



Real life testing of electric vehicles under Aruban climatological conditions

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15 May 2018

TNO innovation
for life



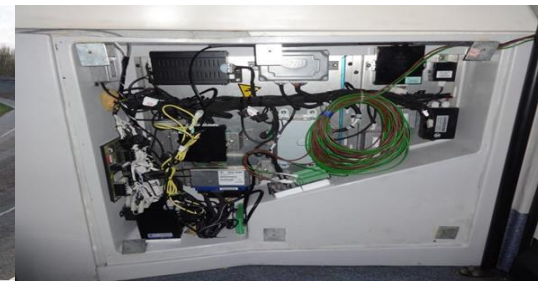
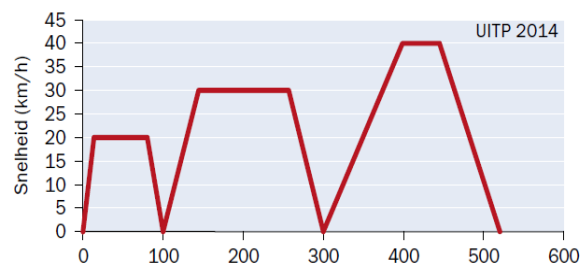
Content

Real life testing of electric vehicles under Aruban climatological conditions

Scope

Background

Motivation



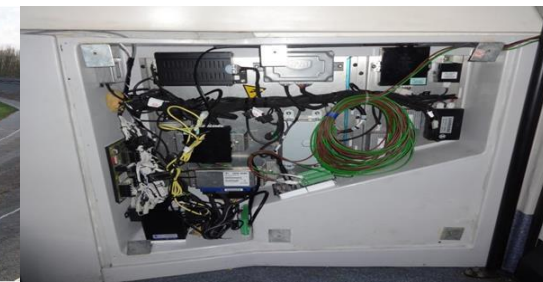
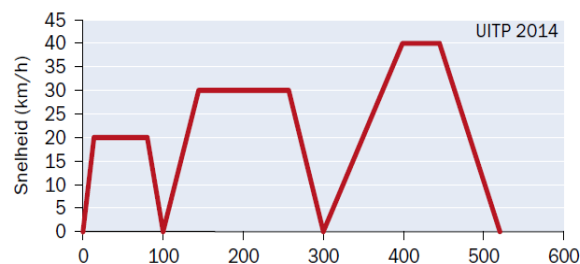
Scope

Rationale

- › Guidelines for comparison of energy consumption and range of a battery electric bus do not exist
- › Performances of electric buses only exist on paper
- › Test infrastructure/lab not available on Aruba

Objective of this document

- › Determine how the electric bus performs in an Aruban setting
- › Outline test procedure/program
- › Compare performance between EV bus vs conventional diesel bus
- › Determine the total cost of owner (TCO) for electric bus vs diesel bus



