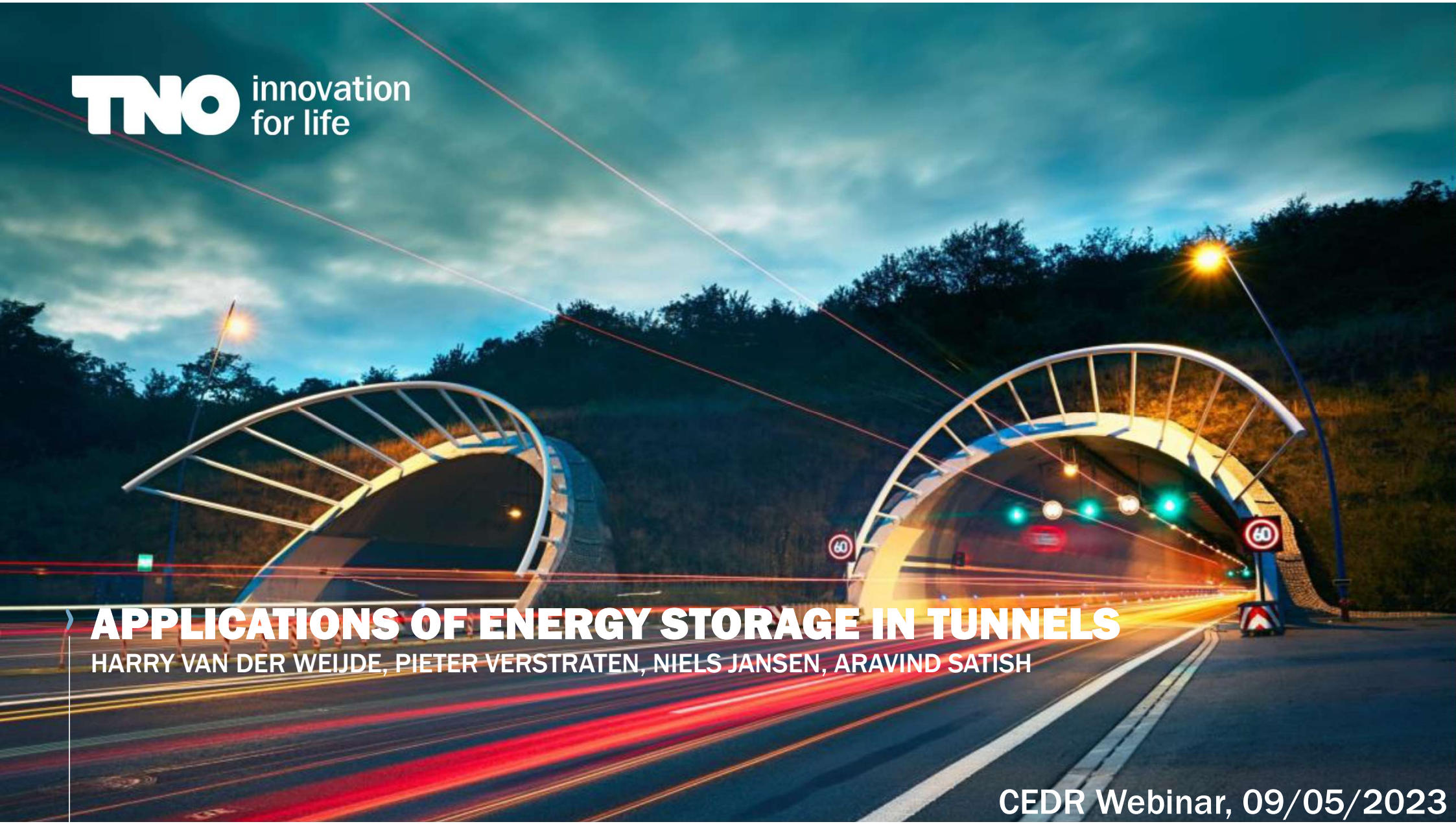
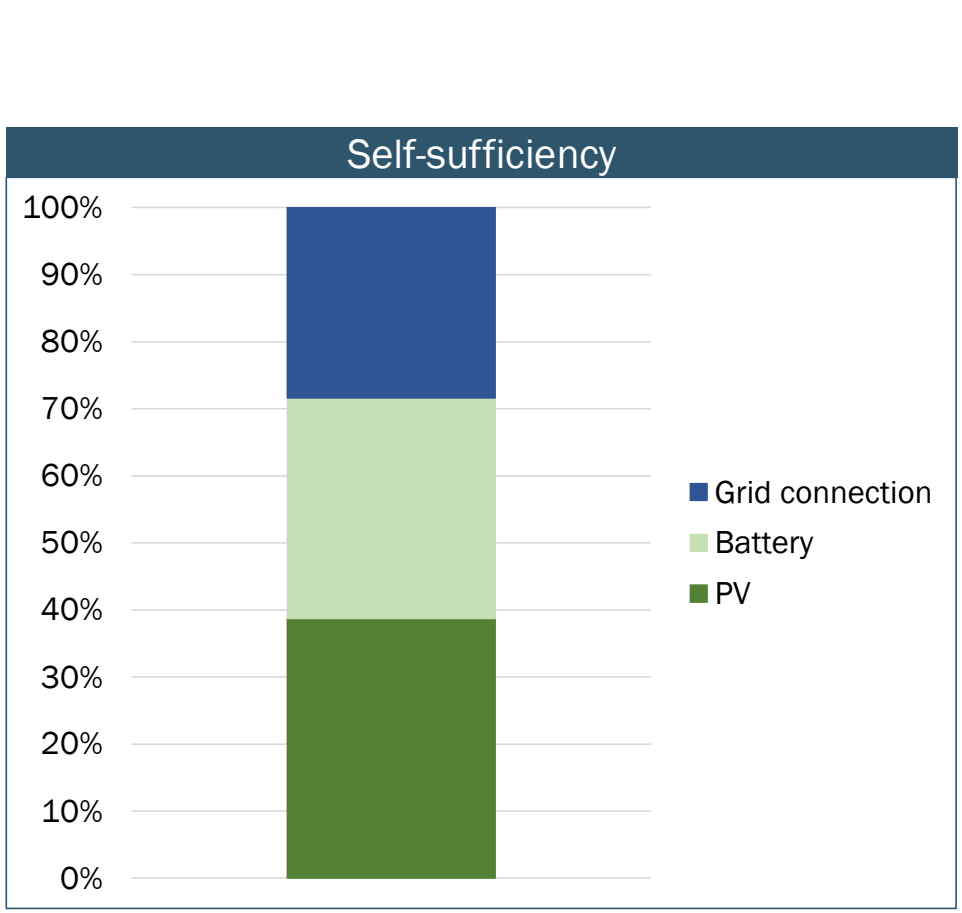

