WHITEPAPER

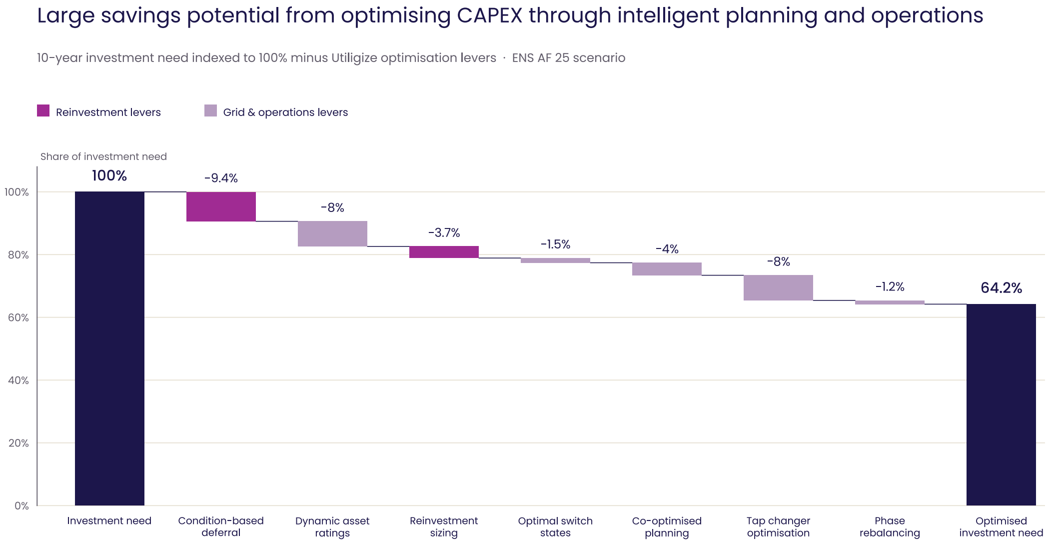
utiligize

for powerful decisions

Reducing CAPEX at DSOs

How Utiligize's Forecast & Investment solution helps DSOs make financially optimal grid reinforcement decisions

How do you operate, reinforce and expand your grid while staying under budget? Utiligize's Forecast & Investment lets DSOs cut CAPEX by 35%.



Europe's distribution grids face a mountain of challenges: electrification of transport and heating, increasing distributed generation, an ageing asset base and a retiring workforce. The consequence is that annual distribution investments double across the EU, from about €33 billion to €67 billion per year through 2050.[1]

DSOs operate under revenue-cap and regulated asset base (RAB) regulation: every CAPEX spend is reviewed by the regulator. Underinvest and the grid becomes the bottleneck for electrification and reliability; overinvest and capital is wasted. The goal is to co-optimise grid expansion, reliability and spending.

Utiligize's Forecast & Investment addresses this challenge. Using smart meter, GIS topology and sensor data, combined with distributed generation, transport, and heating forecasts, Forecast & Investment produces loading and voltage timeseries for all assets at hourly resolution. It does so for past and future years until 2050.

Forecast & Investment has cut CAPEX by up to 35% in documented projects and customer implementations. This is achieved by safely avoiding new builds, deferring the build, and building correctly – the main goal of this white paper.

> **In this report, we show eight cases that demonstrate the impact of Forecast & Investment in practice.** To this end, we use an anonymised dataset of selected DSOs, pointing towards differences before and after the solution's implementation.

1 Eurelectric and EY, "Grids for Speed", May 2024, https://www.eurelectric.org/publications/grids-for-speed/; Eurelectric, E.DSO and Monitor Deloitte, "Connecting the Dots: Distribution grid investment to power the energy transition", January 2021, https://www.eurelectric.org/publications/connecting-the-dots/

CASE 01

Sizing with foresight avoids upgrading the same network twice

Replacing an asset requires two key inputs: when to replace, and at what capacity. Investment creates commitment for decades, but if sized by rule of thumb, an asset can quickly be overtaken by loading increase and must be dug up again. For underground cables, civil works are around 75% of project cost, so a second replacement has severe consequences.[2]

Forecast & Investment produces load and voltage timeseries for all cables and transformers at hourly resolution for past years and all years until 2050. If an asset's peak loading is found to exceed its capacity, the model suggests how to replace that asset only once, at the optimal size and time.