Opportunities and challenges to electrification of public transport

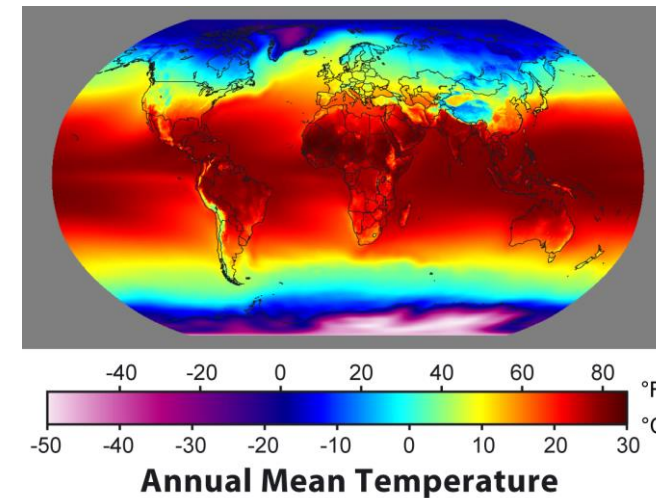
Opportunity

- › Short distance
- › Flat geography



Challenge

- › Climate condition (temperature)
- › Cooling load



Key questions to electrification of public transport

Performance EV

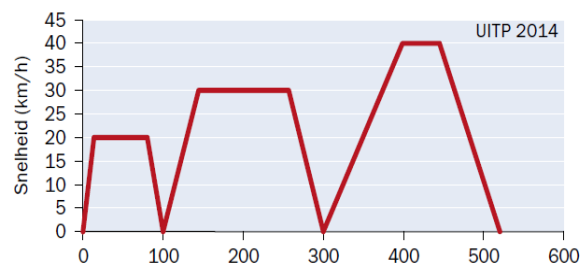
- › Energy consumption and range needs to be measured

TCO

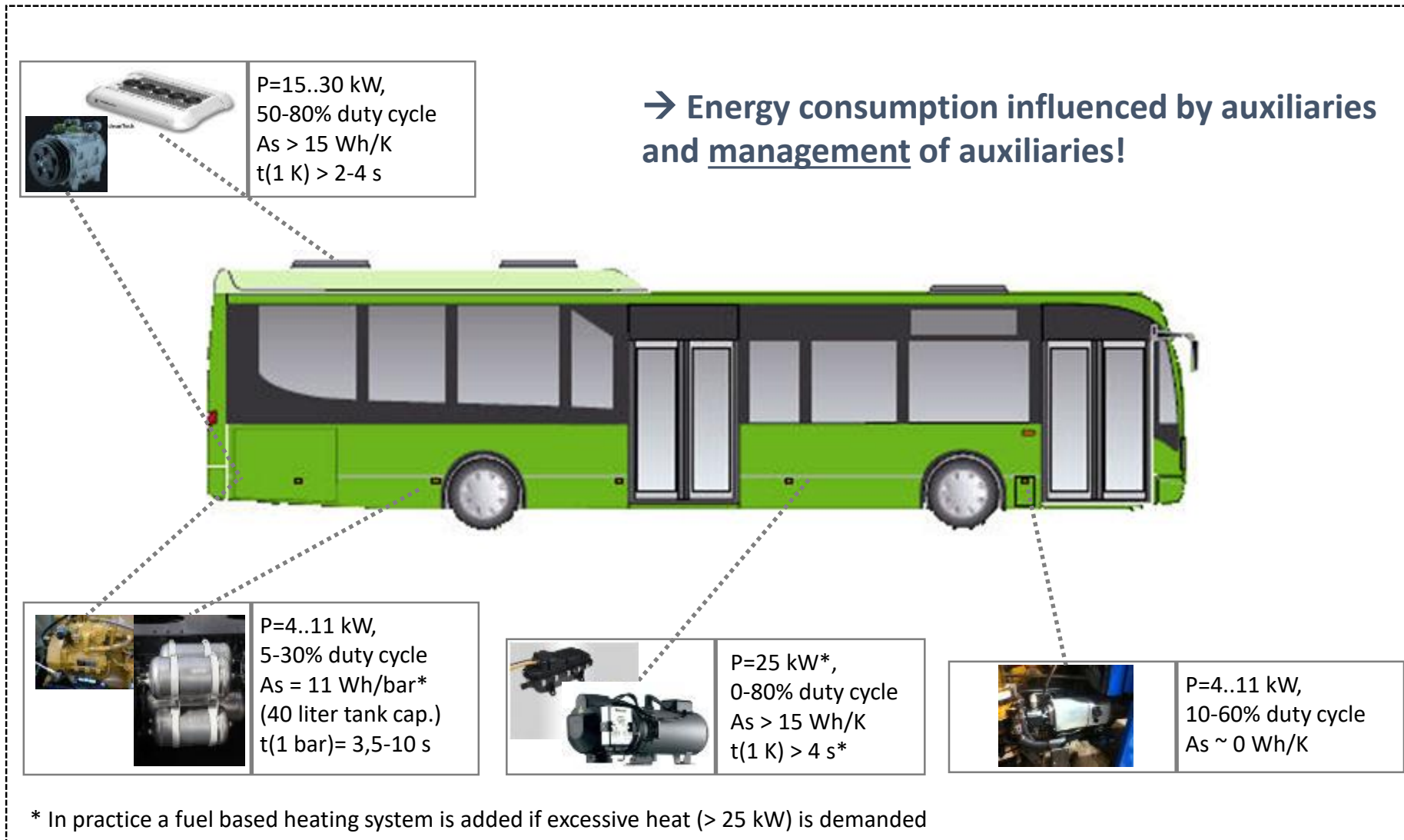
- › Determine the Total Cost of Ownership (TCO) for electric bus vs diesel bus



