AVL Energy Simulation

…from decision-grade simulation to operable energy systems

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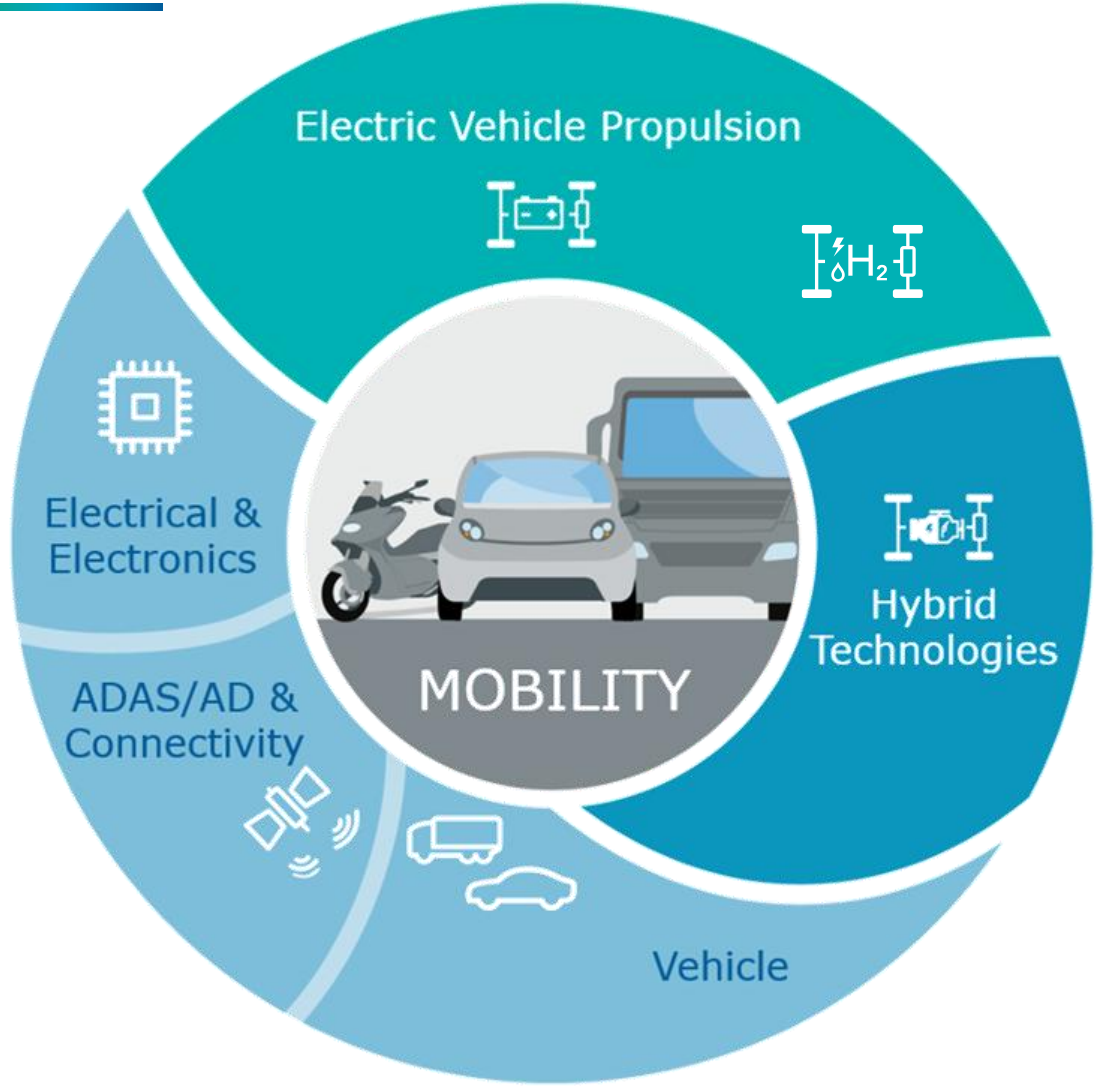
EnInnov Graz | 11.-13.02.2026

