life) included in some definitions but not in others. Nevertheless, different requests are made to the market, often with unclear definitions as to what is included. An example is recycled plastic (see Sprint I).

Needed perspective change

A sector-wide common language is needed regarding circular working. This requires a joint vision and strategy on circular grids instead of individual visions and strategies of the grid operators themselves. For market parties to be able to invest, this vision must then be concretized into indicators and specifications. Alignment with European principles is essential for future robustness.

⇨ This is further elaborated in Recommendations 1, 2 and 3.

Example from the construction sector: uniform language

In the construction sector in the Netherlands, the past few years parties have been working on Het Nieuwe Normaal: a new unified language with feasible and ambitious performance on circular construction. Het Nieuwe Normaal offers three things to look at circular construction in a unified way:

- **A framework with nine indicators, each with its own measurement**
- **A set of design and construction principles per indicator on the framework (see figure)**
- **Possible performance levels per indicator, allowing clients and contractors to make agreements about circular performance.**

This language was developed on the initiative of an independent party (Cirkelstad) for and by parties in the sector. It is now being applied more widely by several parties.

Topic	Indicator	Design & Construction Principle
Environmental Impact	Environmental Performance Building (MPG)	Design and construct with the lowest possible Environmental Performance Building (MPG)
	Material related CO2 Emissions	Design a building with the lowest possible material-related CO2 emissions (embodied carbon)
	Material -related CO2 Storage	Design a building with the highest possible material-related CO2 storage (embedded carbon)
Material Use	Origin of Materials	Design a building with as many responsibly sourced materials as possible: reused, recycled, or renewable
	Healthy Materials	Design a building with as many healthy materials as possible
	Handling of Construction Waste	Design and construct with the least possible construction waste
Value Retention	Adaptive Capacity	Design and construct with the highest possible level of adaptive capacity
	Disassemblability	Design and construct with the highest possible disassemblability
	Reuse Potential	Design and construct with the highest possible reuse potential

Figure 3 | Design and construction principles from Het Nieuwe Normaal for circular construction hetnieuwenormaal.nl

2. From depreciating assets to maximizing the use of components

The production of cables, transformers, and other parts of the electricity system requires a lot of material. Once in use, these assets last a long time: many decades to sometimes even a hundred years. The value retention of existing assets – by using them longer than the depreciation period – can make a significant contribution to the feasibility and affordability of the energy system.

This requires fully utilizing current assets and their parts instead of replacing them. Two examples:

- **Good example:** By increased monitoring of load profiles and placing a fan on a current transformer, the peak capacity can be significantly increased by using a different type of oil. This avoids the need for a new transformer despite an increase in the required transformer capacity (see Sprint II).
- **Learning example:** The first generation of smart meters (approx. 5 million units) must currently be replaced prematurely because the communication module is outdated. Since this module is not adaptable, the meters must be replaced.

Needed perspective change
First, a different way of valuing depreciated assets – or assets that are replaced prematurely – is needed to maximize their value. This also requires purchasing new assets based on adaptability and the possibility for upgrades, thereby preventing future value loss due to premature replacement. By incorporating these benefits into the financial (risk) models of asset management, value retention can be structurally secured.

⇨ This is further elaborated in Recommendation 4.

3. From internal risks to supply chain risks

To perform their societal task properly, risk management is an important part of grid operators' operations. Now, much of the focus is on – often internal – risks such as budget and planning. Think of dependencies on specific contractors or suppliers who do not meet agreements or commitments.

When the risks are mapped out, the mitigating measures are often viewed linearly. This unintentionally makes the problems of other parties in the chain bigger. An example: a possible shortage of raw materials is solved by adding additional own stocks at one grid operator, making them no longer available to other parties. From a societal shortage of materials, it is undesirable for all parties to hold their own stocks.

Needed perspective change
A broader perspective on risks and risk management is needed to manage all chain risks towards the future. This applies to both grid operators and producers. Think of possible disruptions in the supply chain that threaten security of supply. For example, due to a large peak demand or geopolitical disruptions. Increasing insight into the environmental and social impact of mining is also a risk because it allows all parties in the chain to be held accountable for the impact that occurs within their responsibility.

⇨ This is further elaborated in Recommendation 7.