- › Start procedure the SORT (Standardized On-Road Test cycles)
- › TCO analysis



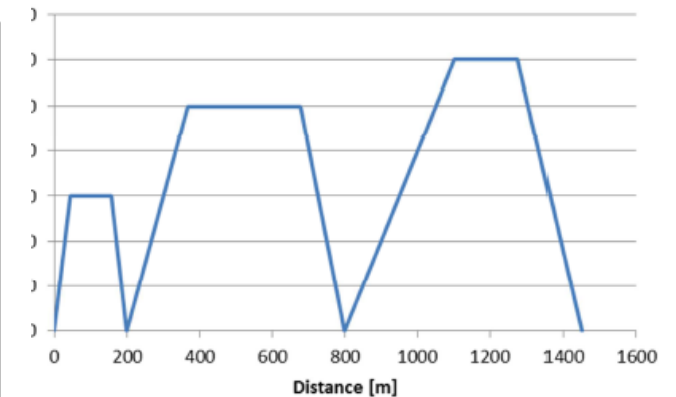
Auxiliary modules: energy consumption and energy storage



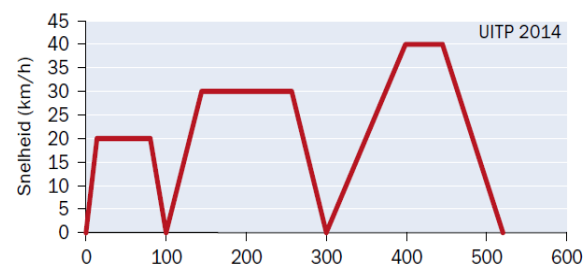
Considerations on Test Procedure

Table 1: Overview of specifications of the different SORT cycles, source [3]

	SORT 1	SORT 2	SORT 3	Unit
Rated average speed	12.1	18	25.3	km/h
Stops/km	5.8	3.3	2.1	
Stop time	39.7	33.4	20.1	%
Trapeze 1 v-const. speed/length	20/100	20/100	30/200	km/h / m
Acceleration	1.03	1.03	0.77	m/s ²
Trapeze 2 v-const. speed/length	30/200	40/220	50/600	km/h / m
Acceleration	0.77	0.62	0.57	m/s ²
Trapeze 3 v-const. speed/length	40/220	50/600	60/650	km/h / m
Acceleration	0.62	0.57	0.46	m/s ²
Length of stops	20/20/20	20/20/20	20/10/10	sec
Total length	520	920	1450	m
Deceleration	0.8	0.8	0.8	m/s ²