USE CASE

A 1980s MV cable at 240A peak is due for replacement. A business-as-usual swap (≈350 A) costs €600/m, 75% of it civil works. If the loading in the area increases such that the asset sees a ≈400 A loading by 2040, a second excavation, with civil works alone worth €450/m, would be due before 2040. With Forecast & Investment, a second excavation is avoided, because the model predicted this peak and suggested an asset suited for this load. This costs the DSO only a few additional percent of material cost during the first replacement but avoids expensive civil works later. Across the eight-DSO dataset, this represents a saving of 21% of the LV/MV reinforcement programme, or about 4% of total observed LV/MV investment.

Sizing behaviour changes 6-12 months after the adoption of Forecast & Investment, consistent with ordinary project lead times. Pooled across multiple DSOs, the typical cross-section of newly built LV cables rose from 159 mm² in the first six months (decisions still from the pre-adoption pipeline) to 181 mm² in months 7-18 and to 213 mm² beyond 18 months; MV cables rose from 177 to 228 mm², and newly added MV/LV transformers from 559 to 771 kVA. At replacement, the median upgrade step grew from 1.6x in the first year to a full catalogue step (2.0x) thereafter. In the DSOs' own price catalogues, cable cost per metre is flat across the relevant cross-sections - the bigger cable is nearly free while the trench is open.

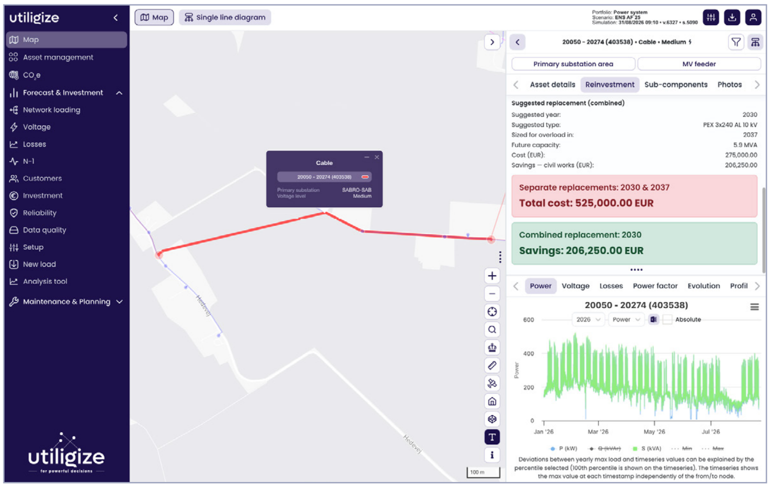


Figure 1 - *Avoid underestimating load increases and reinforcing the same assets twice in the same decade*

2 M. Beehler, "21st-Century Costs of Underground Distribution", T&D World, 19 February 2021, https://www.tdworld.com/intelligent-undergrounding/article/21153400/21st-century-costs-of-underground-distribution; Swivl, "Underground Utility Cable Cost Guide", swivl.tech.

CASE 02

Optimal switch states maximise capacity and cut network reinforcement costs

MV grids are meshed but run radially: switch positions decide how load distributes across the feeders. Historically set and rarely reconsidered, these settings become outdated as some feeders run near their thermal limits while others remain lightly loaded. Reinforcing the impacted feeders is the usual approach, but spare capacity might be one switch away.

Forecast & Investment runs an optimal load flow, revisiting each switch state configuration to find the best balance for all feeders, and outputs an executable switching plan.

USE CASE

On a primary substation with six MV feeders, before and after rebalancing the network:

FEEDER	PEAK LOADING, before	PEAK LOADING, after
1	28.3%	35.4%
2	25.6%	25.6%
3	1.1%	1.1%
4	56.8%	43.9%
5	32.8%	40.6%
6	38.0%	38.0%

The highest-loaded feeder (4) dropped by nearly 23% (12.9 percentage points), and loading spread fell from 18.1% to 16.1%, with average loading unchanged.

Performing this analysis on the other DSOs shows the same pattern. The share of transformers loaded below 20% fell from 31% to 21% while the median maximum loading rose from 30% to 38%. Short, controlled periods of high loading are intentional, and part of how the network is operated, not a sign that something has gone wrong. Overall, we see less unused spare capacity while more of the fleet is used closer to its optimal operating point, cutting network reinforcement costs by an average of 2.4%.

