



The bridge to reality

Agent-Based Model to Design & Support E-Mobility Transformation for Municipal Vehicle Fleets

AnyLogic Conference 2021

Dr. Nadia Galaske

**SIMULATION SOLUTIONS FOR
PRODUCTION AND LOGISTICS PROCESSES**

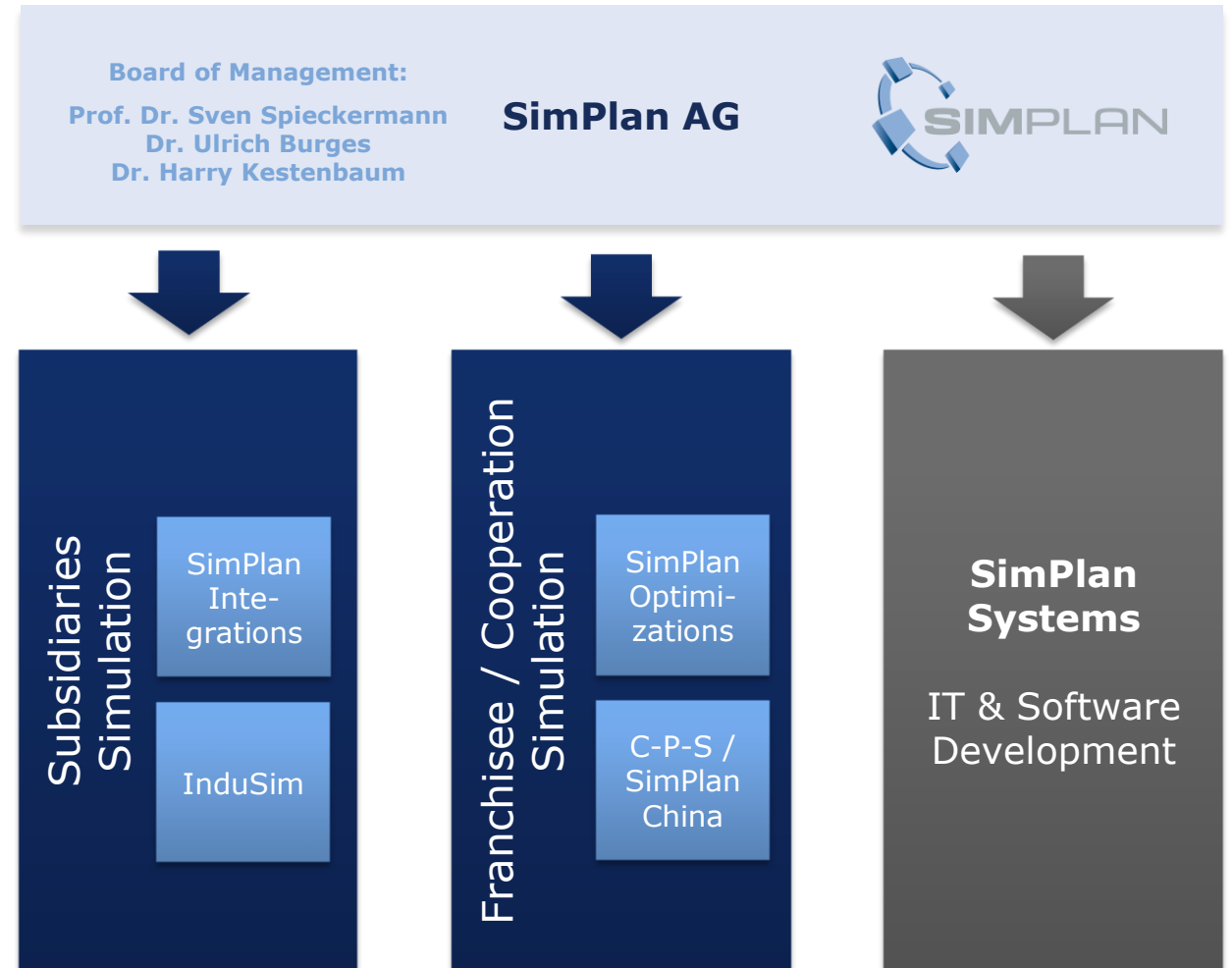
SimPlan

Introduction

SimPlan is a cross-sector full-range supplier with regard to simulation and optimization.