3: SORT 3 cycle



Preliminary insights

Electrical consumption

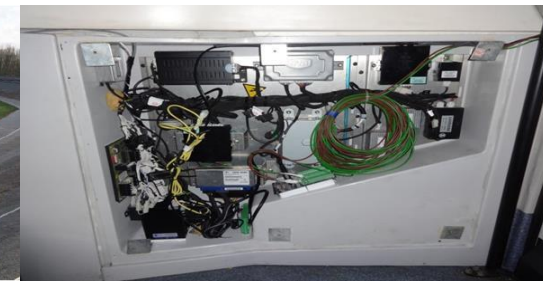
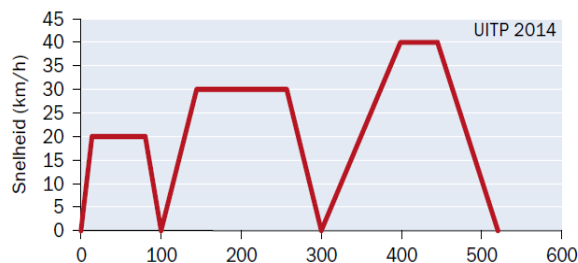
- › Theoretically EV far more efficient than conventional diesel bus
- › In practice.....

Temperature impact

- › Ambient temperature has high impact on battery performance/life and range

Cooling load impact

- › Cooling load has a high impact on the range

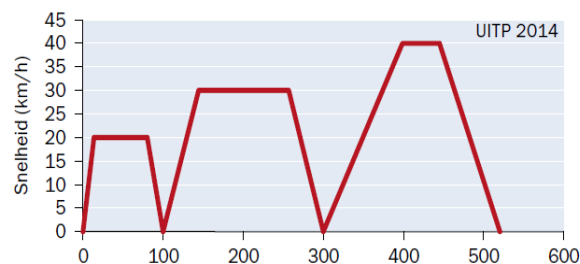


