

THE E3 BUS

ENERGY-EFFICIENT ELECTRIC BUS

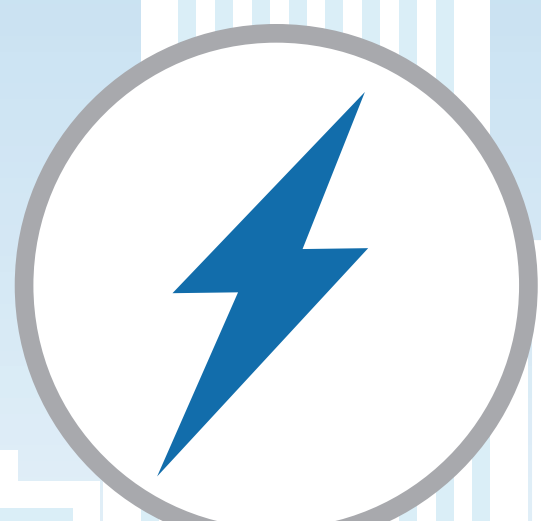
THE GREEN DEAL

In 2012, the Dutch government signed an agreement to work towards a zero emission bus fleet in 2025.

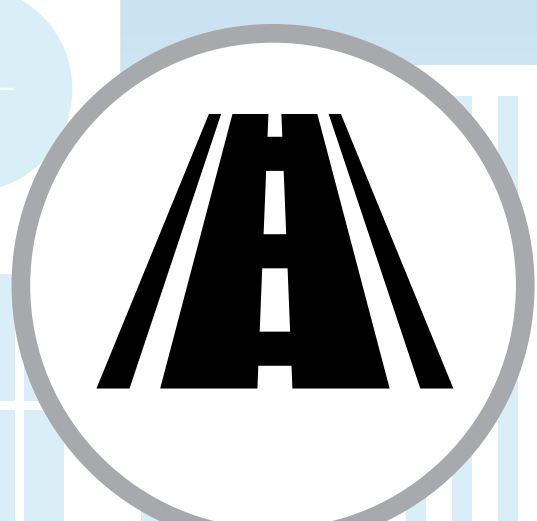
EFFICIENT ENERGY MANAGEMENT

TNO, HEAVAC and VDL cooperate in the E3 Bus project

E3 PROJECT GOALS



ENERGY ↓



RANGE ↑



PASSENGERS ↑



COMFORT ✓



COSTS ✓

ALTERNATIVE DRIVE LINE

🟢 Clean, silent but work in progress.

TRADITIONAL DRIVE LINE

🔴 Reliable, familiar but noisy and not compliant with the Green Deal.

HOW TO DEFINE COMFORT?

A comfortable climate inside the bus is essential. In general, 22°C is considered comfortable, but other factors influence this.