TNO innovation for life
APPLICATIONS OF ENERGY STORAGE IN TUNNELS
HARRY VAN DER WEIJDE, PIETER VERSTRATEN, NIELS JANSEN, ARAVIND SATISH
CEDR Webinar, 09/05/2023

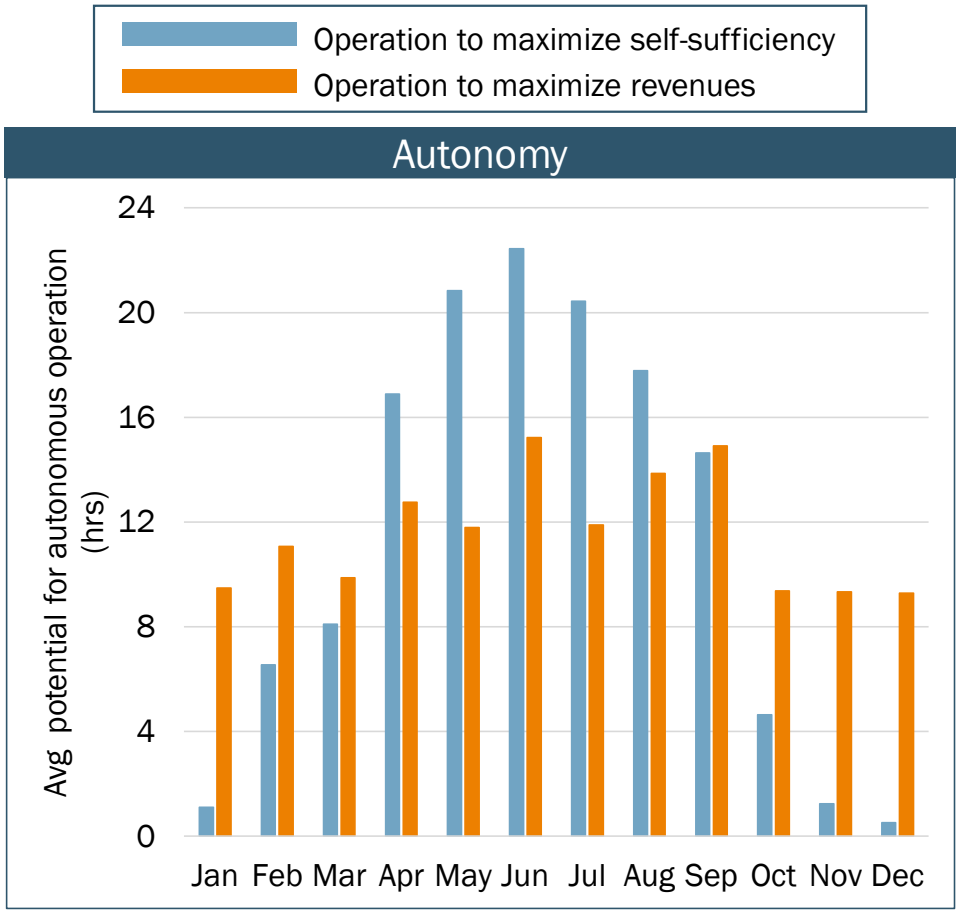
RWS CLIMATE NEUTRAL IN 2030 WITH THE HELP OF ENERGY STORAGE?