We offer a comprehensive range of simulation services: from simulation projects through various simulation software tools to simulation-based planning application

- Founded in 1992
- Headquarter: Hanau, Germany
- Today: 126 employees at 12 locations



- Simulation-based control center
- Advanced production planning
- Sequence optimization

SOLUTIONS

SUPPORT

- Trainings
- Support hotline
- Maintenance

The four **SIMPLAN** service areas

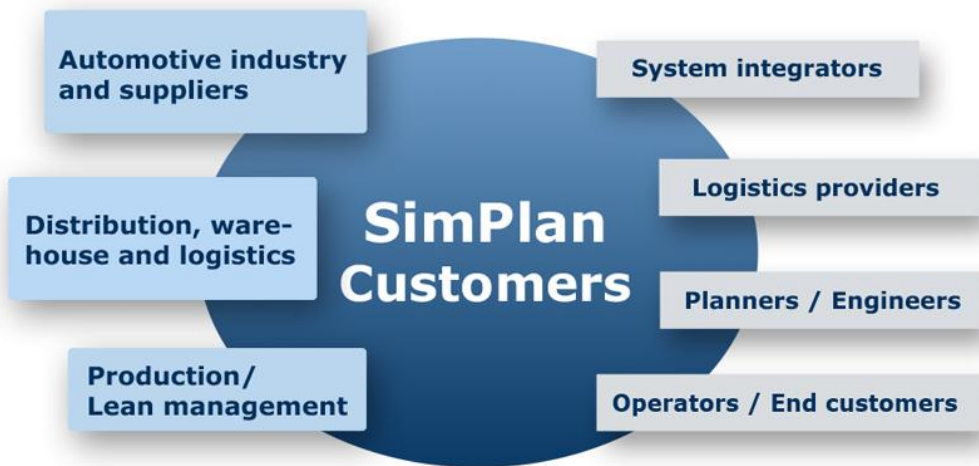
SERVICE

SOFTWARE

- Animation
- Emulation / Virtual commissioning
- Studies
- Model development / „Extended workbench“
- Building blocks / Libraries
- Software consulting

- AnyLogic
- AnyLogistix
- SimAssist
- SimVSM

Customer Projects



... and many more!

Research Projects



Digital twin for e-mobility transformation in municipal vehicle fleets



Simulation-based, assistance system-based engineering and maintenance services for Lean Aftersales Services.



An innovation and lighthouse project for the digital industry co-financed by the EU



Digital twin for the control and monitoring of manufacturing systems with the help of ICT-based systems.

SimCityNet

Digital Twin for E-Mobility Transformation in
Municipal Vehicle Fleets

Climate effects

- Electrifying large vehicles can lead to reduced air pollution and traffic noises, especially in urban cities