HUMIDITY



ACTIVITY



CLOTHING



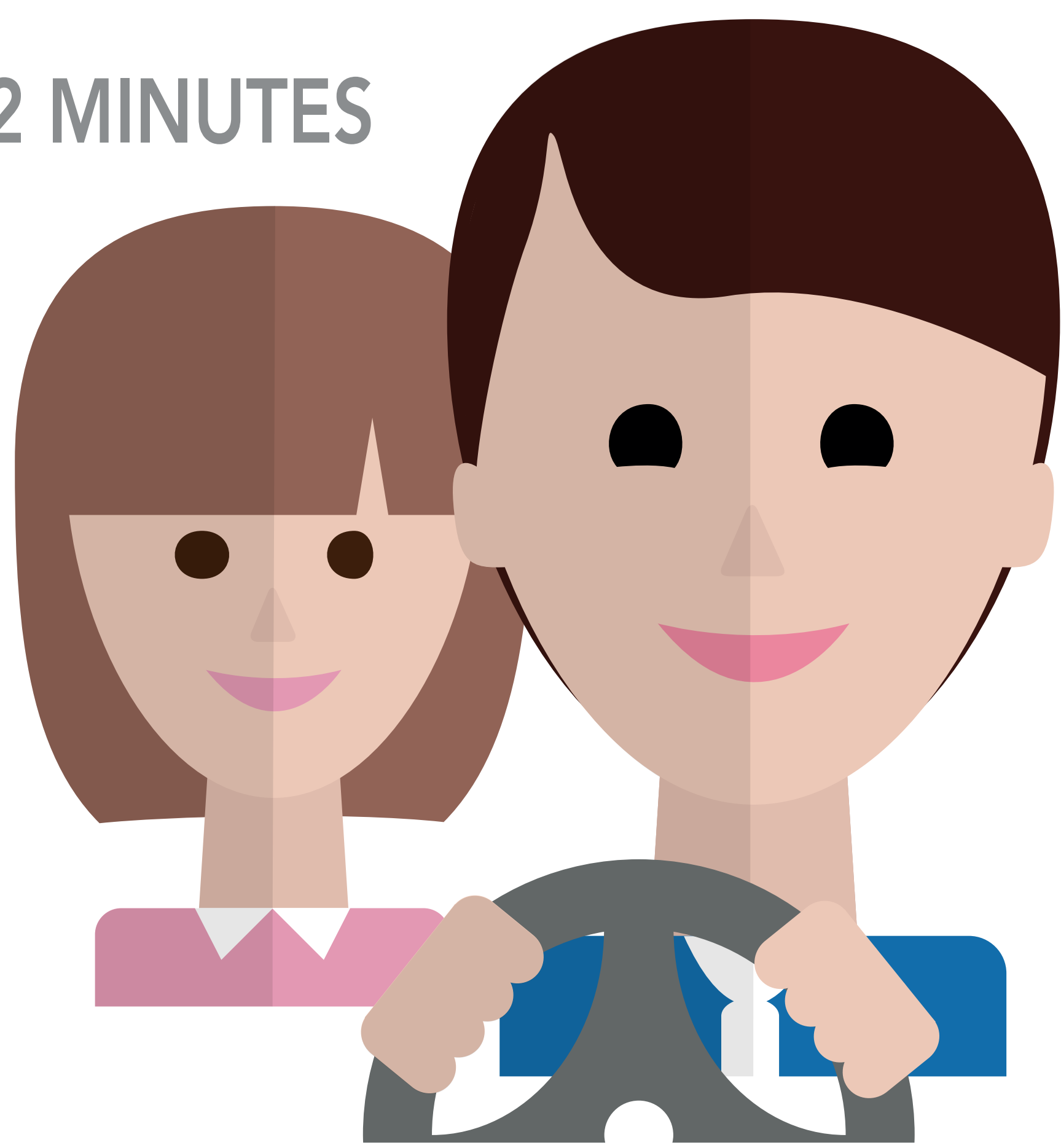
PASSENGERS

PERCEPTION

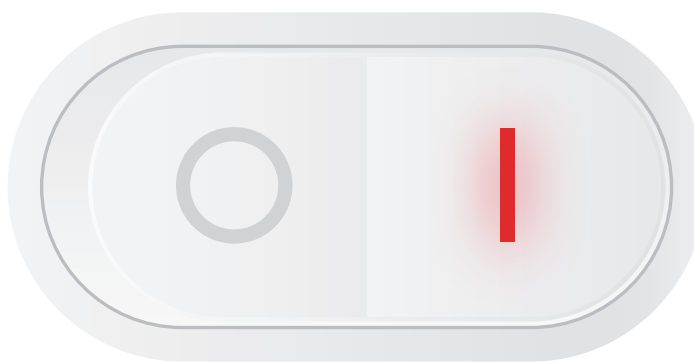
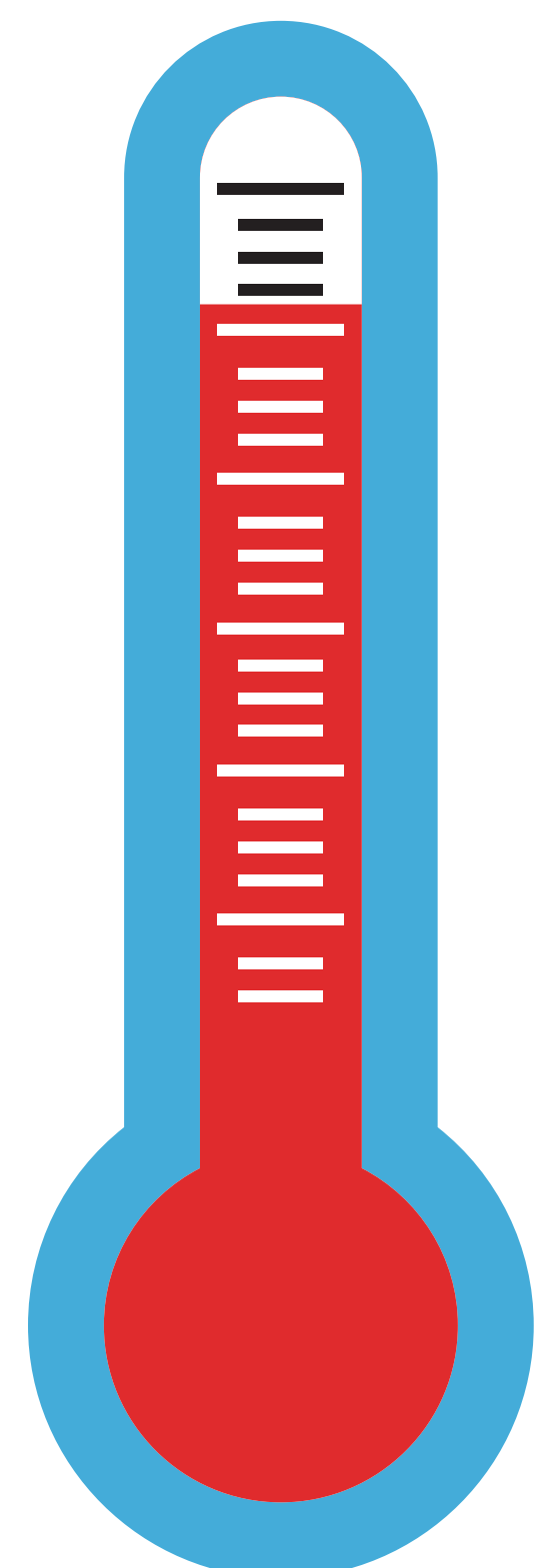
There is also a difference in perception of (and requirements for) comfort between the driver, who stays in the bus for approx. 2 hours, and passengers - who, on average, sit on inner-city buses for 12 minutes.