4. From steering on the lowest price to steering on material use, CO_2 emissions, and environmental impact

The production of cables, pipes, transformers and other parts of the electricity and gas networks requires a lot of material. The production of these materials and the necessary components results in significant CO_2 emissions (linked to the production of physical products in scope 3 of grid operators and manufacturers) and environmental impact in the supply chain. To reduce these emissions and impact, strong and more consistent steering from grid operators is needed.
The strongest steering on CO_2 emissions currently takes place at the European level. From the emissions trading system ETS, total CO_2 emissions in Europe are capped and priced. Additionally, a CO_2 levy is introduced at the European border via the border correction mechanism CBAM to maintain a level playing field for the European industry. This leads to both a cap on CO_2 emissions and higher product prices for products with an energy-intensive production process.
More structural and stronger attention to material use, also in relation to CO_2 emissions and environmental impact, gives the market a clear development direction.

Many circular innovations are already available but are not yet taking off properly. These innovations contribute in the long term to improving security of supply (example: a smaller dependency on new raw materials) or ensuring a longer lifespan (example: modular expandable design).

Needed perspective change
This requires grid operators who, from their role as client, strongly steer on material use, CO_2 emissions and environmental impact instead of the relatively strong steering on price that has taken place in recent years. From insight into current performance, solutions can be sought together with producers to reduce the impact, for example, by making investments in the sustainability of production through a growth-model as part of large supply contracts.

⇨ This is further elaborated in Recommendations 3 and 5.

Dilemmas in implementation

When implementing circular ambitions, practical dilemmas arise. Two examples:

Re-use of old assets versus purchasing new assets.

- **Network components such as transformers are suitable for re-use. However, new transformers have lower network losses. Re-deployment can therefore conflict with reducing energy losses.**
  Assessment: The optimum often lies around a specific construction year of transformers, which should be defined in policy. As a rule: if more than 20% energy loss can be reduced by replacement, this is a more sustainable option than re-use.

Primary material versus recycled material.

- **New material sometimes results in a longer lifespan and lower resistance (network losses from, e.g., EcoDesign directive) than recycled material, for example, in a cable or transformer. This can be solved by adding more recycled material such as aluminum or copper for conduction. This again conflicts with the principles from the R-ladder (R2-Reduce). More material also affects dimensioning. Thicker cables are less flexible and no longer fit connections and connected transformers.**
  Assessment: When minimal performance such as lifespan, dimensioning and energy losses are conditionally set, steering can take place on maximum re-use within that framework.

4

Recommendations: building blocks for a joint roadmap

From the necessary system changes, several recommendations emerge. These recommendations are building blocks for a joint roadmap in co-creation between buyers (grid operators) and the market (producers and supply chain partners) to achieve a circular energy infrastructure. Collaboration based upon a shared ambition is key.

The most promising routes to limit the demand for primary material:

- **Existing assets: lifespan extension** of current network components and optimally utilizing them through re-deployment at different levels (preventive maintenance, monitoring, repair, refurbishing, reuse and modernization on-site).
- **New assets: technological product and material innovation, e.g.,** by redesigning with less material and other materials, for example, by replacing primary material with recycled or biobased material.

To outline the roadmap together, the seven most important recommendations have been formulated:

1. Co-create circular solutions in collaboration between producers, grid operators and other supply chain partners;
2. Formulate joint procurement specifications and category management with corresponding objectives for the different product groups towards the market;
3. Give circularity sufficient weight in tenders and use a clear assessment framework based on the developed common language;
4. Emphasize life extension in technical principles and internal work processes (asset management) of grid operators and apply a 'reuse unless' policy;
5. Jointly adapt current standards and norms to enhance circularity;
6. Develop a strategy for a supply chain approach on circular materials and business models;
7. Invest in supply chain information systems.

1. Co-create circular solutions in collaboration between producers, grid operators and other supply chain partners

Both producers and grid operators have in-depth technical expertise on assets. Grid operators determine the specifications (demand-driven market), while there is currently limited availability of production capacity (supply-driven market). To realize circular ambitions in the short and long term, long-term collaboration is now being pursued. Supply chain parties deeper in the supply and processing chain must also be involved, for example, for the correct and timely supply of high-quality recycled metals and plastics. New forms of collaboration and targeted market dialogue are needed outside tenders and procurement moments.

Many supply chain parties are enthusiastic about co-creating solutions in 'Sprints' such as the three examples in Chapter 5 Sprint I - III. This removes obstacles for specific products and materials and seeks circular solutions from the shared circular ambition. Furthermore, the new risks involved are clarified and addressed.

