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Stuck in Gridlock:
Grid Congestion, Flexibility, and the Energy Transition

Teaching Case

Energy Transition Case Series

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INTRODUCTION

It was March 2024. Sam Towns sat at her desk at the Rotterdam Municipality finalizing the agenda and her notes for an important meeting the next day. As program coordinator of charging infrastructure at the municipality, she had convened an emergency meeting with key stakeholders in the city related to electric vehicle charging. She had been in crisis management mode for the last few weeks. In February, Stedin, a Dutch grid operator, announced it wanted to turn off all public charging stations for electric vehicles (EVs) between 16:00 and 21:00 due to severe grid congestion during peak hours.[1] Stedin explained that the grid was "bursting at the seams" in these peak hours because when people get home from work, they plug in their EVs, turn on appliances, and start cooking dinner. Without putting controls or restrictions into place, 1.5 million households across the Netherlands were at risk of power outages.[2]

The announcement had caused public outrage. Sam's team on the Charging Infrastructure Programme was inundated with calls and emails, not to mention trending on social media. EV owners were upset and worried about how to charge their vehicles; charge point operators wanted assurances about their contracts with the municipality; the electricity retailers complained that this would only make matters worse.

Considering the municipality held the contracts with grid and charge point operators, Sam wanted to avoid a long, drawn-out conflict between actors. She believed that this would not be solved with a unilateral, blanket decision, but needed to bring different perspectives to the table to find a solution that worked. However, the solution was not going to be easy to find. How would she align interests between stakeholders? How would a solution be a win for multiple, and ideally all, sides? How can the municipality play a bridging role?

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The case is based on published sources. It was written to provide material for class discussion rather than to illustrate either effective or ineffective handling of a management situation. Identifiable information may have been anonymised or altered to protect confidentiality. Fictitious information may have been included and claims may have been exaggerated or simplified from reality to enhance the effect of class discussion. This material was developed with the assistance of AI for presentation and accessibility (formatting of supplementary materials).

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ENERGY TRANSITION BACKGROUND

The current energy transition, moving from fossil fuels to renewable energy sources, is an urgent and complex issue. Over three-quarters of the world's energy needs are met through fossil fuel use, which makes the energy sector responsible for 75% of greenhouse gas emissions. With the accumulation of greenhouse gases in the atmosphere, since the industrial revolution, the world is experiencing the negative impacts of climate change, and in need of urgent action. In 2015, the Paris Agreement brought 196 countries together to commit to limiting global temperature rise to 1.5 to 2 degrees C, in comparison to pre-industrial levels. With the world's dependence on fossil fuels, this meant a necessary and significant transition to renewable energy and a change in the energy system as a whole.

Since the Paris Agreement, the UN Climate Change Conference in Dubai in 2023 (COP28) was the most recent milestone in global target setting. Countries agreed that global greenhouse gas emissions must decline rapidly with the long-term target of net zero emissions of CO2 by 2050. These targets include ambitious goals including tripling renewable energy capacity and doubling the annual rate of energy efficiency improvements by 2030.[3] Targets are implemented on an EU and national level: The EU's energy transition policy is guided by the European Green Deal, which aims for climate neutrality by 2050, and the Fit for 55 package, which sets a 55% emissions reduction target by 2030. Key legal frameworks include the Renewable Energy Directive (RED III), which mandates a rising share of renewables; the Energy Efficiency Directive, promoting energy efficiency measures; and the Electricity Directive and Regulation, which aim for increasing electrification of existing technologies.

To mitigate the effects of climate change, the Dutch government aims to cut greenhouse gas emissions by 49% by 2030 (compared to 1990 levels) and achieve a 95% reduction by 2050. These targets are established in the Climate Act, adopted on May 28, 2019. The National Energy and Climate Plan (NECP), and National Climate Agreement outline the policies and measures to reach these objectives.[4]

For more information on the energy transition, read World Energy Outlook 2024, published by the International Energy Agency.[5]

UNDERSTANDING GRID CONGESTION

Reliable power systems require matching energy supply with demand at all times. Integrating renewable energy into existing power systems comes with its own set of complications. Power grids have become a bottleneck in the energy transition, where many companies and homes are on a waitlist to be connected to the grid because there is no extra capacity. This can mean that residential and commercial real estate projects might be postponed or even cancelled, further exacerbating the housing crisis and economic stagnation. There are two drivers behind this: grid design and the nature of renewable energy. First, grids were designed for centralized power generation from fossil fuel sources, which generally were predictable. However, renewable energy sources are irregular and decentralized, making efficient grid management difficult. Second, the intermittent nature of renewable energy (e.g. wind speed changes and the absence of sunlight at night) creates fluctuations in power generation which the grid is not built to handle.