12 MINUTES

22°C



2 HOURS



HVAC ON

30% ↓

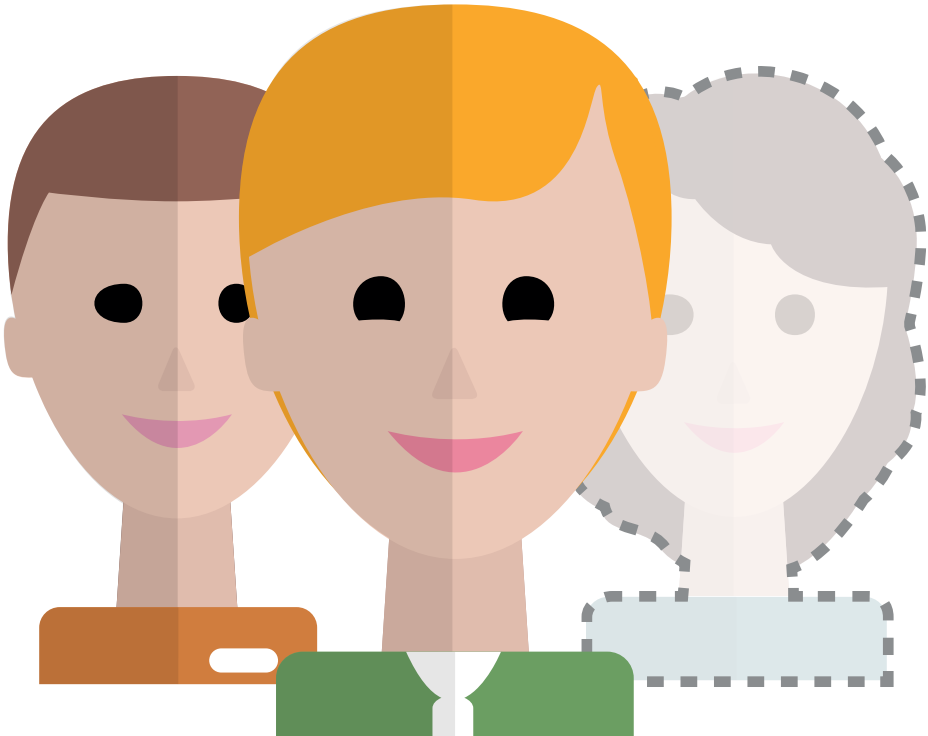
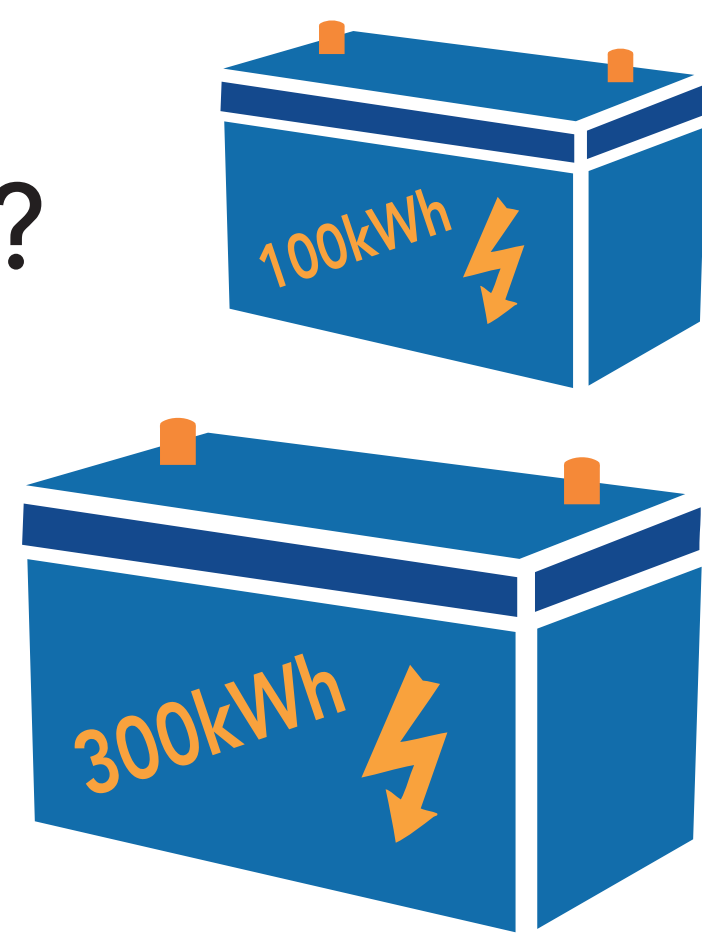
WHY NOT USE A BIGGER BATTERY?



RANGE ↑



PASSENGERS (-20% ↓)



MAIN ISSUES

The biggest impact on energy usage is the climate-control system, which is essential for comfort.

- The climate-control system (HVAC) consumes 30% of battery life.
- The outside temperature greatly influences the range of the battery. Currently the ideal temperature for optimal battery use is 15°C.
- A bigger battery weighs so much more that the number of passengers the bus can carry dramatically decreases.