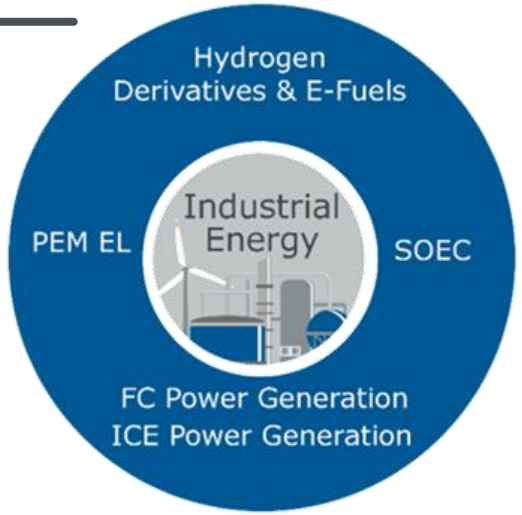
AVL List GmbH

Motivation

~~Future~~ Energy System

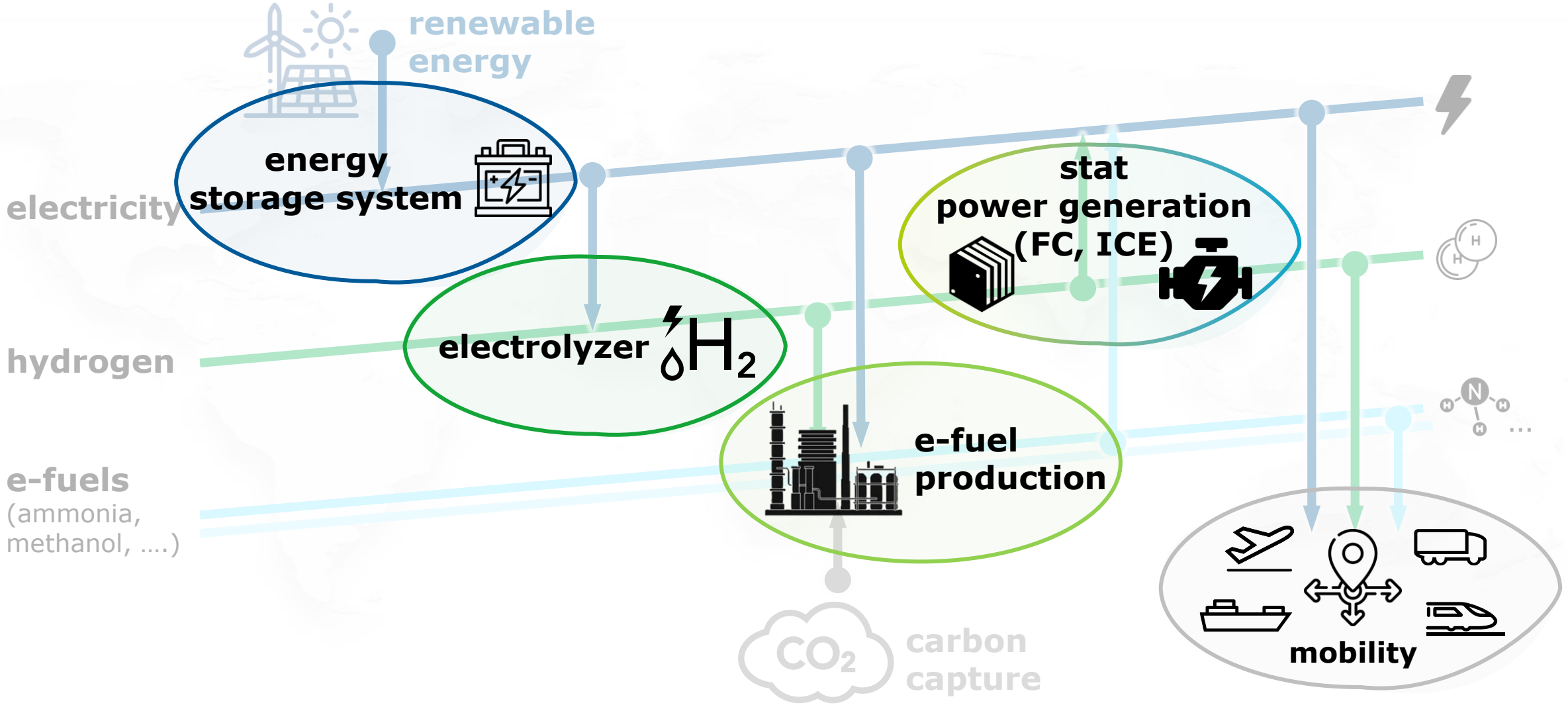
AVL Future Business and Focus Areas





CCS - Carbon Capture Storage
DAC - Direct Air Capture
ESS - Energy Storage System
FC - Fuel Cell
ICE - Internal Combustion Engine