To achieve implementation within individual organizations, these sprints must be followed up in teams with experts from both producers and grid operators as well as other supply chain partners. The results must then be translated into contract management, policy, procurement and execution at the individual grid operators, producers and other supply chain partners.

Desired outcome
Product improvement based on joint coordination between producers, supply chain partners and grid operators.

Conditions
- Open setting where equal and trustworthy dialogue can take place.
- Narrow focus (aimed at one material or product group) with sufficient technical expertise from various supply chain parties, considering cartel legislation.

2. Formulate joint procurement specifications and category management with corresponding objectives for the different product groups towards the market

Grid operators individually use different procurement strategies and specifications to request and ensure circularity of their products. To ensure continuity from the market, consistency is needed.
By posing a more unified question to the market, it becomes possible for suppliers of products and raw materials (e.g., recycled plastics) to make long-term investments. Focus must be on reducing primary material by structurally including this in the awarding of tenders.
Concretely request innovations that:
- Require less material (R2) – with retained functionality.
- Substitute primary material with recycled or biobased content (specifically plastics and metals);

Work out per product group (cables, pipelines, transformers):
- Minimum requirements and criteria regarding circularity;
- A menu of options (criteria) that, in different degrees (ambition levels), contribute to the goal per product group.

Desired outcome
Harmonized requirements and criteria per product group that are structurally requested in tenders by grid operators. These requirements and criteria are prioritized by impact, feasibility and set out in time in case of necessary further development (type testing etc.).

Conditions
- Requirements and criteria must not contradict minimum safety requirements and other laws and regulations (example: nitrogen or other emissions).
- Availability must be guaranteed.
- Affordability must be acceptable, considering (avoided) societal costs.

3. Give circularity sufficient weight in tenders and use a clear assessment framework based on the developed common language

In addition to individual strategies and specifications, grid operators also use different weighting models and often award parties based on already achieved performance.

Award in tenders both on measurable current performance and future performance - which innovations will be implemented during the contract period to achieve ambitions. Record the latter in contracts and joint roadmaps with clear growth model and ambitions in collaboration with suppliers. Ensure successful innovations are communicated and secured sector-wide (e.g., via Netbeheer Nederland) to become a new standard. This helps grid operators and the market take larger steps towards circular products.

Use a TCO (Total Cost of Ownership) approach and include the shadow prices of environmental indicators when partly awarding on price (with a maximum weight of 30% to prevent too strong steering on price).

Desired outcome
Contracts that genuinely reward and secure circularity in the long term. Concretely, request and score in tenders to apply and further develop innovations in long term contracts, on circularity at grid operators.

Conditions
- All applicable standards from safety and laws and regulations remain in force.
- Use a ceiling price or contract clauses to keep expected costs fair and predictable. Possibility to work overarching through framework contracts, in addition to tenders, that offer the market more long-term certainty and feasible frameworks.

4. Focus on life extension in technical principles and internal work processes (asset management) by grid operators and apply a 'Reuse, unless' policy

All grid operators have circular ambitions at a strategic level to make 50% less primary material possible in 2030. Despite some good examples, these ambitions are insufficiently reflected in daily operations.

To realize the ambitions, a clear translation from management to middle management and execution is needed. In addition, the consequences must be made clear. Internally, this far-reaching ambition leads to a strong development of departments in the field of re-deployment. In this, make technical experts at both strategic and operational levels co-owners of the policy on re-deployment and define internal objectives at organization and team levels. This can also directly benefit the cost-saving objective and acceleration of available assets to expand grid capacity and relieve grid congestion.

Externally, more structural emphasis must be placed on product innovations and closing loops, among other things, by returning old network components to producers or recycling partners.

This means concretely:
- Steering on lifespan extension by re-deployment from Asset Management through circular strategy and approved policy;
- Aligning and training (young) technicians to develop re-deployment (repair and upgrading, e.g., transformers) as a profession;
- Seeking cooperation between grid operators and the market to optimally exchange knowledge and components.

Desired outcome
Lifespan extension of assets as a norm. Through concrete translation of internal policy to the implementation departments and collaboration with fellow grid operators and the market. Ownership to be taken by the technical experts.

Conditions
- Right capacity and knowledge at grid operators to implement re-deployment policy.

5. Jointly adjust current standards and norms to enhance circularity

The application of circular materials is partly still limited by what current standards prescribe. For example, it is currently not possible to apply recycled material in gas pipelines.