- Ambitions of the Dutch Directorate General for Public Works and Water Management (Rijkswaterstaat, RWS):
  - Climate neutrality in 2030
  - Positive contribution to the broader energy transition
- Energy storage in/near tunnels could help achieve both objectives
- Focus of our research project: What is the best way to do this?
  - Which technology?
  - Which operational strategy?
  - What is the resulting public and private value?

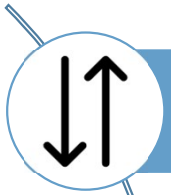
MAIN CONCLUSIONS

ENERGY STORAGE CAN SIGNIFICANTLY INCREASE THE AUTONOMY AND SELF-SUFFICIENCT OF A TUNNEL





ENERGY STORAGE CAN CONTRIBUTE TO TUNNEL OPERATION AND THE DUTCH ENERGY SYSTEM



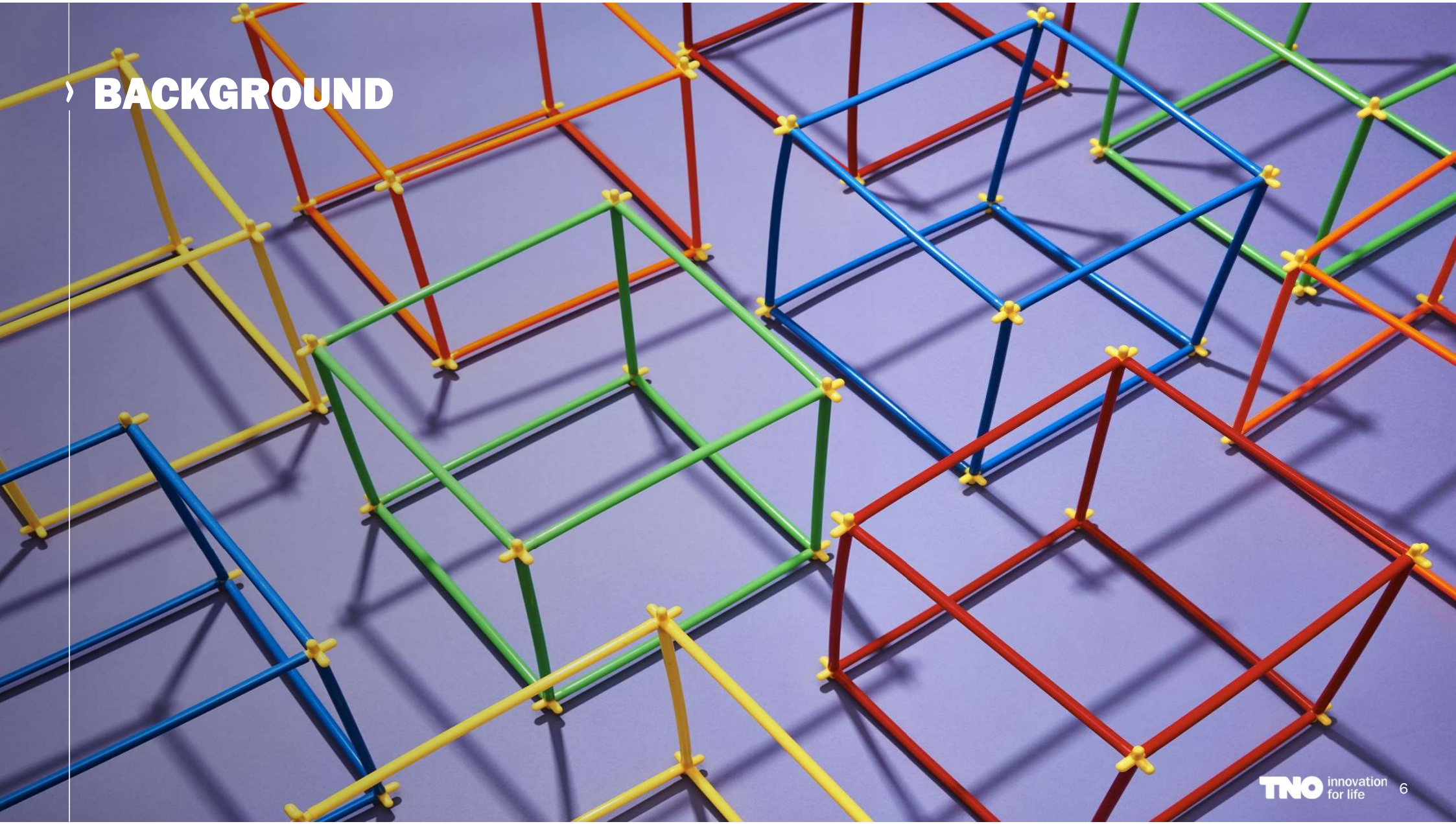
Energy storage can have benefits for the wider energy system, e.g., increasing efficient integration of renewables through arbitrage at the system level.

For most Dutch tunnels, energy storage is currently not attractive from a purely financial perspective. CO_2-savings are also small.

Batteries are, at this moment, the most appropriate storage technology for most tunnels. The best type of battery depends on local requirements and constraints.

Operational strategies can focus on self-sufficiency of a tunnel, but can add more value to the broader energy system at relatively little cost if capacity is made available in electricity markets in winter periods.