Economical aspects

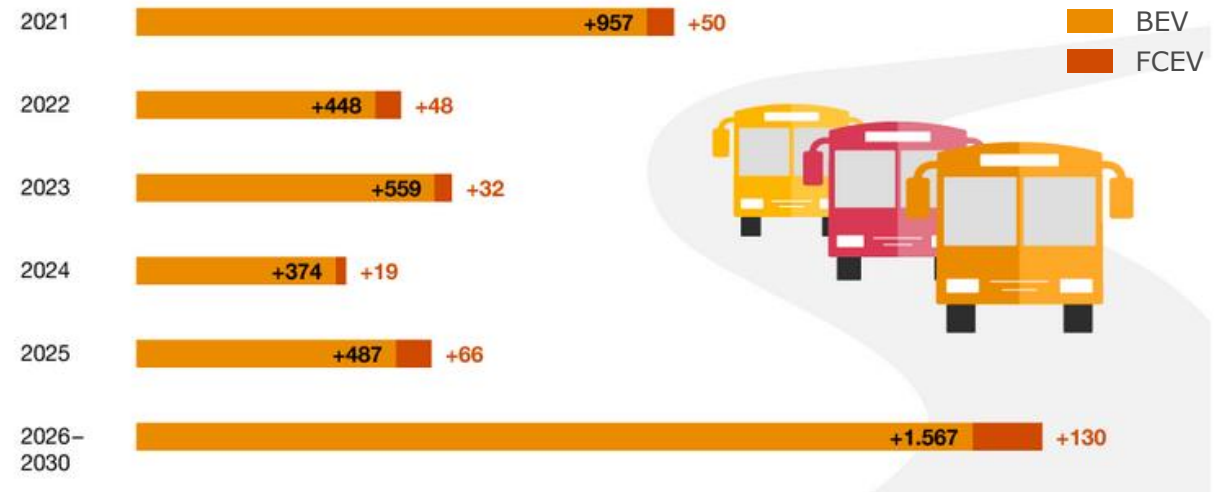
- Higher investment costs vs. lower operational costs in the long run

Regulation

- **Clean Vehicle Directive in Germany**

The Clean Vehicle Directive (CVD), precisely known under the denomination **2019/1161 EU**, provides for quota of low and zero emission buses that must be observed in public transport bus procurement. In Germany and Western European countries, 45 % of buses purchased by 31 December 2025 must be low-emissions. And half of them (22.5%) must be zero emissions. Then, from 2026 to 2030, the quotas grow to 65% and 32,5% respectively.

Planned procurement of electric buses



Source: PwC „E-Bus-Radar 2021“

- Create digital models (simulation) to assess alternative vehicle mixes (on a global scale)
 - BEV (battery electric vehicles)
 - FCEV (fuel cell electric vehicles)
- Assess impact on number of required vehicles
- Assess impact on infrastructure (charging, refueling)
- Assess operational consequences
 - Will schedules or lines have to be adapted (HSB)?
 - Can waste collection tours still be served (HIS)?
 - Which vehicle type is suitable for which tour?



HSB

- Public transport carrier in Hanau
- Fleet: 65 diesel-fueled buses
- 13 bus lines, 166 bus stops
- >100 km network



HIS

- Waste collection operator in Hanau
- Fleet: 16 garbage collection trucks
- 4 different waste types

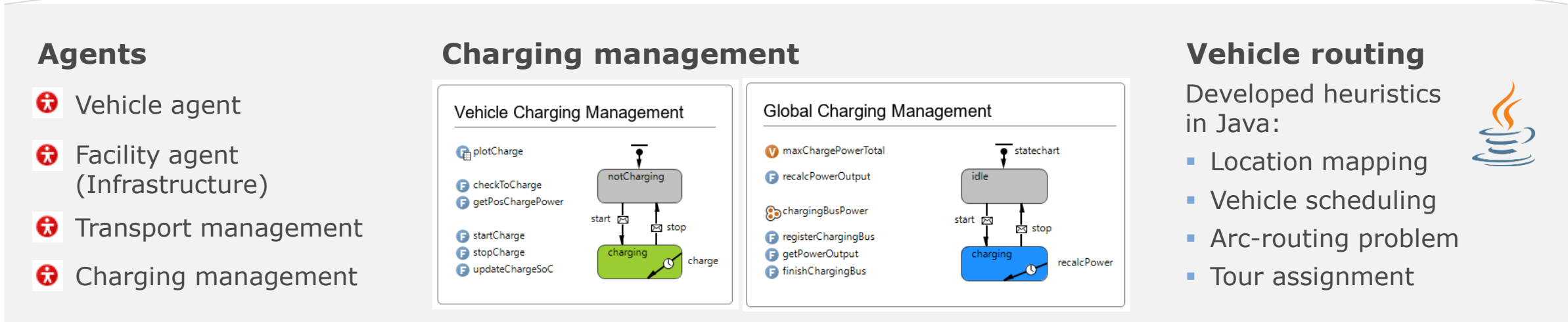
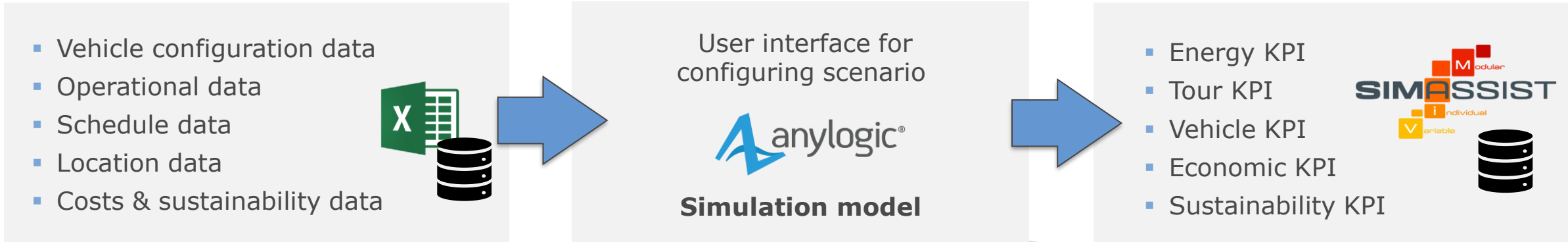