AVL Energy Focus Areas



AVL Smart Grid Engineering

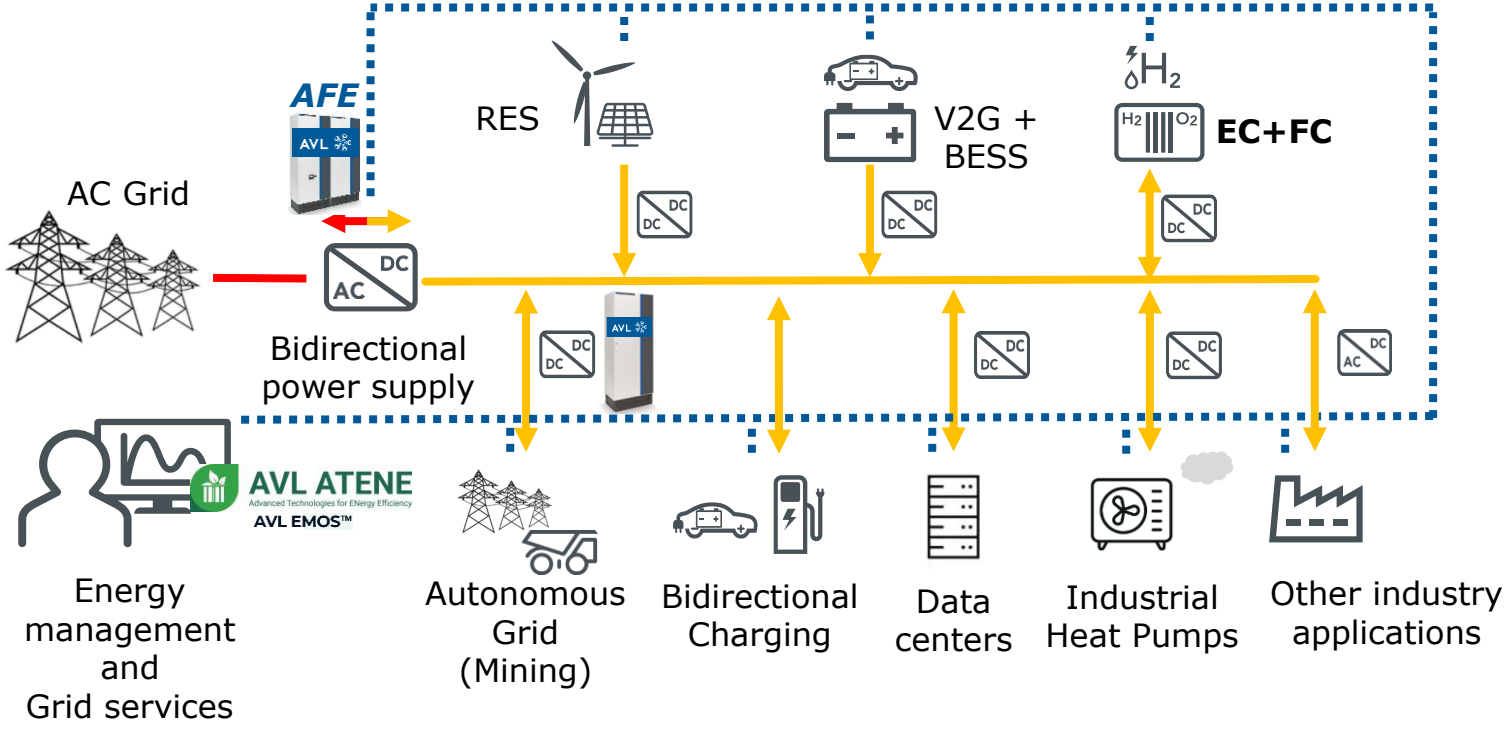
Example: Smart open DC grid for sustainable industries

1 **System architecture & safety**

2 **Model-based simulation**

3 **Energy Management**

4 **Control & protection design**



Smart Grid Obstacles – Why can’t Rome be built in a day?