BACKGROUND



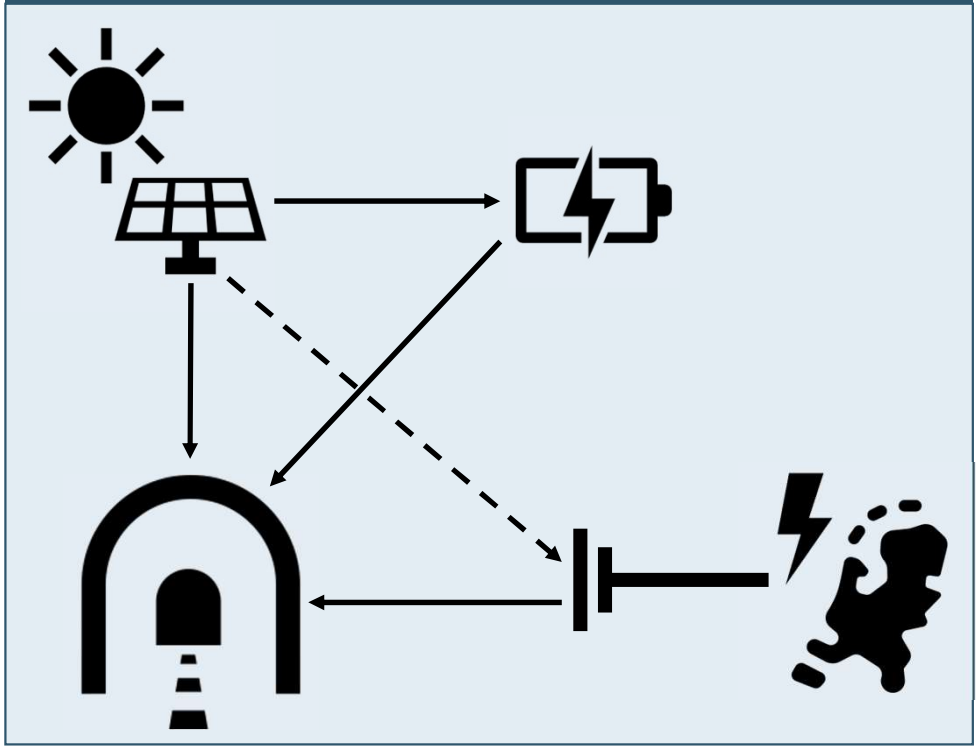
PHASE 1: CHOOSING VALUE DRIVERS AND VARIANTS

Value streams
Emergency power supply
(Energy neutral tunnel)
→ Highly self-sufficient tunnel
(Spot markets)
Balancing
Congestion management

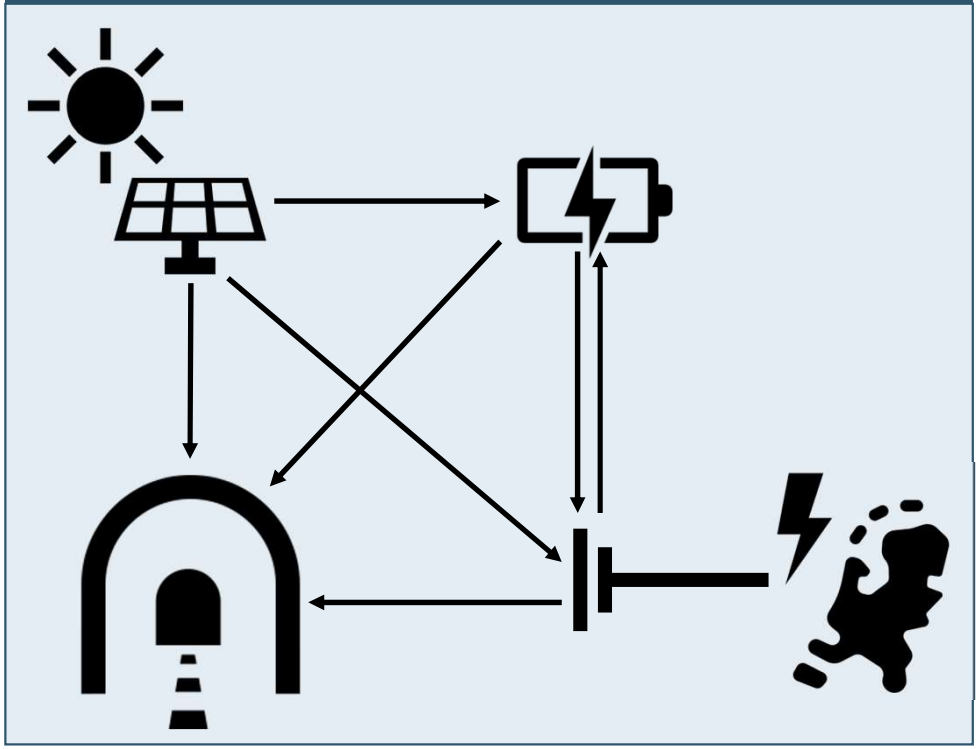
Technologies
Vanadium Redox Flow
(Li-Ion batteries)
LFP-batteries
Na-S batteies
NaNiCl batteries
Pb A batteries
NiMH batteries
CAES