Preliminary insights

**Electrical
consumption**

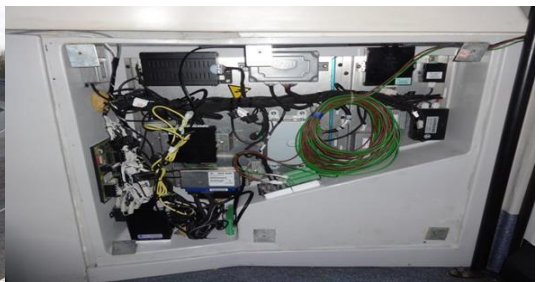
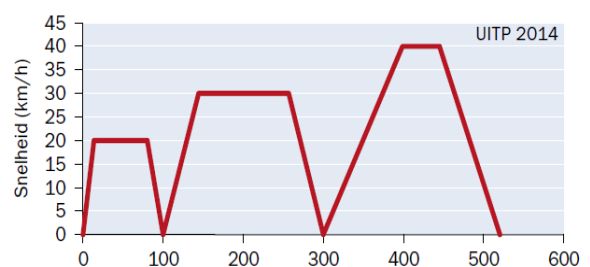
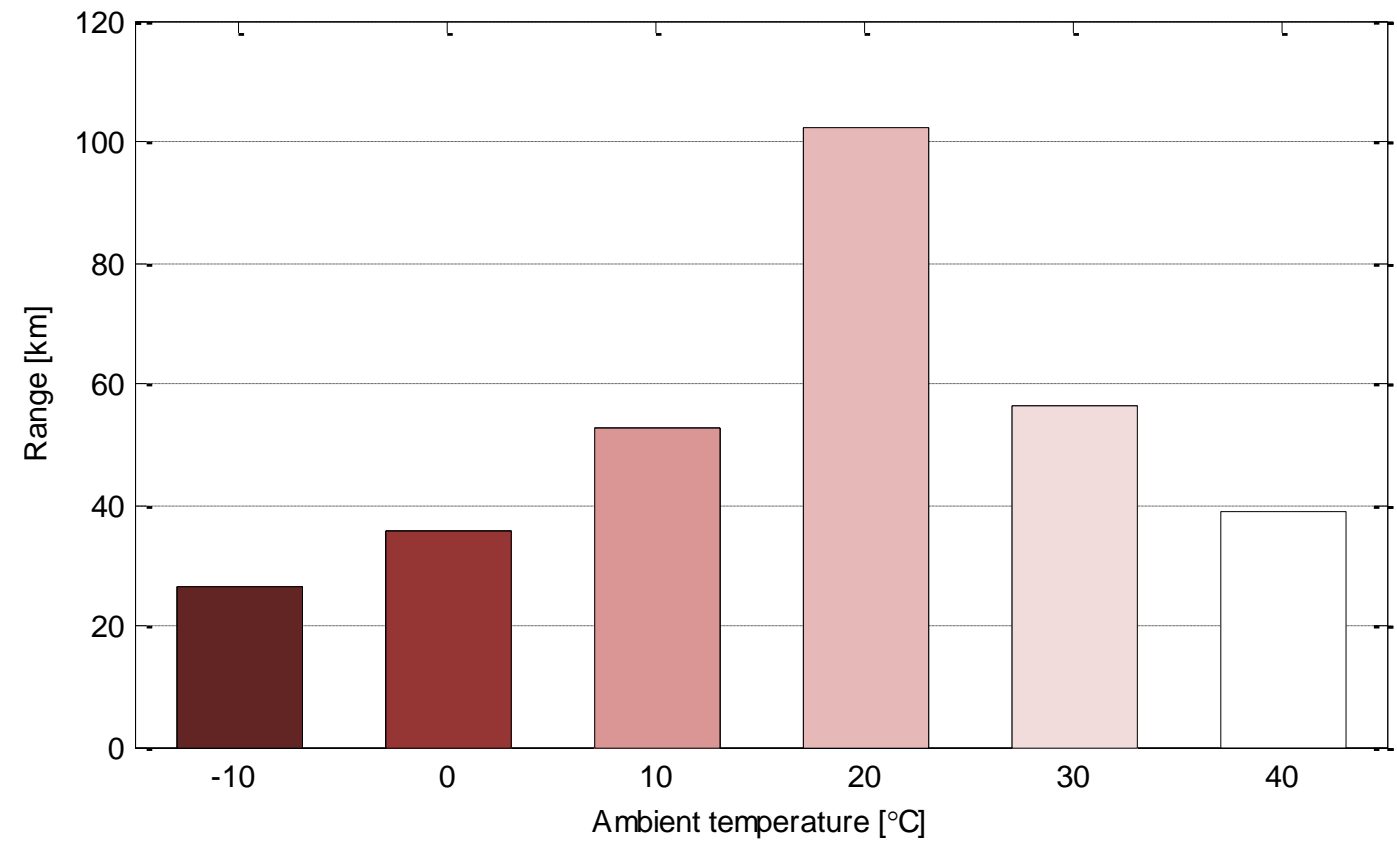
Table 4-1: performance of electric bus on Aruba vs. other bus tests by TNO NL.

TNO Nederland	Euro VI Diesel Bus	Electrical Bus	Hydrogen Bus	
	3,8 - 4,2	1,1 - 1,7	1,9 - 2,1	Energy consumption in kWh/km
	520	90 - 240	400	Operational range in km