Range limitations

- 100% EV fleet has limited range in comparison to current diesel-fueled fleet
 - Diesel-fueled bus: 500 km
 - BEV bus: 150 – 300 km
 - FCEV bus: 350 km
- Current tour distance exceeds EV range
 - Vehicle scheduling & routing need to be adjusted based on available fleet range

Charging process

- Non-linear charging speed, influenced by:
 - Limited charge power available for charging compound
 - Limited charge power for each charging station
 - Effective charge power depends on vehicle SoC (state of charge)



Modeling waste collection tour as arc routing problem (ARP)

- Solution using construction heuristics and improvement heuristics

Waste container handling

- One-sided (right-hand side) vs. two-sided waste collection
- **Solution:** Distance matrix
Waste volume matrix
Operability matrix

One-way street

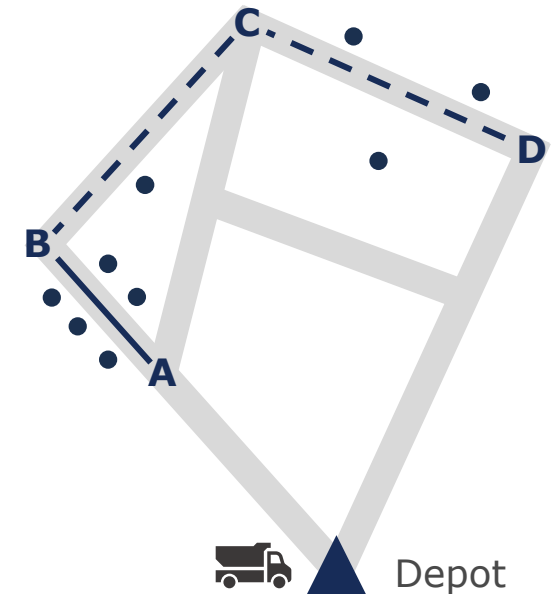
- Only two-sided waste collection applicable
- No information, whether a street is one-way street
- **Solution:** Detect one-way street using distance calculation

Avoid U-turn

- Large vehicle cannot and should not do a U-turn at a junction
- **Solution:** If $a \rightarrow b \rightarrow c$, then $a \neq c$

Waste container location

- Waste container not directly located on a street
- **Solution:** Projecting waste container location to the nearest street based on latitude & longitude data



Model configuration

SimCityNet
Digitaler Zwilling zur Konzeption und Bewertung von E-Fahrzeugen in kommunalen Flotten