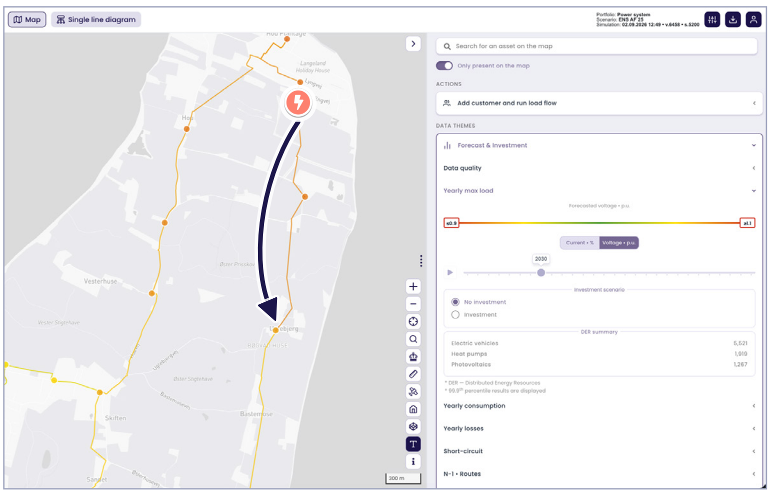


Figure 2 - *Cutting meshed grids makes grid loading more balanced across assets*

CASE 03

Reinvestment based on asset condition and loading rather than age prioritises assets likely to fail, while letting low-risk assets live into old age

Replacing assets at a fixed age is the costliest commonly used rule. It scraps healthy assets with years of life left and misses stressed ones that age faster. Age is a poor proxy for the two things that decide replacement: condition, and how loaded the asset is, now and in future.

Forecast & Investment uses a data-driven approach to compute each asset's replacement year, using:

- Condition: CNAIM Health Index, Probability of Failure and Consequence of Failure, giving a monetary risk score.[3]
- Historical loading (the dominant driver of ageing): from our load flow model based on smart meter and topology data; the model produces load and voltage timeseries for all assets at hourly resolution
- Forecasted loading to 2050: from our future load flow model, a combination of historical data and distributed generation, transport, and heating forecasts

Some Utiligize customers have healthy, lightly loaded assets in a low-corrosion environment living to be 80+ years, while degraded or increasingly loaded assets have their reinvestment date brought forward before they fail.

USE CASE

Combining asset condition data from Maintenance & Planning and loading data from Forecast & Investment, the following table shows the share of calendar-based reinvestments that Utiligize customers have been able to defer:

HORIZON	Share of deferred reinvestments
Up to 5 years	25%
Up to 10 years	28%
Up to 15 years	38%
Up to 20 years	35%

On average, reinvestments that can be deferred can be pushed 16 years beyond their standard-lifetime replacement date, enabling cashflow and RAB-optimised investment planning, along with crew and resource planning. Additionally, at a 4% WACC, deferring an investment by 15 years reduces its present-value cost by 45%, on top of the cashflow relief. That the share declines beyond 15 years proves the point: risk-based planning does not cut the reinvestment volume, it re-times it. The deferral is largest where a calendar plan over-concentrates spending: the up-to-15-year wave, when the 1970s build-out reaches its standard lifetime, and shrinks again as deferred assets fall due.

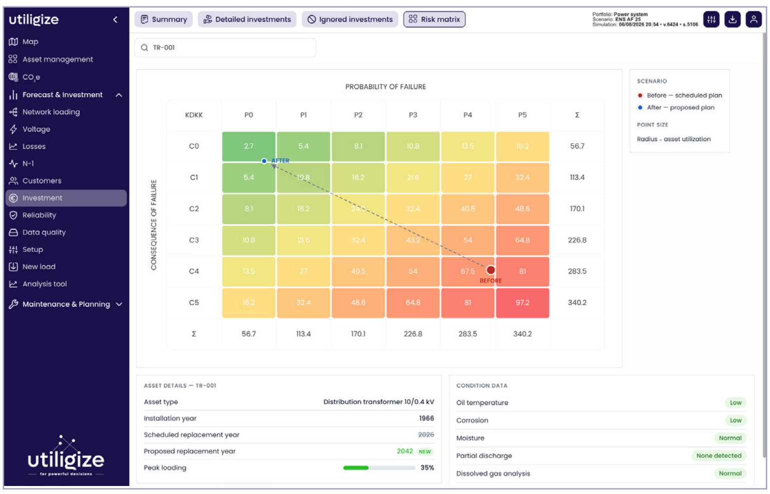


Figure 3 - *Risk-based reinvestment decisions give huge CAPEX savings over rules of thumb*