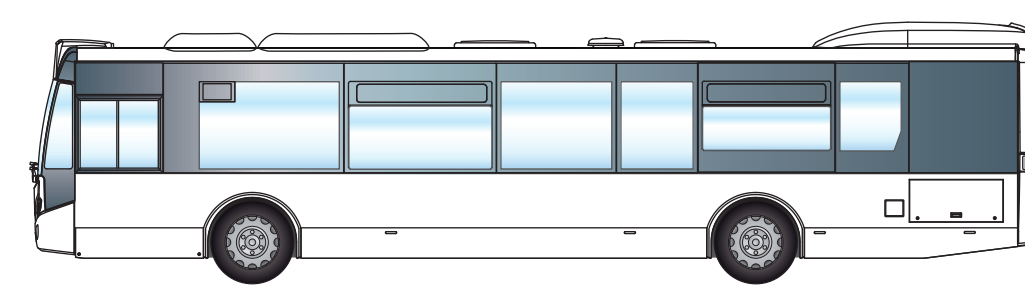
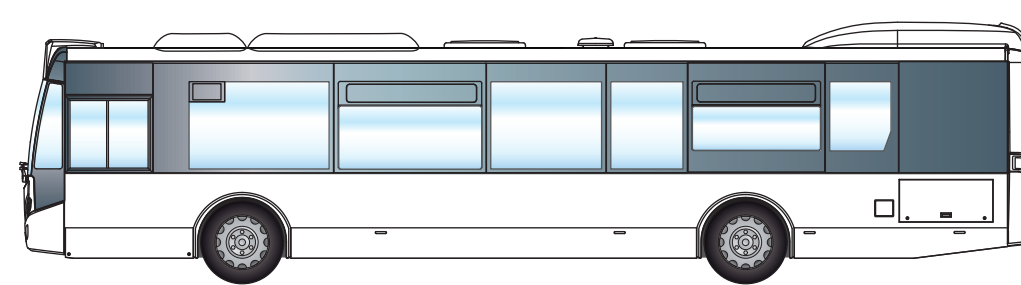
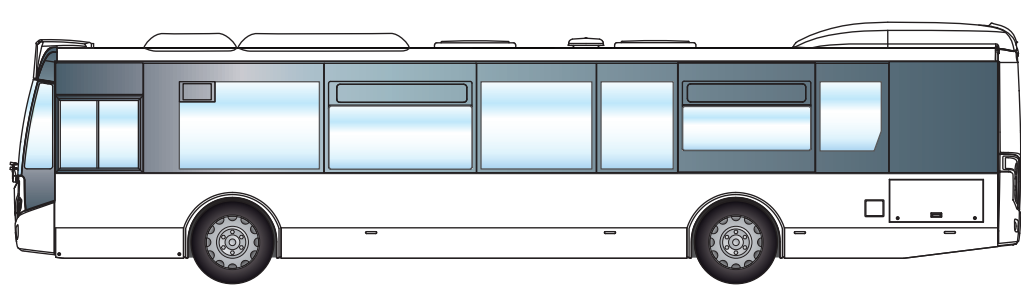
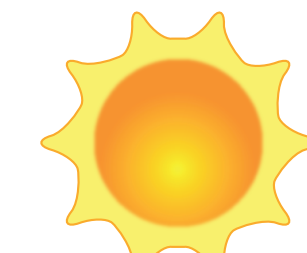
15°C



-5°C



35°C



← RANGE IN KILOMETERS

← START

OUR APPROACH

The E3 project investigates how to optimize the energy use of HVAC systems, in particular of heat pumps. The project team looked at:

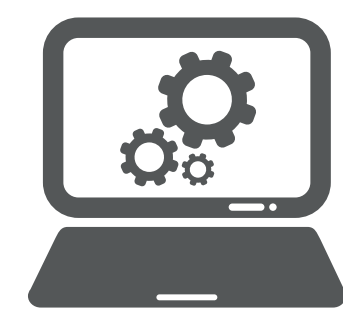
SOFTWARE SOLUTIONS

- Integrated control
- Peak shaving (when the bus is accelerating, the HVAC temporarily shuts down to save power)
- Intelligent air recirculation (CO₂, humidity)

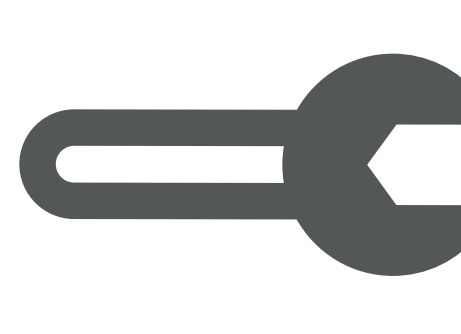
SUSTAINABLE HARDWARE

- Insulated glass, floor, roof, panels
- Glass coating
- Personalized heating, e.g. heated seats
- Waste heat utilisation