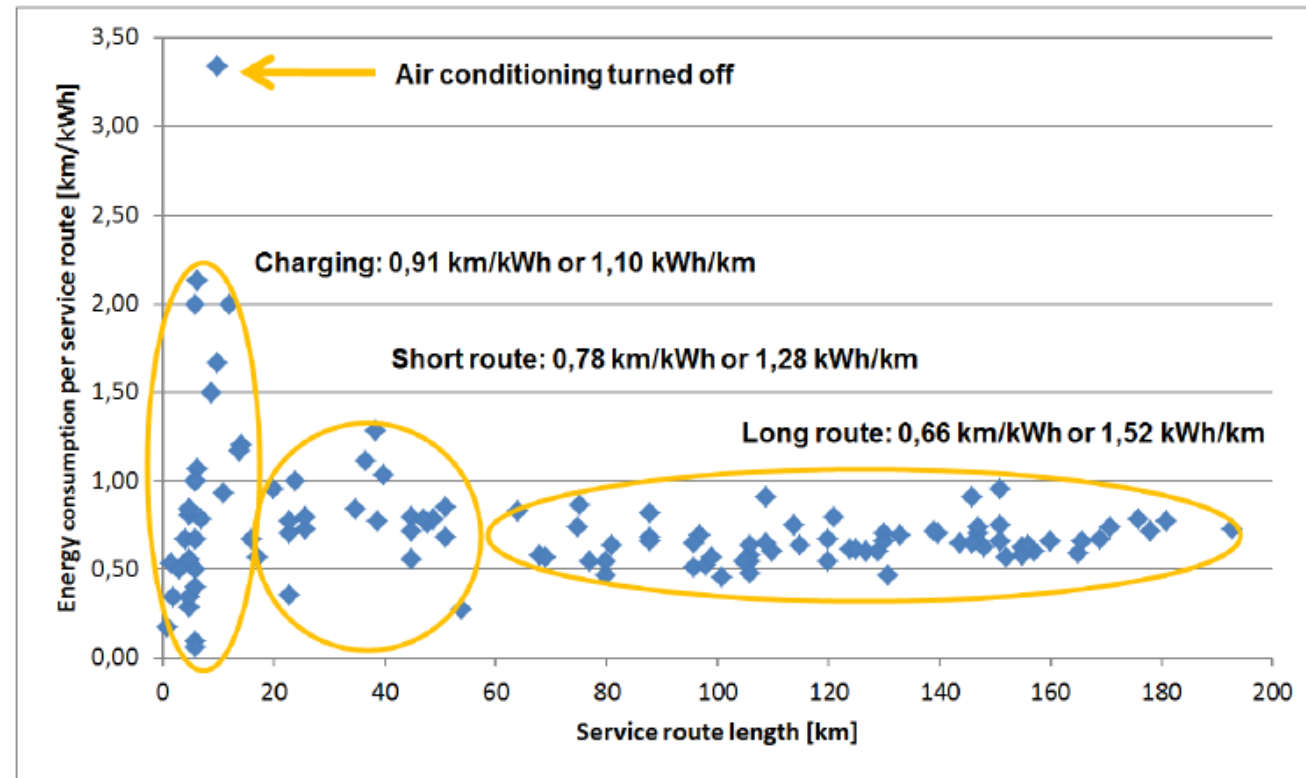
Preliminary insights

Temperature impact

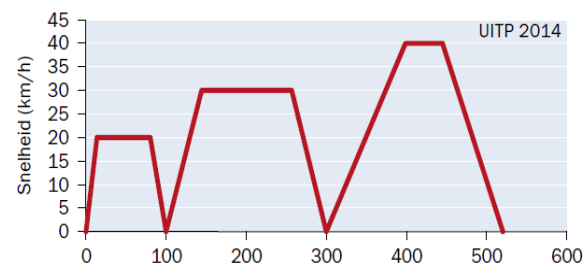


Preliminary insights

**Cooling load
impact**



Figur 3-3: energy consumption in km/kWh and service route length for each drive.