Step 1: Scenario definition

Scenario choice: Current Future

Simulation start date: 21 9 2020

Vehicle types: (future scenario)
 Diesel
 BEV
 FCEV

Next

Logos: Hanauer Infrastruktur Service, HSB, HWG, FRANKFURT UNIVERSITY OF APPLIED SCIENCES

Model run

SimCityNet: HSB
Monday, 07:00:00

Menu

Show: Tour Journey

Bus: GL-689
Start: FHPL:C3
End: FH KA:1

Legend: Diesel (red), BEV (green), FCEV (blue)

Show state of charge
 Show range
 Show energy type

Logos: Hanauer Infrastruktur Service, HSB, HWG, FRANKFURT UNIVERSITY OF APPLIED SCIENCES, SIMPLAN

SimCityNet

Digitaler Zwilling zur Konzeption und Bewertung von E-Fahrzeugen in kommunalen Flotten

Step 1: Scenario definition

Scenario choice: Current ⓘ Future

Vehicle types: (future scenario) Diesel BEV FCEV

Simulation start date: ⓘ

Next

Hanauer Infrastruktur Service | **HSB** Hanauer Straßenbahn GmbH | Hanau Wirtschaftsförderung GmbH | FRANKFURT UNIVERSITY OF APPLIED SCIENCES

Foto: HSB



Model Demo - HSB



Menu **SimCityNet: HSB** **Monday, 06:30:26**

Hanau

St. Vinzenz Krankenhaus
Westbahnhof
K 965
B 45
Klinikum
Friedrich-Ebert-Anlage
L 3309
B 43
L 3193
B 43a
WOLFGANG
L 3193
B 43
Hauptbahnhof
L 3309
B 43

Hanauer Infrastruktur Service
HSB
HWG
FRANKFURT UNIVERSITY OF APPLIED SCIENCES
SIMPLAN

Running



Model configuration

SimCityNet Digitaler Zwilling zur Konzeption und Bewertung von E-Fahrzeugen in kommunalen Flotten

Step 1: Scenario definition

Scenario choice: Current Future

Vehicle types: Diesel BEV FCEV

Next

Logos: HS Hanauer Infrastruktur Service, HSB Hanauer Straßenbahn GmbH, HWG Hanau Wirtschaftsförderung GmbH, FRANKFURT UNIVERSITY OF APPLIED SCIENCES, SIMPLAN

Model run

SimCityNet: HIS Monday, 06:10:00

Map showing vehicle locations and routes in the Hanau area.

Legend: Diesel (red), BEV (green), FCEV (blue)

Options: Show state of charge, Show range, Show energy type

Waste type: Paper, Glass, Plastic, Food

Week: 1 2 3 4

Weekday: M T W T F

Map labels: HOCHSTADT, Maintal, DÖRNIGHEIM, jhlheim in Main, Markwald, Lämmerspiel, Klein-Adheim, GROSSADHEIM, Großkrotzenburg, Alze

Logos: HS Hanauer Infrastruktur Service, HSB Hanauer Straßenbahn GmbH, HWG Hanau Wirtschaftsförderung GmbH, FRANKFURT UNIVERSITY OF APPLIED SCIENCES, SIMPLAN

Model Demo - HIS



☰ Menu SimCityNet: HIS GENDIEBACH Monday, 06:00:00

The screenshot displays a simulation of the Hanau region. The map features a network of roads, including major highways (A 45, A 66) and local roads (B 43, B 45, B 45a, K 854, K 857, K 859, K 191, K 872, K 900). Several urban areas are visible, such as Erlensee, RÜCKINGEN, Niederrodenbach, Oberrodenbach, KESSELSTADT, DIETESHEIM, LÄMMERSPIEL, and KLEIN-AUHEIM. A river flows through the center of the map. The simulation shows traffic flow and various infrastructure elements like buildings and green spaces. A red 3D building icon is visible in the upper right quadrant. The interface includes a 'Menu' button on the top left and a 'Paused' status indicator on the bottom right. A zoom level of 'x10' is shown in the bottom left corner.