3 Ofgem, "DNO Common Network Asset Indices Methodology", version 2.1, April 2021, https://www.ofgem.gov.uk/sites/default/files/docs/2021/04/dno_common_network_asset_indices_methodology_v2.1_final_01-04-2021.pdf

CASE 04

Solve voltage issues without huge CAPEX spend with optimal tap changer settings

In Forecast & Investment, we see that voltage problems are typically responsible for 25% of network reinforcement costs. On low voltage and long rural feeders the first limit hit is usually voltage, not thermal capacity. EN 50160 requires voltage within ±10% of nominal for 95% of each week, so a feeder can breach compliance while being thermally fine.[4] The reflex is to build, but a voltage problem is usually a regulation problem, not a capacity one.

An on-load tap changer (OLTC) or voltage-regulating transformer (VRDT)[5] can continuously regulate voltage downstream, at a fraction of reinforcement cost. By modelling new OLTC and changes to fixed tap settings, we see that 91% of today's voltage issues in the low voltage grid can be corrected. Forecast & Investment identifies these cases and outputs a tap changing plan, resulting in savings of 8% of the entire investment plan. This is a much cheaper route when compared to the alternative of conventional grid reinforcement where low voltage cables with a larger diameter and lower resistance would typically also solve this issue.

Figure 4 - *New tap positions can solve voltage issues, without conventional grid upgrades*

4 CENELEC, "EN 50160:2022 Voltage characteristics of electricity supplied by public electricity networks", 2022.

5 VDE FNN, "Voltage Regulating Distribution Transformer (VRDT) – Use in Grid Planning and Operation", FNN Recommendation, July 2016.

CASE 05

Big wins from coordinating reinvestments with capacity upgrades

DSOs typically use different systems to plan reinvestments and capacity upgrades, leading to suboptimal planning. But by combining asset conditions, probability of failure, future loading forecasts, and outage consequences in a single planning framework, investments can be prioritised where they deliver the greatest reduction in future risk exposure per invested CAPEX.

In a joint development project between Utiligize and the Danish DSO Trefor[6], we developed algorithms to combine asset replacement and capacity upgrades and avoid unnecessary project overheads, repeated construction work, and premature investments. This allows DSOs to address ageing infrastructure and future capacity constraints more efficiently while maintaining reliability targets. *Our algorithm cut costs by approximately 4% over a planning horizon until 2050 while reducing expected interruption from 2.5 to 0.9 minutes per customer annually. This demonstrates how integrated planning can improve SAIDI and SAIFI performance, reduce future outage risk, and increase the value delivered by network investments.*

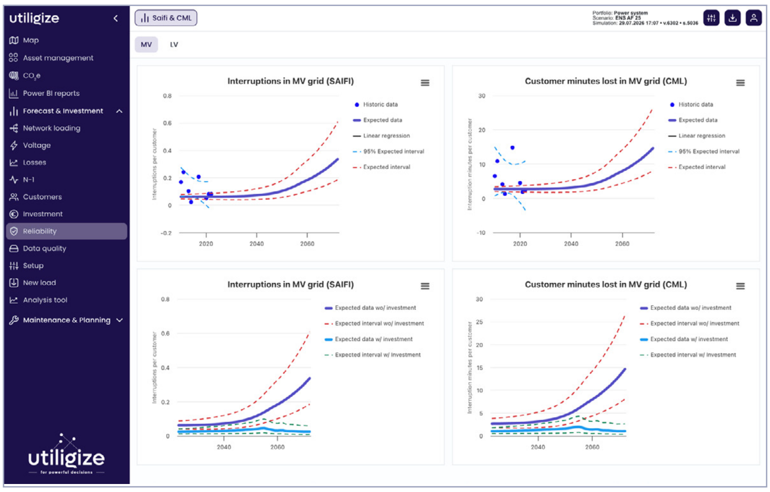


Figure 5 - *Long-term SAIFI and SAIDI forecasts, with interruptions reduced by over half with reinvestment & reinforcement coordination*