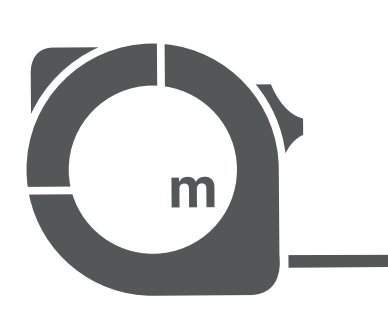
THE PROCESS



SIMULATE



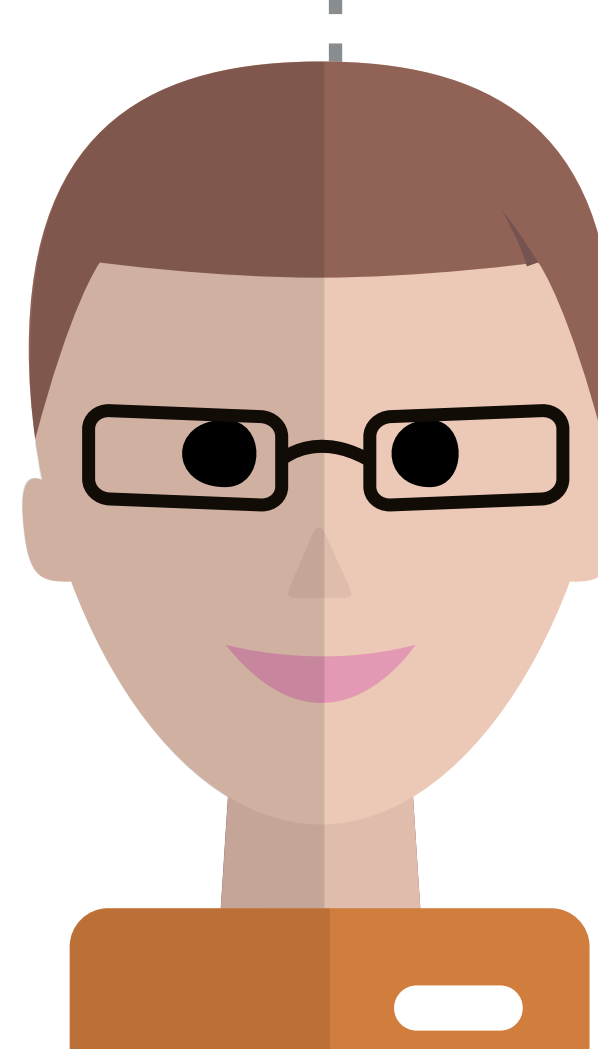