© OpenStreetMap contributors

Hanauer Infrastruktur Service | HSB | HWG | FRANKFURT UNIVERSITY OF APPLIED SCIENCES | SIMPLAN

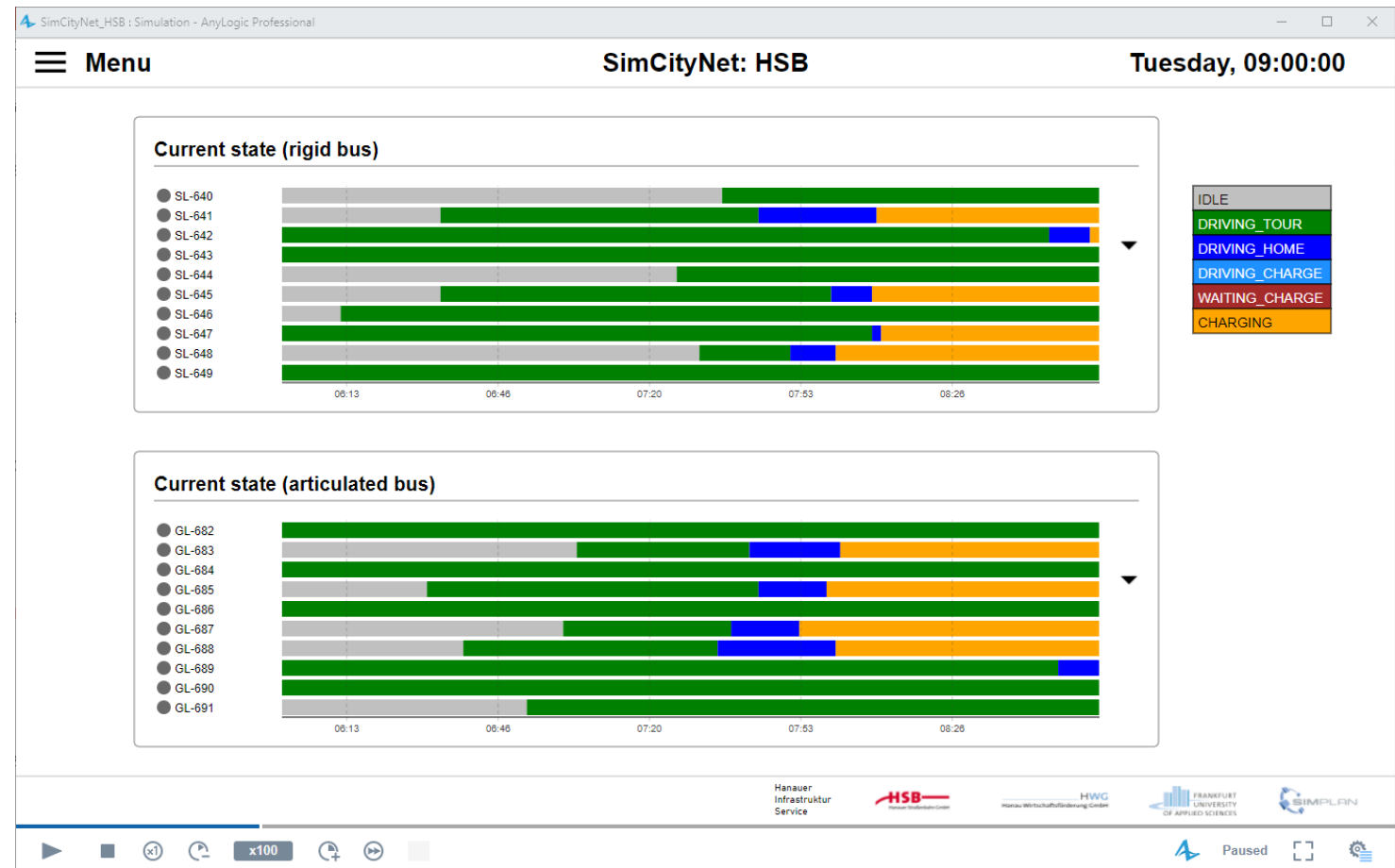
Paused



KPI Visualization in AnyLogic