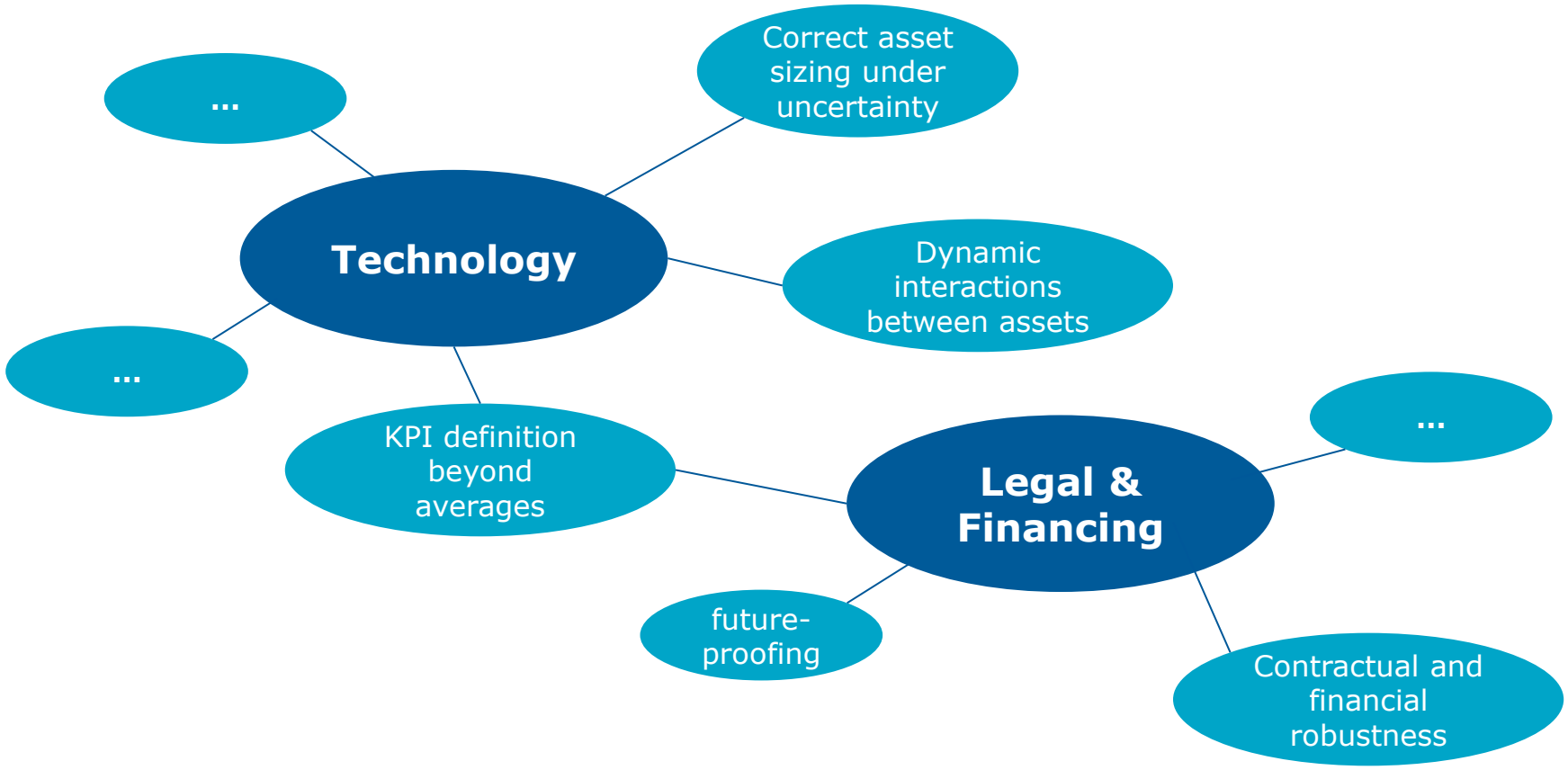
? Projectability

? Tendering eligibility

? Contractual readiness

? Investment security

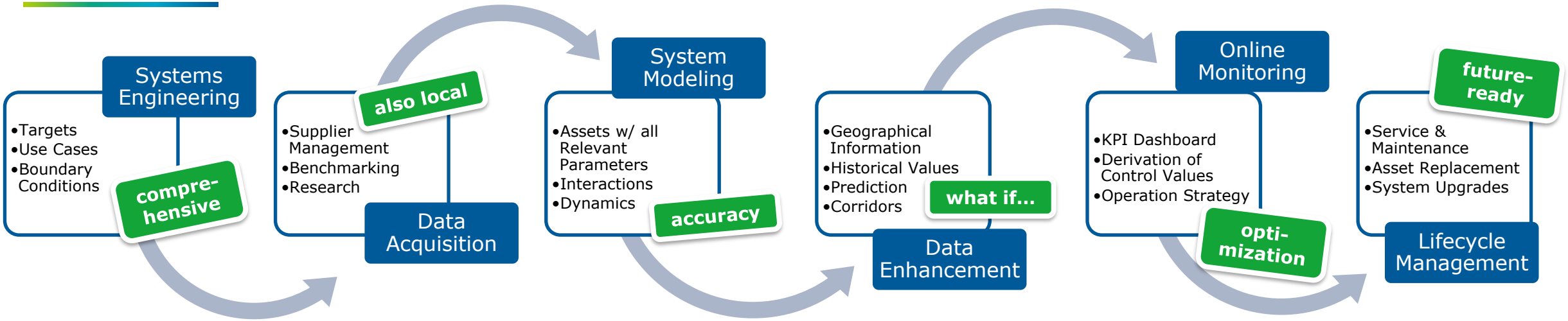
? …



The problem is not lack of ambition – but lack of decision-grade foundations.

Solution: **Systems Engineering** and **Simulation** as key enablers

from Planning to Operation – based on Expertise/Experience

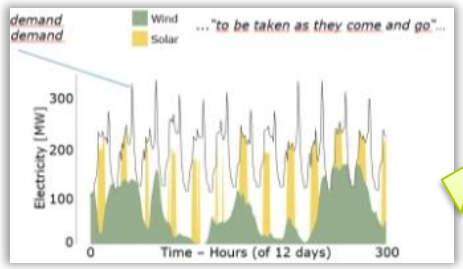


- Scalable Approach
  - a) SW License & Support
  - b) Systems/RQ-Engineering and/or Modeling as a Service (includes elicitation and maintenance of data)
  - c) Full Support for Individual System Life Cycle Phases as well as Across System Generations