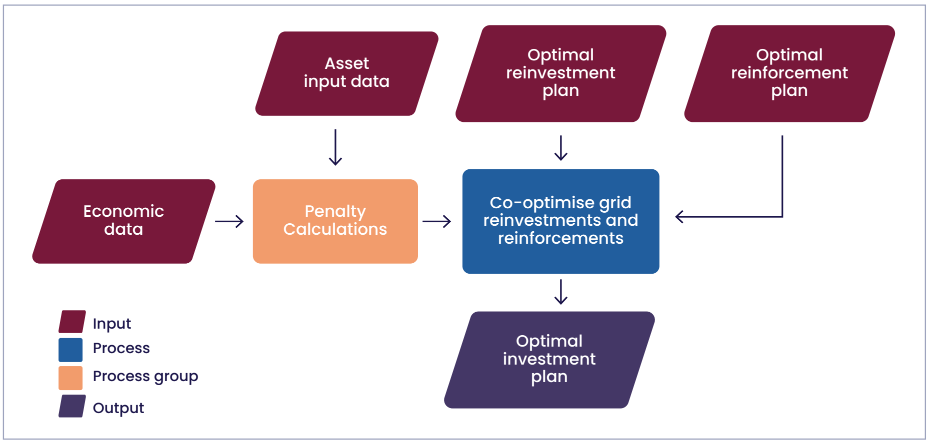


Figure 6 - *Sophisticated algorithms for coordinating reinvestments and reinforcements, cutting CAPEX by 4%*

6 C. H. Thellefsen et al., "Co-optimising grid reinvestments and reinforcement to support distribution grid planning", CIRED 2026 Workshop, Brussels, June 2026, https://orbit.dtu.dk/en/publications/co-optimising-grid-reinvestments-and-reinforcement-to-support-dis/

CASE 06

Connect more customers on non-firm connections to shorten the queue and increase revenues

To accelerate the connection request process and follow regulatory requirements, non-firm connection requests give DSOs and developers a tool to use the existing grid capacity and get customers online while the grid gets built out to support 100% availability. Utiligize simulates the connection of new customers with a combination of firm and non-firm power, enabling grid planners to assess the difference and make a data-based decision.

Utiligize computes the number of forecasted curtailed hours on non-firm connection requests, enabling better planning for developers trying to connect to the grid. In addition, short-term capacity forecasts, up to 14 days ahead, made available to non-firm customers through our API allow them to minimise their risk when bidding into wholesale markets.

USE CASE

Grid capacity is at its limit today, as DSOs reserve existing capacity for organic growth. How can you connect new customers without waiting for grid expansion? Non-firm connections make it possible to use existing spare capacity and maximise grid tariffs' income, depending on local regulation. Instead of sitting on unused capacity today, a DSO can allocate a non-firm 3 MW connection with 1.5 MW firm, and with a curtailment of 1,000 hours a year create an additional yearly revenue of €230k.

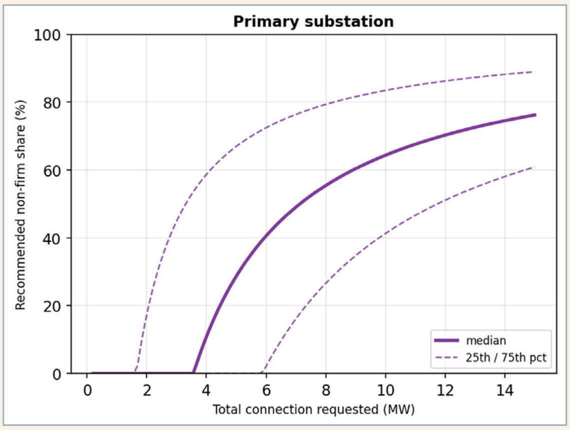


Figure 7 - *DSOs with Utiligize offer customers connections that combine firm and non-firm contracts, with estimates for how many hours per year their non-firm share will be disconnected*

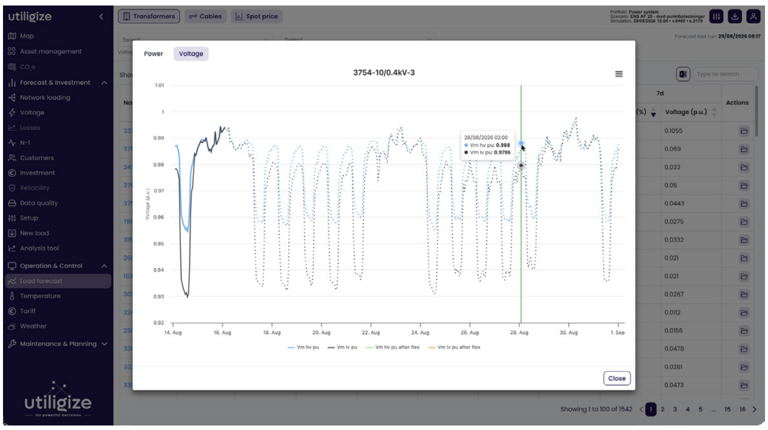


Figure 8 - *Short-term congestion forecasts, up to 14 days ahead, make non-firm connections less risky and more attractive*