Ensure that the standard committees are sufficiently involved to jointly create room for circular innovations within the set conditions. Bring the experts from grid operators and the market, who both take part in these committees, to sufficient alignment. Present a unified position, aiming to make circular materials applicable.

Desired outcome
A re-evaluation and relaxation of existing standards for the various asset groups, creating space for circular materials.

Conditions
- The standards remain when minimum safety and quality requirements are at risk.

6. Develop a strategy to secure a supply chain approach for circular materials and business models

The availability of materials is under pressure, leading to grid operators building up stocks. The availability of circular materials is also uncertain, and the continuity of circular solutions is uncertain.

Develop a fair strategy together with grid operators and producers to ensure sufficient timely and continuous availability of network components and expertise. Include the necessity of level playing field conditions from the government. From grid operators, clauses and incentives are needed that offer the market a long-term and predictable investment climate to produce, among other things, circular materials. Both the front (suppliers of materials and producers) and the back (processors, recyclers, smelters) of the chains are actively involved. Where possible, create close loop material chains.

Desired outcome
A joint strategy and implementation plan for the market and grid operators to secure long-term sufficient supply of network components and expertise.

Conditions
- A 'level playing field' within current laws and regulations, also in the European context, to prevent cartel formation or unfair pricing.

7. Invest in supply chain information systems

Material shortages, in addition to cost volatility, also lead to increasing environmental and social impact in the chain. Where in the chain and to what extent these effects lead to risks is still insufficiently clear.

Work together to gain insight into chain dependencies and risks. Make it clear where products come from, where raw materials are mined, and to what extent there are delivery and chain risks. Work from the data in material passports and existing platforms such as Ksandr and based on data from reporting guidelines, e.g., CSRD. This information serves as a basis for strategic decisions about procurement and asset management. Hereby considering scarcity and availability, environmental impact and social effects in the chain to decide, for example, whether or not to build additional stocks.

Desired outcome
Insight into material chains and the effects on environmental, social and broader societal levels as a basis for strategic decisions by grid operators.

Conditions
- As much alignment as possible with existing systems and resources, such as material passports, CSRD data, etc.

Example: circular cable

Cable producer TKF, in collaboration with grid operator Liander, has developed a medium-voltage cable with recycled plastics, which has been purchased since 2024. Specifically, 50% of the outer jacket consists of recycled PE, including old shampoo bottles. This achieves both material savings of new plastic and a significant CO_2 reduction.[6]

Example: fair meter

Grid operators Liander and Stedin have significantly weighed circular principles in the tender for smart meters, after a thorough resource identification study starting in 2013. They awarded suppliers based on the structural implementation of material passports and circular innovations after tendering, concretely shaped in two pilots with two different suppliers.

This has, among other things, removed unwanted materials with high environmental impact from the design and applied about 10% less primary metal and 20% less primary plastic in the new sector standard for the meter.[7]

5

Sprints for a circular energy infrastructure

Dutch Power Congress: how do we satisfy our hunger for resources? April 2023

Sprint I.

Recycled and biobased plastics in cables

December 4, 2023 | Lead: Enexis - grid operator

Desired end result

- Clarity on common language regarding the application of recycled and biobased plastics
- The energy infrastructure sector is consulted on the national plastic blending standard
- Tender criteria regarding plastics (e.g., in cables and gas pipes) are uniformly formulated and applied in tenders by the participants

Goal of the sprint

- Bringing together the cable chain (grid operators, cable suppliers, material producers) in a fruitful dialogue
- Prioritizing bottlenecks and identifying necessary actions and frameworks to include circular plastics in cable design
- Additionally, clarifying the playing field for the coming years from the government with norms, pricing and stimulation

Insights

- Current status: lack of a uniform question from the grid operators
- Current status: lack of a clear assessment framework including low weight / score in tenders
- Conducting the necessary type tests is costly and has a long lead time; therefore, clear agreements on joint standards and uniformity are important before starting these tests

Next steps

- Working out the top 3 bottlenecks in expert teams in 2024:
- Buyers and asset managers from grid operators work on formulating (1) a uniform question with (2) a clear assessment framework for a predictable, workable and fair playing field
- Also, (3) the manufacturers (through Fedet industry branch organization) provide input on the upcoming national plastics norm and online market consultation as well as exploring the setup of a more efficient process for type tests of non-fossil plastics (recycled and biobased) in consultation with the industry

Desired effect

- Contributing to the reduction of the application of primary materials in electricity cables

For illustration: Enexis alone uses 2,5 million kg of plastic in purchasing new cables per year.