With increased renewable energy in the grid, there is a mismatch between supply and demand of energy, for example energy demands peak in the evening while solar energy is produced during the day when the sun is shining. At the same time, with the shift from fossil fuels to renewable energy, more energy needs are being met by electricity, such as switching from combustion engines to EVs, gas to induction stoves, gas to electric ovens, and gas boilers to electric (heat) pumps, among others. In particular, the widespread adoption of EVs can exacerbate peak demand, as many vehicles are charged simultaneously during evening hours.

FLEXIBILITY IN POWER GRIDS

Power systems need to be able to manage, both reliably and cost-effectively, the unpredictability and fluctuations of supply and demand, known as power system flexibility. The goal is to maintain a continuous balance between supply and demand, but when this balance is disrupted, either over generation or under generation occurs. Over generation happens when supply exceeds demand. In response, curtailment—deliberately reducing renewable generation—is often used to prevent system overload. Under generation occurs when demand surpasses available supply, increasing the risk of power shortages. In addition, flexibility is needed to respond to physical limitations of the grid (e.g., capacity limitation, ramp-rate/min-load constraints, etc.).

To address these imbalances, flexibility solutions can come from both the supply and demand sides. On the supply side, flexibility includes adjusting power plant output and storing excess energy in batteries, flywheels, or hydrogen storage for later use. On the demand side, flexibility involves shifting or adjusting electricity consumption to better align with supply. This can be achieved through price-based mechanisms, such as dynamic pricing that encourages electricity use when supply is high, or through direct control mechanisms, where energy consumption is actively managed in response to grid conditions.

A key example of demand-side flexibility is smart charging for electric vehicles. Smart charging allows charging operators to adjust the charging schedule to better match supply and demand. This can be done through grid operator direct load control, where the operator actively increases or decreases charging rates based on grid conditions, or through tariff-based approaches, where time-varying electricity prices incentivize consumers to shift their charging to periods of low demand or high renewable generation. An extension of smart charging is vehicle-to-grid (V2G) technology, which enables electric vehicles not only to adjust their charging but also to discharge stored energy back to the grid when supply is low, effectively acting as mobile energy storage units that enhance grid stability.

STEDIN AND THE GRID

Stedin claimed that for every charging station turned off in peak hours, one additional home could be connected to the grid. According to the company, about half of EVs are plugged into charging stations as soon as owners get home from work in the late afternoon or early evening. Usually, these vehicles stay connected until the next morning. However, many EV owners charge their cars at home, and not at public charging stations. Home chargers are connected via the household grid connection, which means that grid operators cannot directly control the charger. The proposed measure would only impact EV owners that did not have access to home charging.

Sam understood that EV charging was and would continue to be a large portion of electricity use. It was estimated that around 20% of large cities' grid capacity will be used by public charging stations. The current adoption level of 450,000 EVs in the Netherlands was projected to increase to 2 million by 2030. Despite Stedin's reinforcement of the grid infrastructure, Sam and her team were unsure if the grid would be able to catch up with demand in time.

EMERGENCY MEETING CALLED BY THE MUNICIPALITY

Sam worked with her team to define achievable objectives for a path forward, at least to quell the crisis. They highlighted four areas where decisions (and possibly concessions) needed to be made to be able to stabilize the grid emergency. First, the number of public charge points needed to be on the table. Increasing the number of charge points had positive impact on people buying EVs, however that in turn puts more stress on the grid. At a municipal level, the rate of increase of charge points needed to be addressed. Second, all parties involved needed to address the investments in grid upgrades. Considering the current predicament, stakeholders needed to determine whether upgrades of the physical infrastructure of the grid should be increased, especially considering these investments and upgrades take time. Third, a frank assessment of flexibility options was important. Options like smart charging, battery storage, and V2G charging could release flexibility on the grid, however investment and leadership were needed. Last, and possibly the most controversial, was the issue of direct control by the grid operator. Stedin had announced they wanted direct control during peak hours. While this would relieve potential blackouts from too much load, much of the outrage from the announcement linked to this unilateral way of working.

After careful consideration, Sam and her team had defined the list of invitees. They wanted to have everyone in the negotiation that had a stake and decision-making power. The final list of participants was:

- **Will Watts, Stedin (Grid Operator):** Responsible for energy distribution from high-voltage transmission to end consumers, Stedin's primary goal is maintaining grid stability, reliability, and safety at all times, even during peak demand periods. Will had engaged with Sam over recent weeks, explaining, "We don't want to be the bad guys. We are trying to make sure that there is a reliable energy system and manage grid congestion, at the same time. Believe me when I say, we're trying to work this out, but we feel like we're out of options."
- **Luz Powers, Enessfall Direct (Electricity Retailer):** Enessfall buys electricity on the market based on demand predictions and ensures reliable energy supply to residents and businesses, balancing supply and procurement costs. Luz confirmed her participation, stating, "Fluctuations in energy generation, and increased demands have us on our toes at all times, not to mention the unpredictability of renewable energy generation. We need a system, protocols, and tools that work."