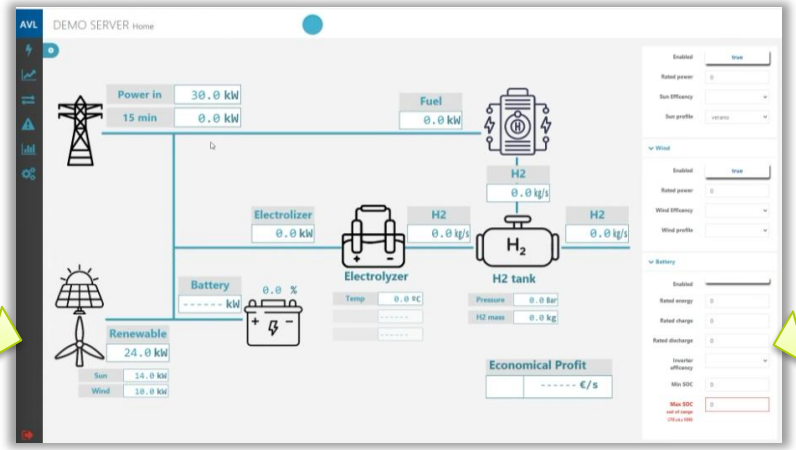
➔ Applied with right-sized systems-engineering principles from industrial series development

Multi-Objective Energy Simulation

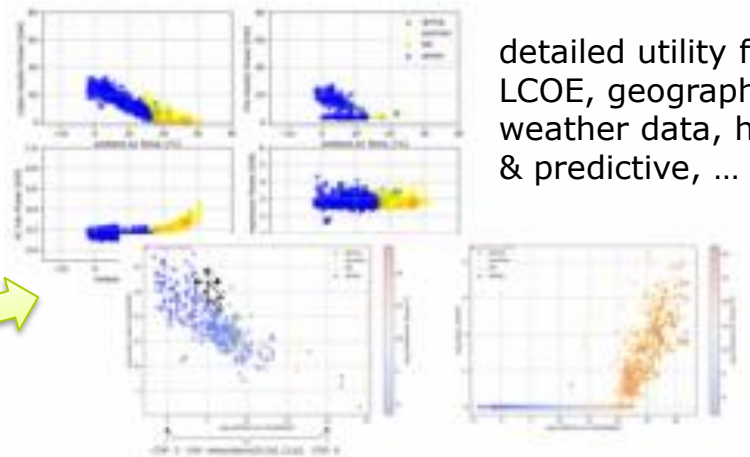
- Understanding **Supply & Demand** → ready for Projecting
- Adequate **Specification** of Energy System Components → ready for Tenders („automotive grade“)
- **Simulation/Prediction** w/ Historic and day-ahead Data → ready for Investment/Amortisation
- Online **Monitoring & Optimization** of Operation Strategy → ready for best TCO/LCOE
- Predictive **Maintenance and Service** Planning → ready for Lifetime Support and Upgrades