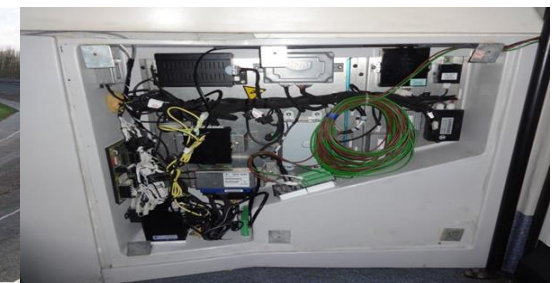
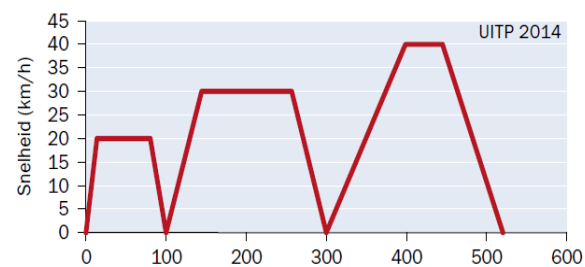
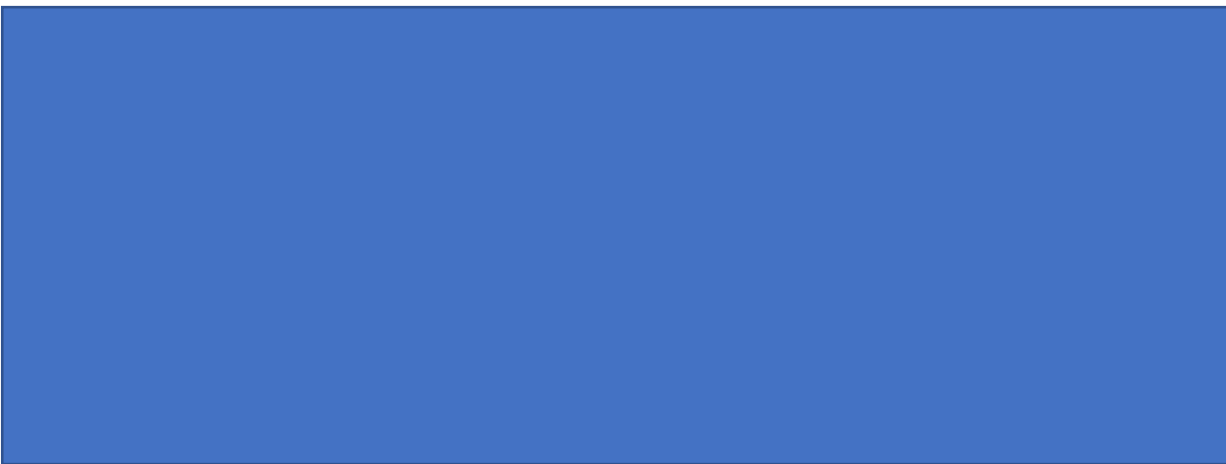
Economic considerations

Investments

- › Purchase price EV bus higher than conventional diesel bus

Savings

- › Lower fuel cost
- › Lower and less maintenance
- › Tax benefits



Conclusions and Recommendations

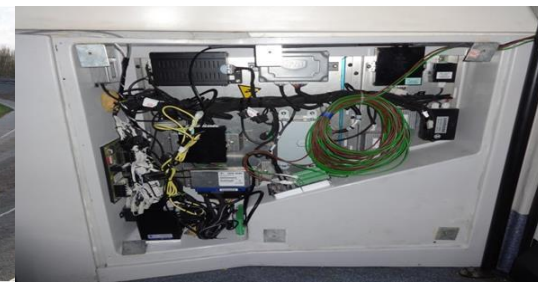
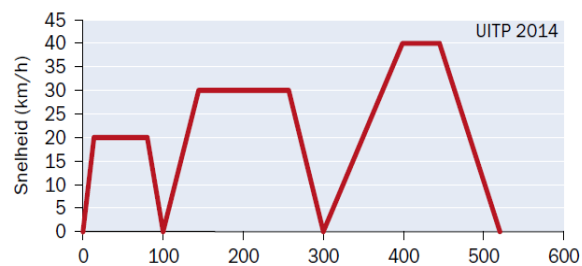
**Fuel cost
consideration**

**Maintenance cost
considerations**

**Fleet renewal
considerations**



- ▶ Favorable policy
required incentives,
etc.)
- ▶ Airport showcase
potential



Thank You!