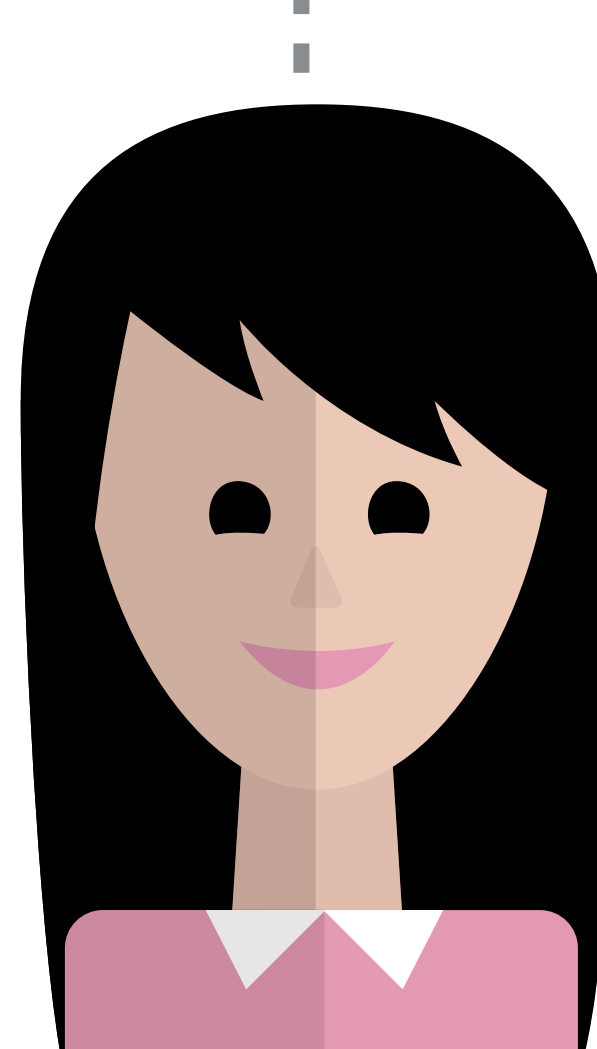
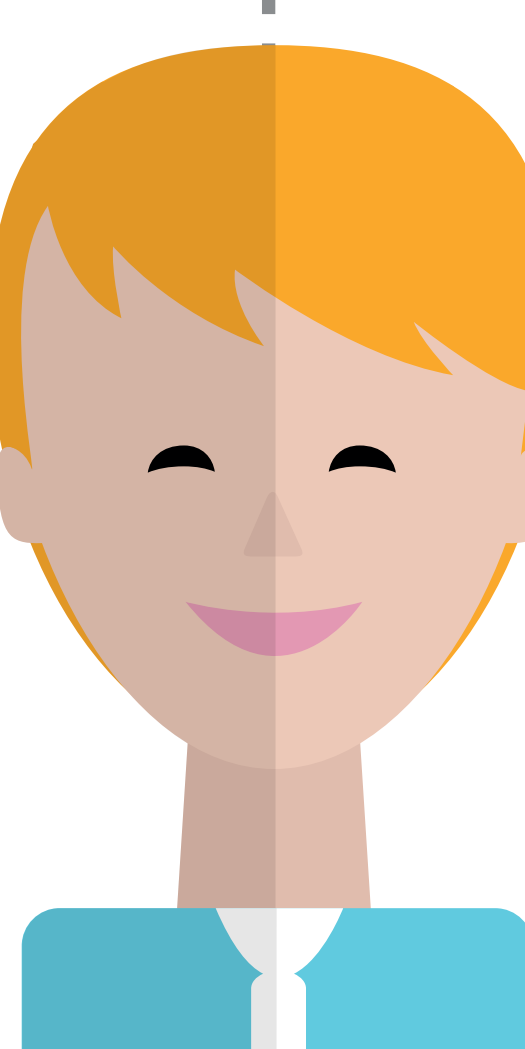
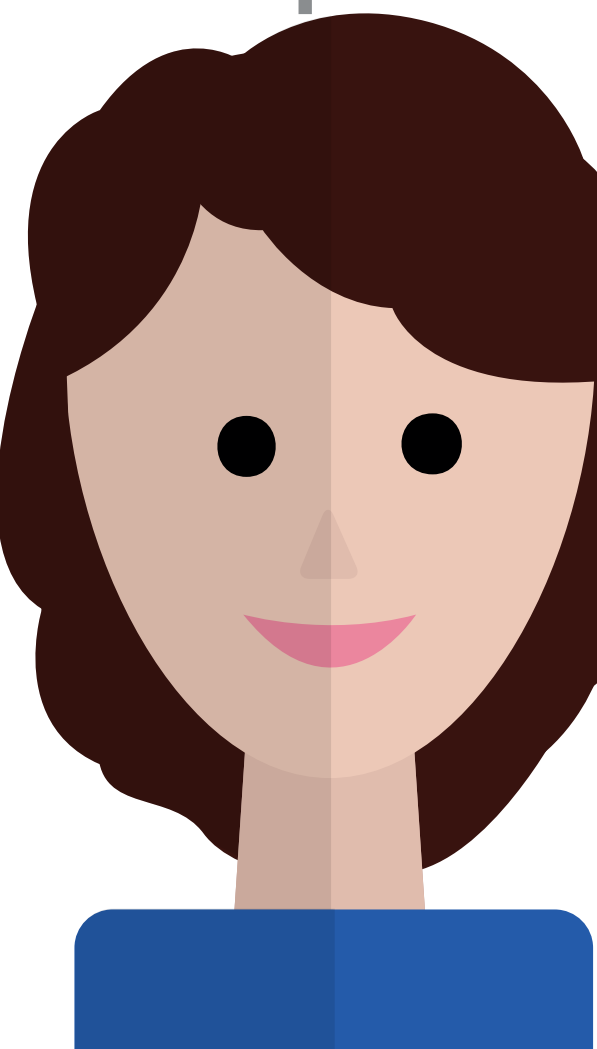
PROTOTYPE