Sprint II.

Upgrading power transformers

March 27, 2024 | Lead: Alliander - grid operator

Desired end result

- Develop a clear policy framework, conditions and appropriate business case through a test pilot for upgrading smaller types of power transformers to higher capacity

Goal of the sprint

- Lifespan extension and optimal utilization: preventing premature obsolescence of small transformers that can no longer provide the desired power with a test case of 50MVA
- Prioritizing barriers and clarifying necessary actions together with various chain players (grid operators, manufacturers and material partners as well as implementation partners during conversion)
- Making re-deployment and revision of assets and components the standard in the mindset of grid operators

Insights

- Service level agreement needed to clarify and ensure ownership, risks, and guarantees
- Develop a test case where all innovations for upgrading capacity can be tested, such as placing additional fans and using and circulating innovative oil with lower viscosity and higher potential heat load

Next steps

- Testing the technical upgrade innovations through a reserve unit at Alliander to increase the capacity of transformers with knowledge sharing to other grid operators
- Creating a “broad value case” within Alliander with calculation on the 6 capitals of broad prosperity (financial, produced, social, natural, human and intellectual capital)
- Insight in population, organizing the process, approaching (new) chain players, and creating new business models with the right incentives to the market
- Besides the test case, also developing a new modular standard for transformers that is adaptable, expandable, climate-resistant and future-proof

Desired effect

- Feasibility and utilization: accelerated relief in network congestion through better utilization and increased load profiles of current transformers
- Solutions from technical innovations such as additional cooling and different oil.
- Extending the operating time and lifespan of transformers at current locations
- Significant reduction of assets and raw materials needed and much shorter lead time with much less required manpower through conversion compared to new construction.
- Large cost savings compared to purchasing new transformers; lowering the energy bill for all citizens in the Netherlands

Sprint III.

Towards emission-free and circular steel

March 19, 2024 | Lead: Gasunie - grid operator

Desired end result

- Clarity on common language regarding green and circular steel
- Possibility of collaboration by formulating a joint procurement question from the perspective of *"being a good launching customer"*
- Accelerating the introduction of green and circular steel in the Netherlands

Goal of the sprint

- Inventory of current roadmaps at grid operators and other infrastructure clients towards green and circular steel.
- Collecting progress from market parties in both the scrap and base metals sector.

Insights

- European focus needed in supply chains, considering leaders in sustainable production in neighboring countries
- Shortage of scrap on the market where *"urban mining"* from own waste streams towards own suppliers in a closed loop becomes important to ensure high-quality scrap
- Joint significant demand offers the market the right incentive

Next steps

- Dialogue with the steel industry including FME and Fedet and the scrap industry. Also, with the possible goal of jointly accelerating the transition to green and circular steel

Desired effect

- Significant CO_2 reduction by greening steel production
- Ensuring optimal material use in design with a reduction in primary material where possible (steel assets made from more scrap)
- High-quality recycling returns raw materials to production, and nothing is incinerated or landfilled (more scrap in steel assets such as gas pipes with equal performance)
- Establishing strategic partnerships with suppliers to strengthen the market's long-term necessary investments
- Closing the loop; where possible, applying *"urban mining"* such as from old wind farms or gas networks to secure sufficient supply of high-quality scrap in the Netherlands

APPENDIX I.

Process approach

This final report is the result of collaboration between the coalition Groene Netten (Green Grids) of the Dutch sustainability network organization MVO Nederland, including the grid operators Enexis, Alliander and Gasunie, in connection with Invest -NL, Fedet (Federation of Electrotechnical industry) and various market parties. This appendix explains the process steps taken and the parties involved.

Process

From September 2022, a joint overview of the challenges and a joint ambition from the collaborating grid operators have been worked on. The following steps have been taken:

1. Inventory of circularity KPI's, goals and ambitions of grid operators
2. Market consultation with manufacturers of primary assets: cables, switches, transformers
3. First report (June 2023) with insights and conclusions from market consultation
4. Prioritization of the most impactful and feasible circular product innovations, resulting in the organization of three sprints (in-depth supply chain dialogues) with formulated action plans.
5. Follow-up approach on the three sprints in 2024 with concrete expert teams defining building blocks for a joint roadmap per product group towards 50% less primary material use by 2030.

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APPENDIX II.

Reference list

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