PHASE 2: ANALYSIS OF TWO OPERATIONAL STRATEGIES FOR STORAGE IN A LOW-ENERGY TUNNEL

Minimize use of grid connection



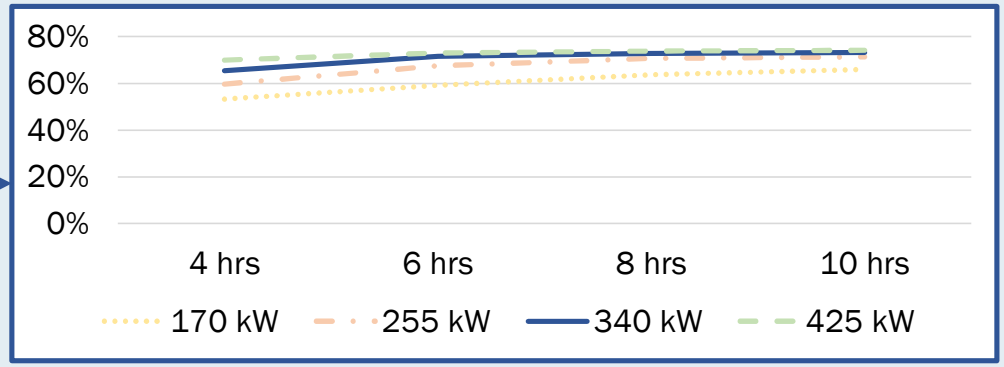
Maximize value on spot markets

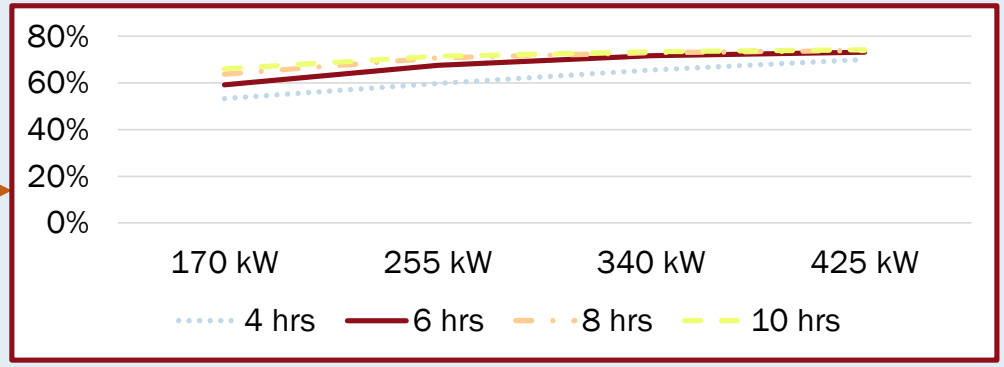


WHICH CAPACITY?

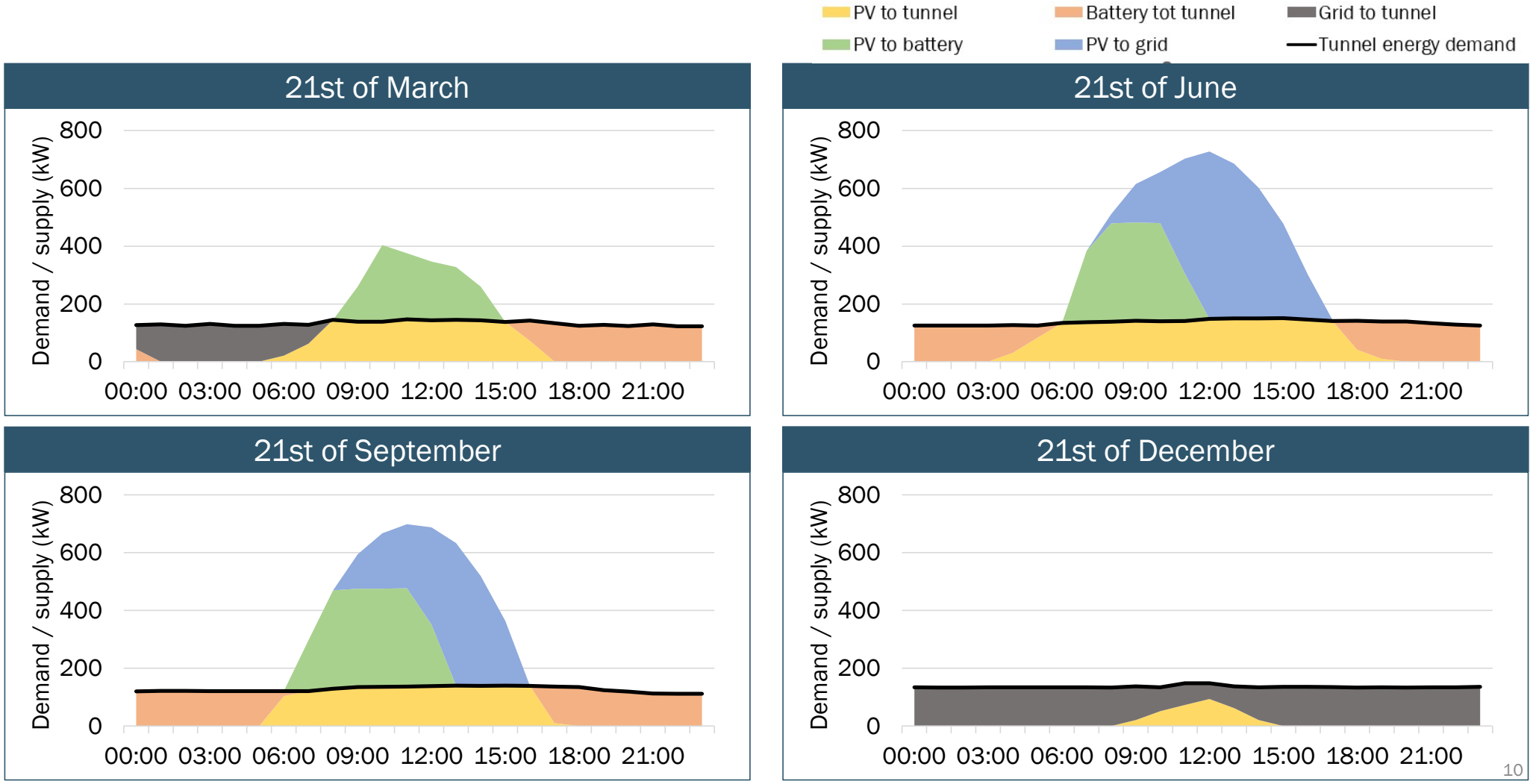
The effect of (power and energy) capacity on self-sufficiency