MEASURE



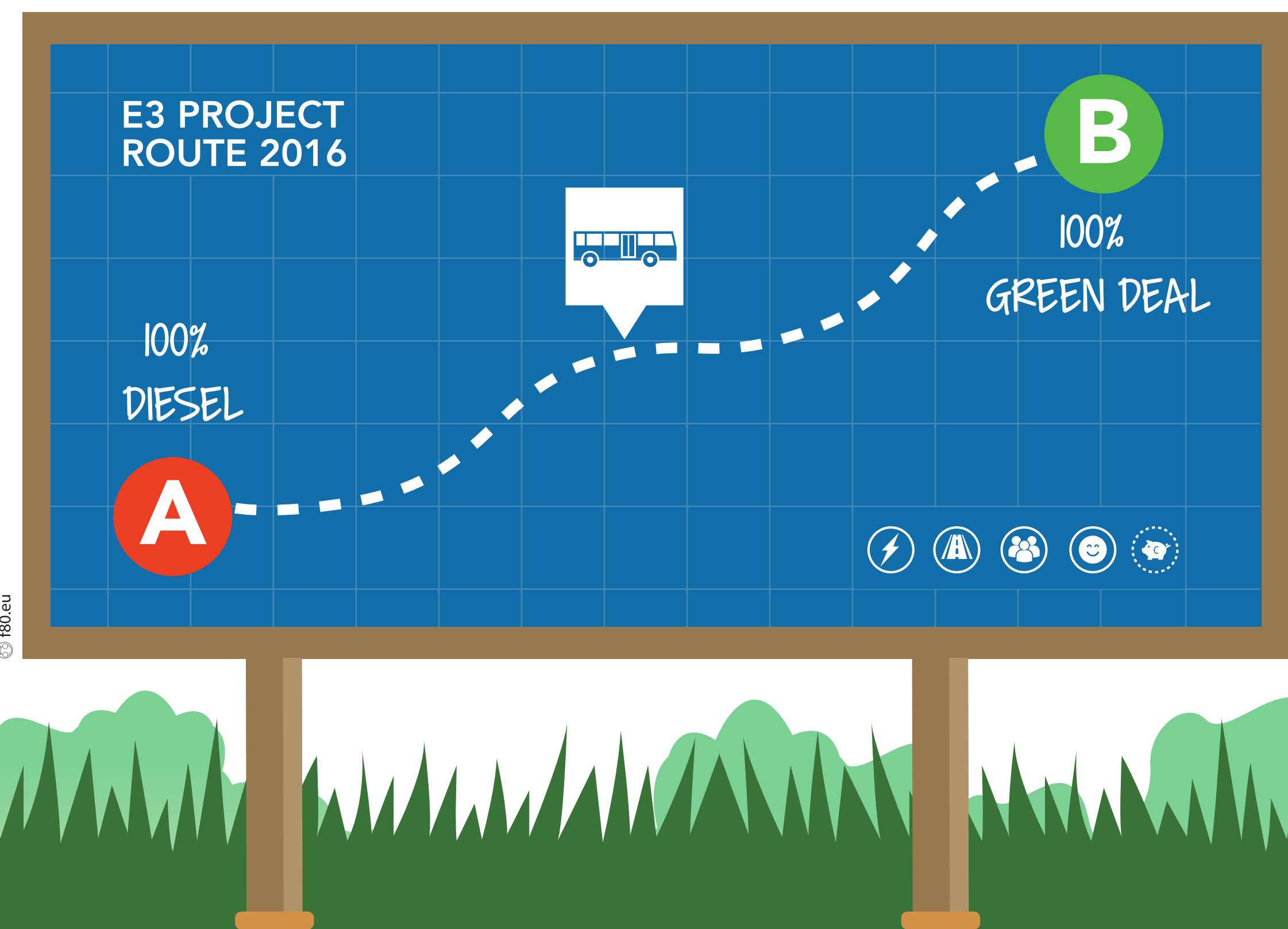
IMPROVE



MORE INFORMATION?

Visit the website to learn more:

WWW.TNO.NL/E3BUS



2016 (AND BEYOND)

The E3 project team and partners are dedicated to taking the optimal route to even more energy-efficient and comfortable electric buses!

TNO innovation for life

HEAVAC Member of Aurora Group

VDL BUS & COACH

Qbuzz

Fontys

Holland High Tech Global Challenges, Smart Solutions

Holland