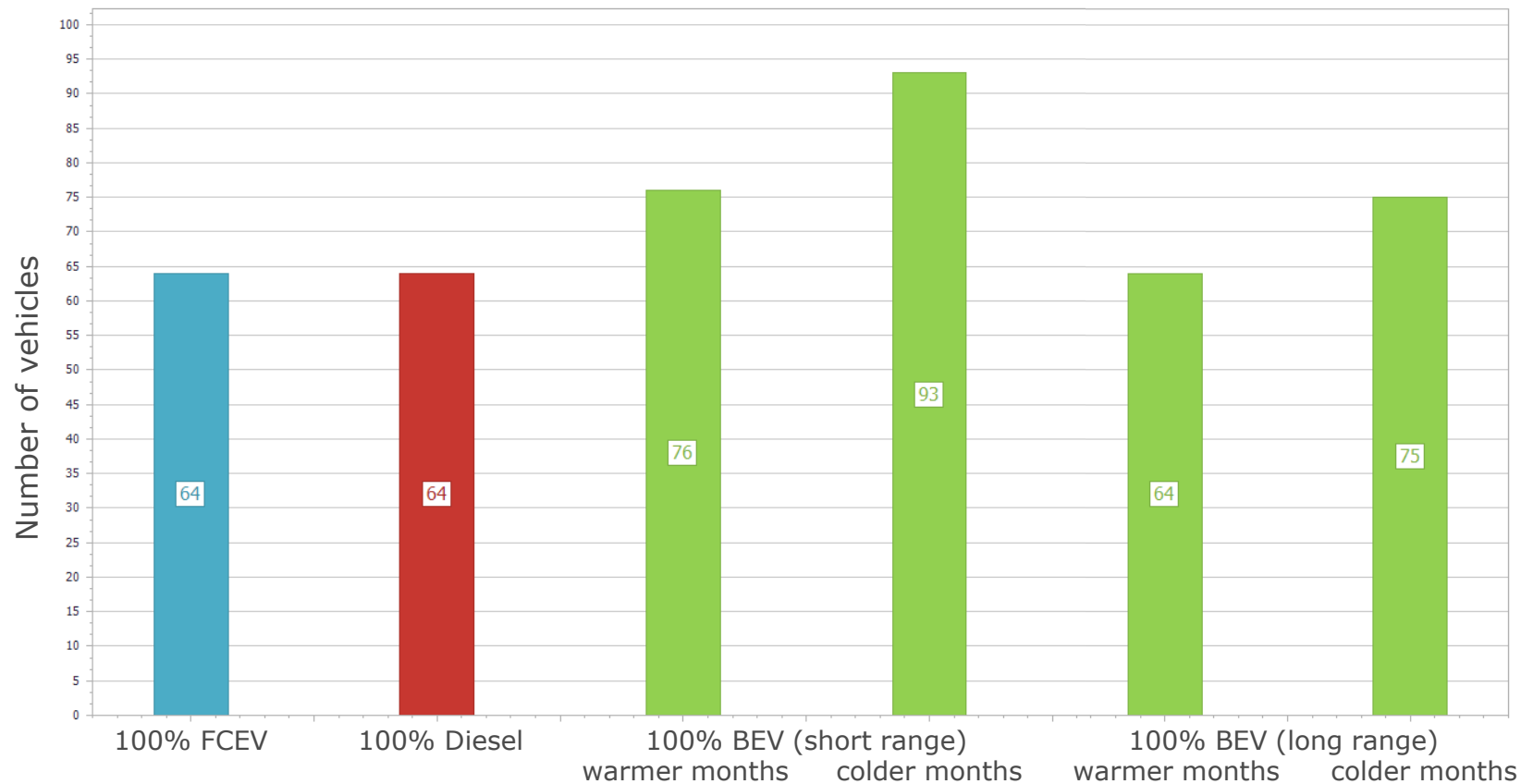
Mixture of high-level and low-level of details:

- Fleet utilization
- Current vehicle state
- Vehicle assignment
- Tour duration
- Tour distance
- Required energy amount
- etc.