Fluctuating Supply & Demand



Energy Modeling & Simulation



detailed utility factors, LCOE, geographical weather data, historical & predictive, …

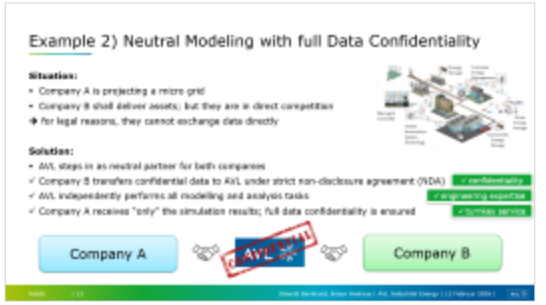
Optimization of System & TCO

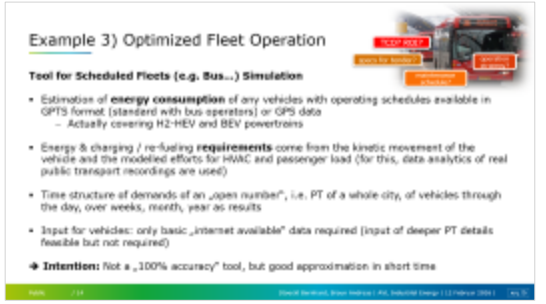
Application Examples

1. **Logistics centers** energy system (dm, Post)
   → Optimal asset specs, avoided misinvestment
   → Reduction of operational costs

2. **Neutral modelling** between partners with full data confidentiality

3. Optimized **Fleet Integration**



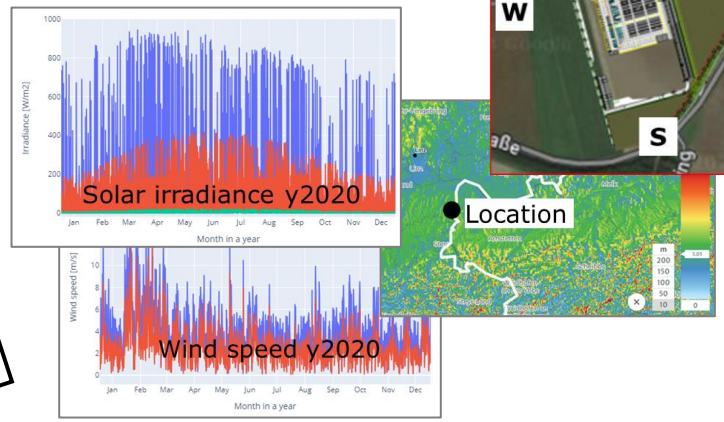


Example 1) Energy System for a Logistics Centre

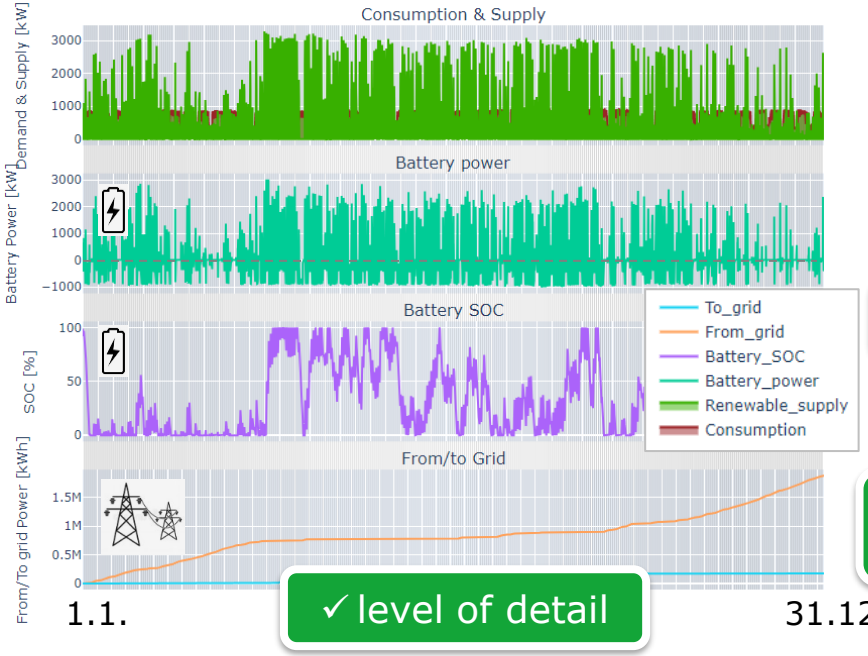
Supportive Collaboration New Large Logistic Centre