CASE 07

Dynamic asset and line ratings (DLR) allow assets to run over 50% higher than nominal capacity, with big CAPEX deferrals

Cable and transformer static ratings are set under conservatively high temperature assumptions; Forecast & Investment calculates actual safe thermal operating limits for assets based on current and forecasted weather conditions. Utilising these can avoid investing in assets that can still be safely operated year-round.[7]

Utiligize's short-term forecast runs for all assets every hour following the IEC 60287 and IEEE C57.91 standards based on forecasted soil and air temperatures. The result is a weather-aware thermal rating for each asset for the coming two weeks, as well as the last two years.[8]

Compared with long-term load flow results, investments where the weather-aware thermal rating consistently lies above the peak-load projection for an asset can be deferred.

Limits that offer the best balance between savings and safety margins are built in to guarantee voltage and short-circuit compliance.

USE CASE

A significant portion of thermal limit-driven investments are due to assets exceeding their nameplate thermal limits by only up to 27%. The weather-aware thermal ratings of these same assets sit between 1.5 and 1.8 times the nameplate capacity at their tightest hour. Hence, if these assets are not replaced and simply operated at 1.27x their nameplate thermal rating, they still operate within an 18-42% safety margin; and that is the worst-peak case. In most hours these assets operate well below peak, hence even further within safety margins.

This allows substantial savings across asset classes: HV transformers are the highest-value single wins, as they only marginally exceed their ratings in the 2040s, have thermal headroom, and have high individual CAPEX. Deferring low-voltage distribution cable investments contributes to a large, accumulated benefit as heat-pump and EV growth pushes each rural feeder marginally over its rating in the 2030s.

For the examined investment plans of DSOs under conservative risk gates until 2050, 8% of the CAPEX is deferrable. Some DSOs saw higher savings due to large HV assets falling within the deferrable band or setting risk gates less conservatively.

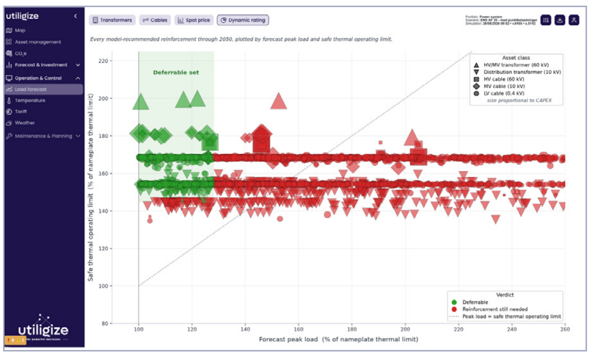


Figure 9 - *Model-recommended reinforcements to 2050, plotted by forecast peak load against safe thermal operating limit; the green set can be deferred*

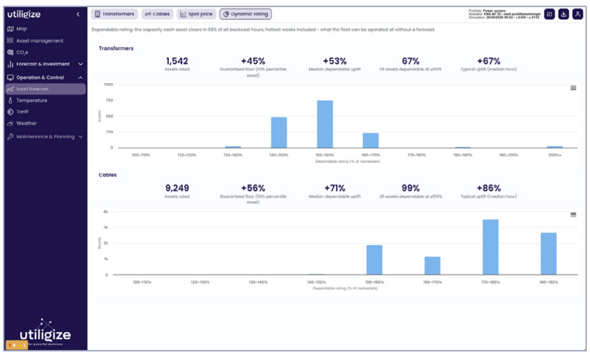


Figure 10 - *In cooler climates, like Scandinavia, the median transformer uplift is 53%, while cables can be driven 71% harder than nominal capacity*

7 A. Borbuev et al., "Investment Deferral of Feeder Upgrades Revealed by System-Wide Unbalanced Dynamic Rating: Harvesting the Hidden Capacity of Distribution Systems Discovered by Thermal Map Technology", IEEE Transactions on Power Delivery, vol. 36, no. 3, pp. 1594–1602, June 2021, https://doi.org/10.1109/TPWRD.2020.3011618

8 IEC, "IEC 60287-1-1:2023 Electric cables – Calculation of the current rating – Part 1-1: Current rating equations (100 % load factor) and calculation of losses – General", 2023; IEEE, "IEEE C57.91-2011 Guide for Loading Mineral-Oil-Immersed Transformers and Step-Voltage Regulators", 2011.