Data Export & Analysis

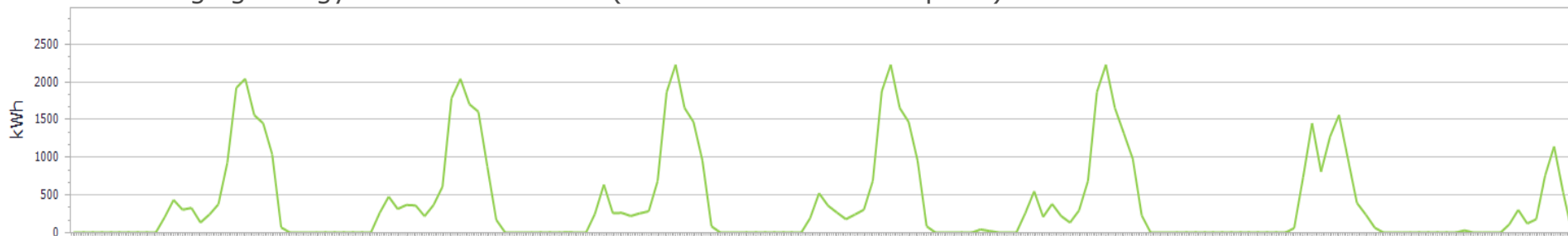
- Export detailed information to Excel and SQLite DB
- Evaluate results and compare different scenarios using our own-developed tool (SimAssist)



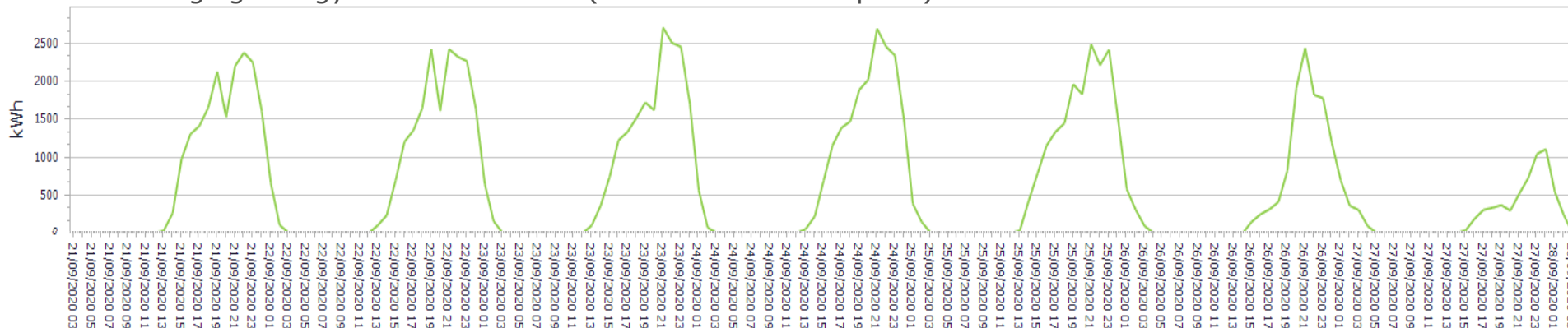
Data Export & Analysis

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BEV charging energy in warmer months (without added consumption)



BEV charging energy in colder months (with added consumption)



Conclusion:

- Simulation models are the means to forecast the requirement of a large-scale application of EV fleet and assess the impact in daily operation
- Modeling approach can also be applied to support the e-mobility transformation of municipal vehicle fleets in other regions

Possible further development:

- Opportunity charging instead of overnight charging
- Autonomous vehicles, on-demand tours

Finally:

- Develop simulation model as digital twin to be used in daily operational process

SERVICE

SOLUTIONS

SOFTWARE

SUPPORT

Thank you for your attention!



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