- Assessment of viability of energy concepts been offered by Third's
- Successfully prevented mis-investment in wrong/oversized addt'l asset
- Tradeoff investigation for energy & cost: prosuming vs. selling to e-trucks vs. adding co-generation elements

Input*:
- Plans of facility
- Local geo & legal bounds



Approach: Full „example year driven" hourly simulation of all cases



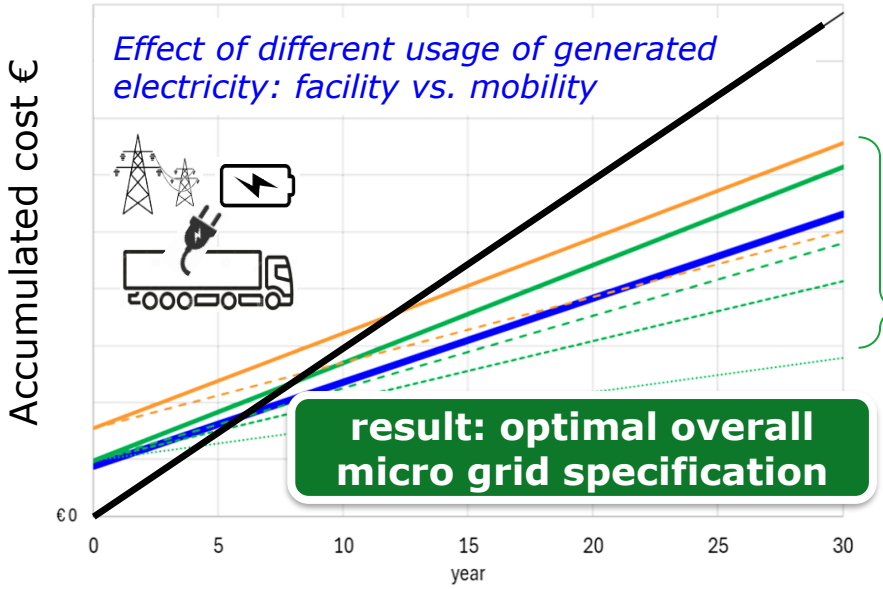
✓ level of detail

✓ corridors

✓ what if…

✓ multi technology

Amortisation over the years (CAPEX, OPEX)



Traditional approach

Reduction…

Building PV&Storage (w/o e-trucks)