	4 hrs	6 hrs	8 hrs	10 hrs
170 kW	53%	59%	64%	66%
255 kW	60%	68%	71%	71%
340 kW	65%	72%	73%	73%
425 kW	70%	73%	74%	74%

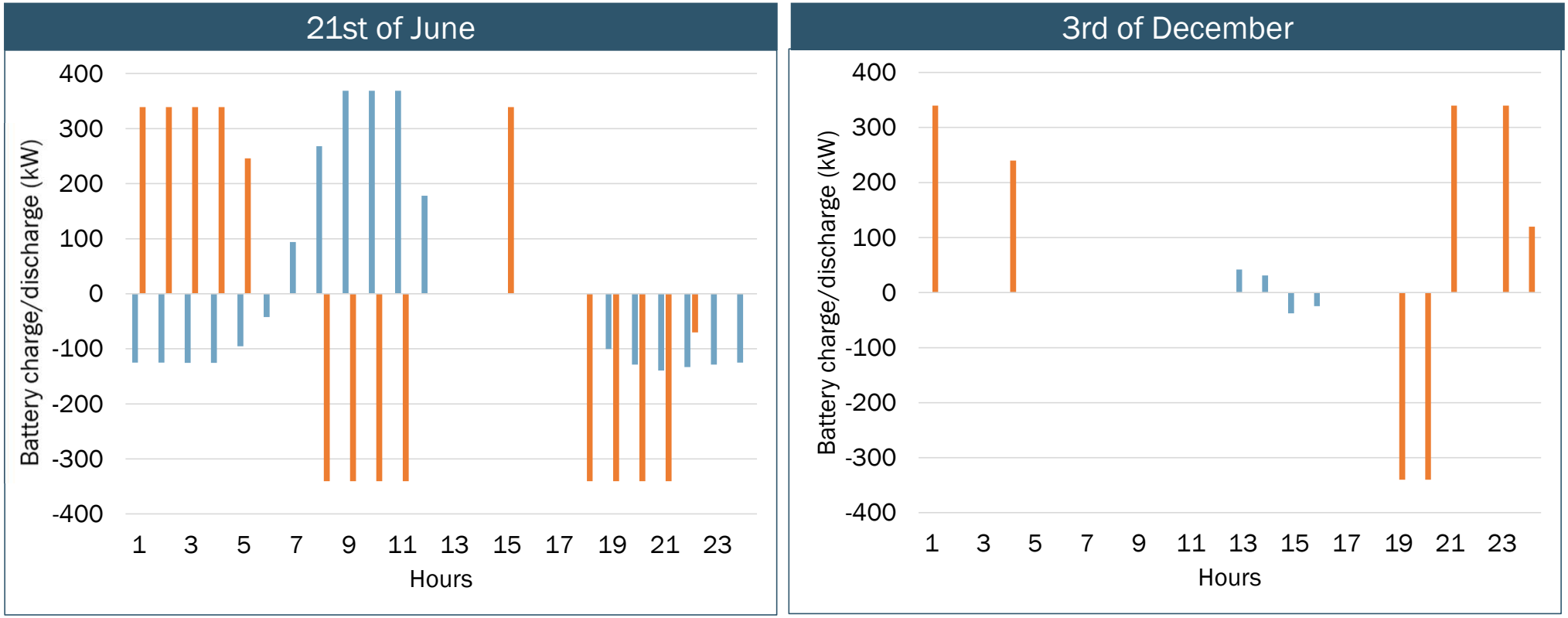




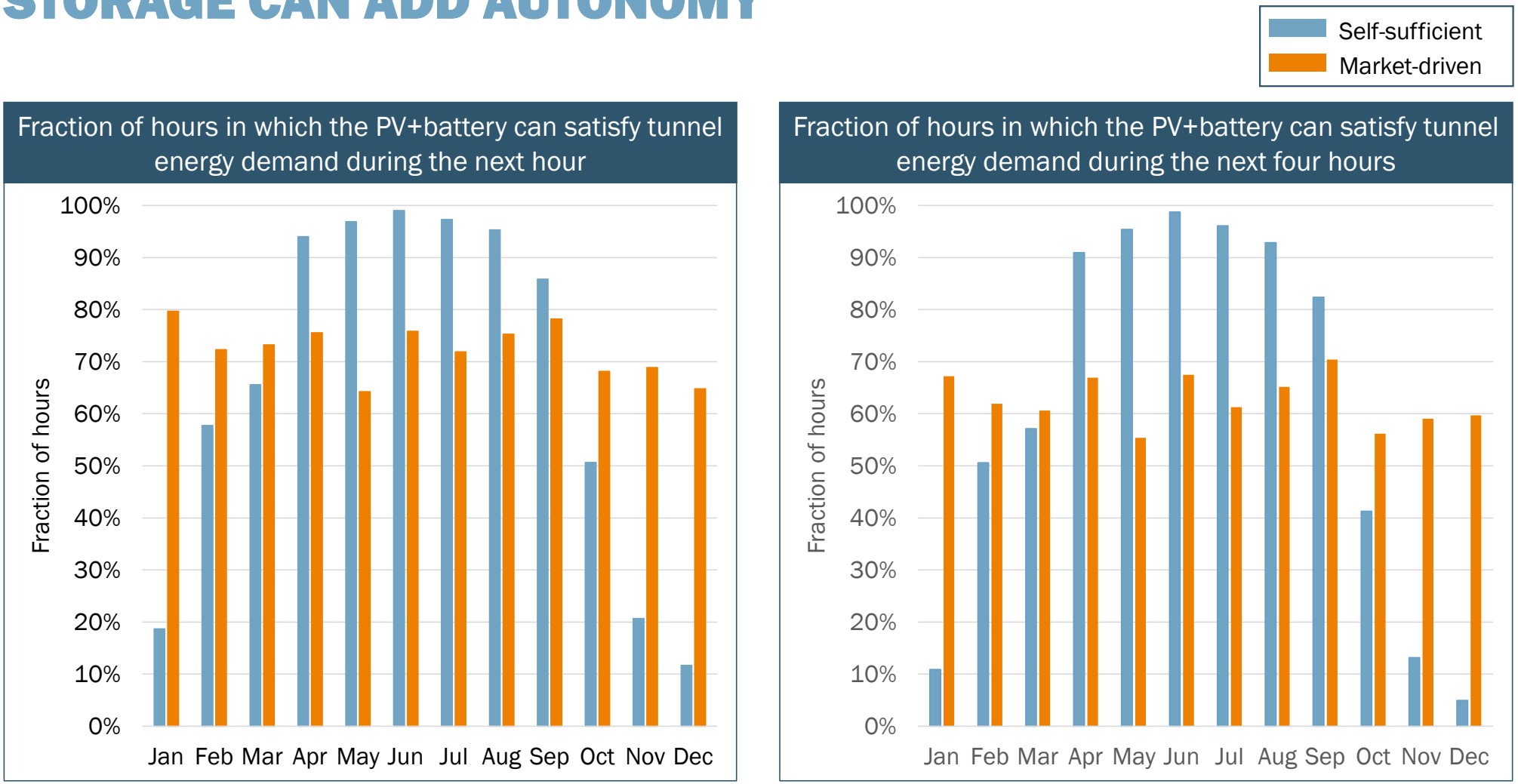
HIGHLY SELF-SUFFICIENT TUNNEL



IN WINTER, SELF-SUFFICIENCY AND MARKET-DRIVEN STRATEGIES ARE COMPATIBLE

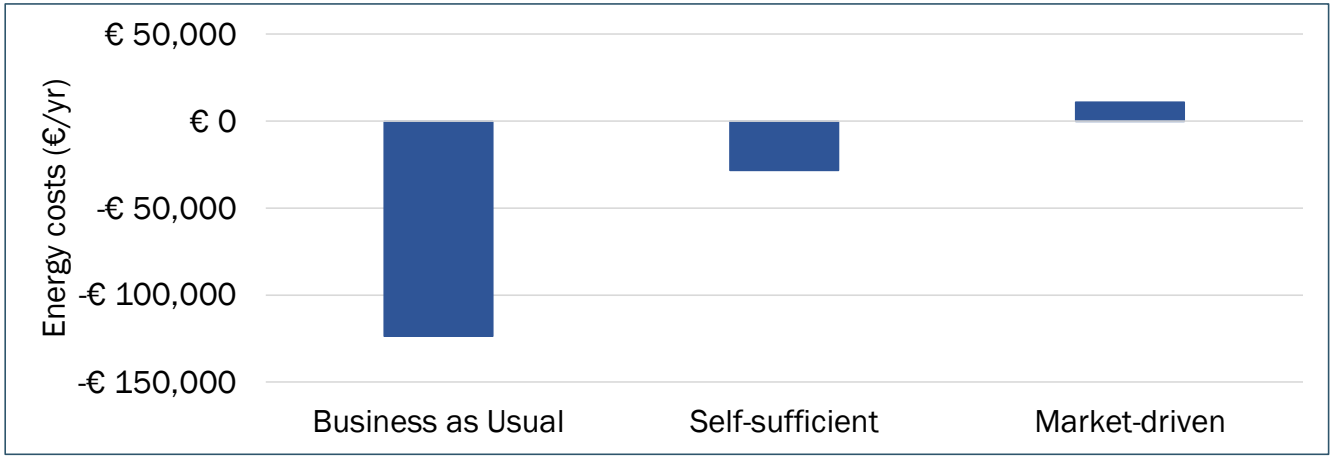


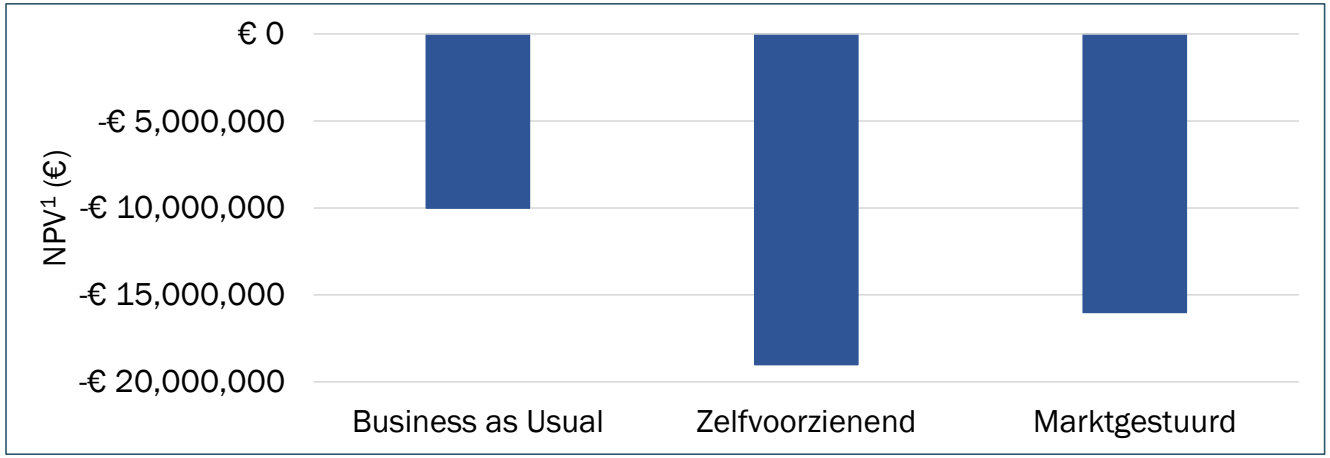
STORAGE CAN ADD AUTONOMY



ADDITIONAL VALUE STREAMS ARE NECESSARY TO COMPLETE A FINANCIAL BUSINESS CASE

- Financial analysis for three cases
  1. Business-as-usual: to battery or PV
  2. Self-sufficient strategy
  3. Market-driven strategy
- Imbalance markets can add additional revenue, but probably not enough to achieve a positive NPV.