CASE 08

Rebalance phases to free hidden low voltage capacity

Low voltage grids are rarely loaded equally across the three phases. Single-phase loads, heat pumps and EV chargers land on whichever phase the installer chose, and the phase recorded in the GIS is often wrong. The most loaded phase reaches its thermal or voltage limit long before the cable is fully used, so the reflex is to reinforce a cable that still has spare capacity on two of its three conductors.

Utiligize identifies the real phase connection of every customer from smart meter data. A load in one house moves the voltage of every neighbour on the same phase, so a machine learning model trained on 15-minute per-phase voltage and current finds which meters share a phase and corrects mistagged connections. Where meters report only aggregate power, a second model estimates per-phase active power from the per-phase voltages and currents. Measurement equipment on a single substation is enough for calibration and validation: with a month of training data the model identifies the most overloaded phase over 99% of the time, with around 3% error on the transformer's phase voltage unbalance rate. The outputs are a verified phase map per customer and a per-phase loading timeseries per feeder.

Rebalancing then becomes an operational decision rather than a construction project: move single-phase loads, steer new heat pumps and EV chargers to the least loaded phase, and run the corrected phase map through an unbalanced three-phase load flow to see which current and future congestions and voltage imbalances disappear from the plan. The gain sits in the LV cables, which physically carry the unbalanced currents; secondary transformers and the MV grid aggregate many customers and see little change.

USE CASE

Field studies on around 100,000 Danish smart meters show that phase rebalancing frees about 8% of line capacity on average.[9] Applied to a DSO's investment plan, an 8% reduction in consumption-driven loading deferred around 40% of the LV cable reinforcements planned for the next two years and around 30% of those planned for the next four, at the cost of a switching plan instead of civil works.

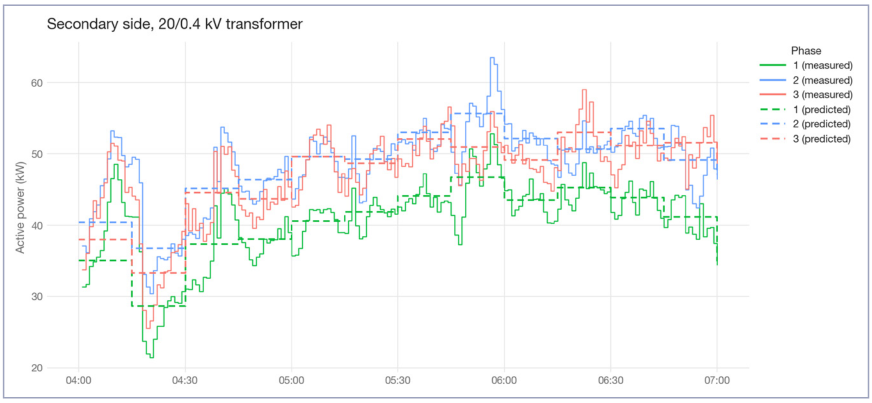


Figure 11 - *Per-phase predictions in Utiligize, using machine learning models to understand true phase order, ultimately leading to deferrals worth 40% on low voltage lines and cables*

9 M. Secchi et al., "Generating insights for low-voltage distribution grids from per-phase smart meter data", CIRED 2026 Workshop, Brussels, June 2026, paper 1544, https://orbit.dtu.dk/en/publications/generating-insights-for-low-voltage-distribution-grids-from-per-p/

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CHIEF EXECUTIVE OFFICER
Kalle Thorbjørn Hansen
+45 28 43 88 25 ·
kalle@utiligize.com

CHIEF TECHNOLOGY OFFICER
Emil Mahler Larsen
+45 31 27 00 78 ·
emil@utiligize.com

CHIEF COMMERCIAL OFFICER
Jens Knudsen
+45 42 67 04 14 ·
jens@utiligize.com

Utiligize ApS
Sjæleboderne 2, 1122 København K
Denmark