- **Joanna Amp, All Box Force (Charge Point Operator):** All Box Force installs, operates, and maintains EV charging stations, ensuring availability and functionality while addressing operational challenges tied to grid constraints. Joanna thanked Sam for the invitation: "Our business model depends on resolving this crisis and coming up with solutions that work for all parties."
- **Miles Lane, Dutch Electric Vehicle Drivers Organization (VER):** Representing EV owners, VER advocates for consumer-friendly policies and access to reliable charging infrastructure without disruptions during peak hours. Miles emphasized his concerns: "Direct control is not the solution that will help the transition. How much longer are companies and governments going to make end consumers carry the brunt of the problem?"
- **Penny Wise, Rotterdam Small Business Association (RSBA):** Representing small businesses, RSBA highlights the importance of uninterrupted energy access for operations during peak hours. Penny noted, "Supporting small businesses means supporting a sustainable city. Our members rely on reliable electricity, both to run their operations, as well as ensuring that their customers can charge their batteries to get to their locations."
- As convener, the **Charging Infrastructure Program at the Rotterdam municipal government** would facilitate the discussion, aiming to balance these competing interests while advancing sustainable urban mobility goals for the city.

All invitees received the same information package with the decision points (in **Table 1**) and agenda for the meeting. Sam told her team, "The more information we give everyone, the better they can prepare and be able to make decisions in the meeting itself."

Decision	Decision options
Charging stations	• 0% - no change from current plan • 10% - small increase in charging stations from current plan • 20% - large increase in charging stations from current plan
Grid upgrades	• 0% - no change in investments in grid upgrades • 10% - small increase investment in grid upgrades • 20% - large increase in investments for grid upgrades
Flexibility options	• 0% - no change to flexibility investments and options • 10% - small increase to flexibility investments and options • 20% - large increase in flexibility investments and options
Grid operator direct control	• 0% - no change, meaning Stedin does not have direct control • 10% - small increase, meaning Stedin has some control and decision power for direct control of charging stations • 20% - large increase, meaning Stedin can directly control the charging stations

Table 1: Decision Points

Emergency Meeting Agenda

1. Opening statements (3 minutes per stakeholder, maximum 18 minutes in total)
    - Opening statements should include stakeholder introduction, challenges, and positions on the issue.
2. Clarifying questions (10 minutes)
    - Each stakeholder can ask one brief question to one other stakeholder. These questions are not to start a debate or negotiation, but rather to clarify any questions on position or role.
3. Roundtable discussion (20 minutes)
4. Side-bar / bilateral talk break (10 minutes)
    - Stakeholders can speak to each other to discuss possible solutions
5. Roundtable discussion (20 minutes)
6. Final agreement and steps forward (10 minutes).

Tension had been high since Stedin's announcement in February. Sam and her team at the municipality had a daunting task: how were they going to bring the different stakeholders together to discuss how to manage the charging stations, grid upgrades, flexibility options, and direct control in a way that would lead to a solution that everyone could support?

ENDNOTES

[1] Koster, R. (2024, February 27). *Netbeheerder: Elektrische auto's niet opladen tussen 16.00 en 21.00 uur.* NOS. Retrieved November 1, 2024, from https://nos.nl/artikel/2510535-netbeheerder-elektrische-auto-s-niet-opladen-tussen-16-00-en-21-00-uur

[2] DutchNews.nl. (2024, February 27). *Switching off car charging stations may prevent network meltdown.* DutchNews.nl. Retrieved November 1, 2024, from https://www.dutchnews.nl/2024/02/switching-off-car-charging-stations-may-prevent-network-meltdown/

[3] United Nations Framework Convention on Climate Change. (2023, December). *COP 28: What was achieved and what happens next?* unfcc.int. Retrieved February 3, 2025, from https://unfccc.int/cop28/5-key-takeaways

[4] Netherlands Enterprise Agency (RVO). (2023). *The netherlands national system for policies and measures and projections.* Netherlands Enterprise Agency (RVO). https://english.rvo.nl/sites/default/files/2023-10/National-System-for-PAMs-and-projections%20in-NL.pdf

[5] IEA. (2024). *World energy outlook 2024.* Paris: IEA. https://www.iea.org/reports/world-energy-outlook-2024. (Licence: CC BY 4.0 (report); CC BY NC SA 4.0 (Annex A))