- Opportunities for congestion management may exist, but are highly local (and temporary)
- RWS is already investing in storage in the form of UPS systems. Synergies could decrease costs or increase benefits.





[1] The NPV is calculated over 15 years with a WACC of 4%.

INVESTING IN ENERGY STORAGE, ESPECIALLY DURING RENOVATIONS, MAKES SENSE IF AUTONOMY AND SELF-SUFFICIENCY ARE IMPORTANT

- Set realistic goals instead of focusing on, e.g., absolute self-sufficiency.
- Look for operational strategies that combine private and public benefits.
- Talk to the DSOs. Use local opportunities, e.g., for congestion management.
- No one size fits all: choose a technology and capacity that best suits an individual tunnel.

OTHER LESSONS LEARNED

- Discuss the role of a public agency such as RWS early on
  - Stick to core competencies or take on broader responsibilities?
  - Minimize own costs or use broader objectives
  - Leave investments to market participants or take an active role
- Ensure the ‘why’ is clear
  - Why is self-sufficiency/autonomy/etc. important? What does that mean for targets? Is only 100% good enough?
- Get clarity on regulatory constraints and the scope for discussing changes to these
  - Reliability levels
  - Market participation by public bodies
  - Etc.

FOR MORE INFORMATION, CONTACT

Dr Harry van der Weijde
TNO ICT, Strategy, and Policy
harry.vanderweijde@tno.nl
+31 6 15 18 17 60

TNO innovation for life