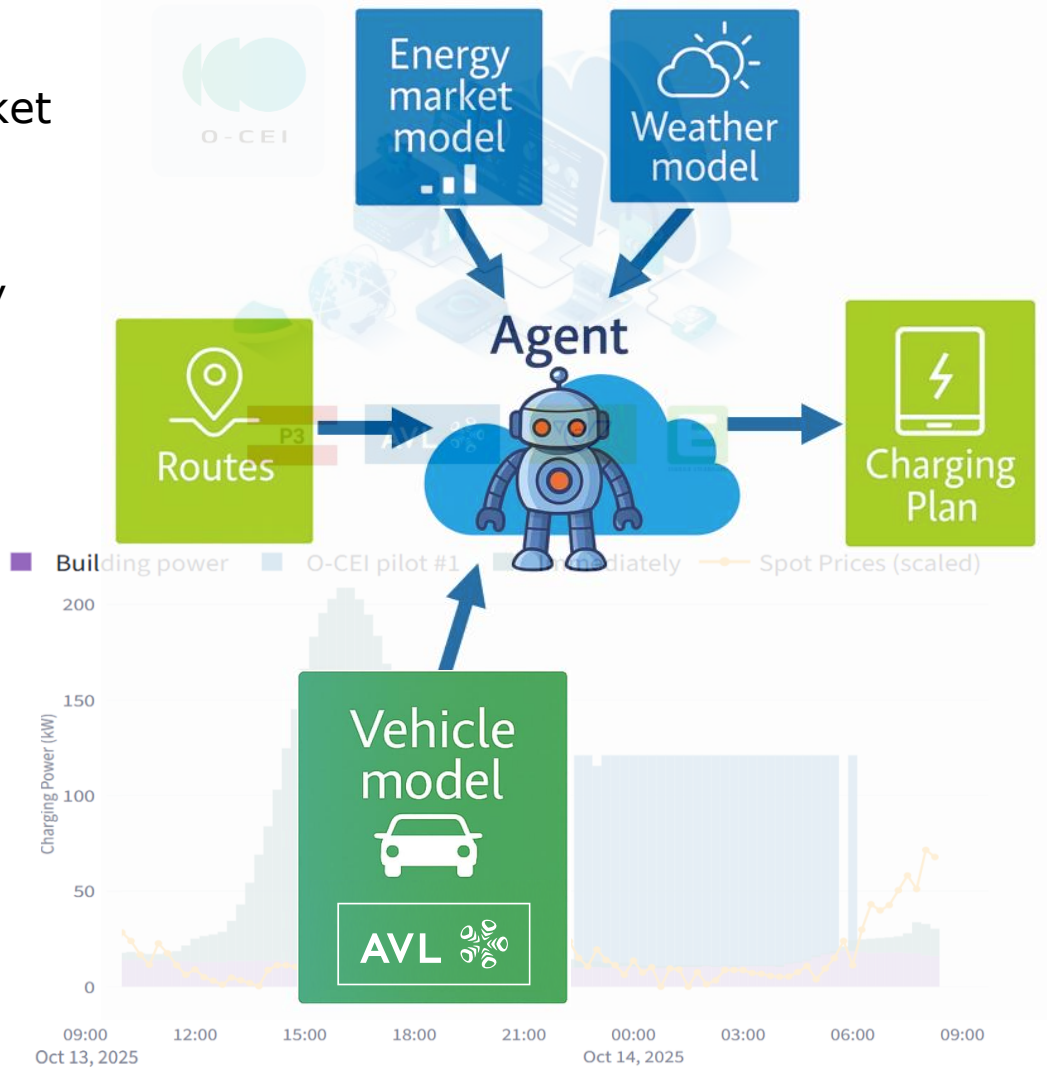
„what if…"

…incl. E-trucks, different ct/kWh pricing models #1-4

…incl. additional biomass CHP (price model #1 & 2)

Machine Learning Based Energy and Fleet Management

- Optimized charging schedules based on **dynamic** spot market energy **prices**
- Integration of **local energy assets** like PV and local energy storage
- V2B, V2V, and V2G to **maximize** cost savings
- Training of **Machine Learning-based Intelligent Agents** with accurate vehicle models



Calculated average savings:

➢ **€1 per 20 kWh** charge at this location.

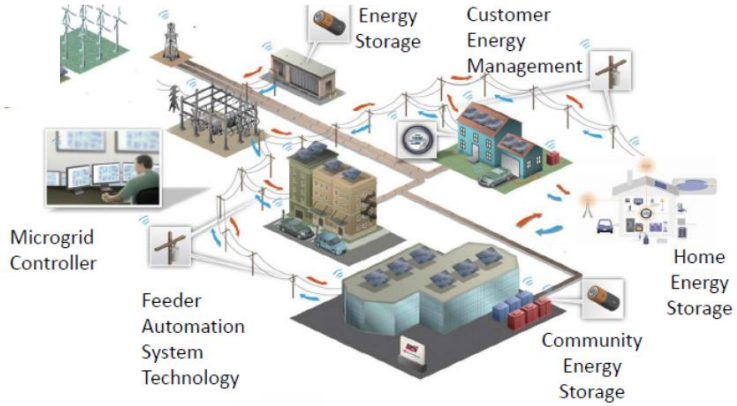
Estimated savings for a fleet of 2.000 vehicles (different locations): **€100.000 – €300.000 per year**.

Example 2) Neutral Modeling with full Data Confidentiality

Situation:

- Company A is projecting a micro grid
- Company B shall deliver assets; but they are in direct competition

➔ for legal reasons, they cannot exchange data directly



Solution:

- AVL steps in as neutral partner for both companies

✓ Company B transfers confidential data to AVL under strict non-disclosure agreement (NDA) ✓confidentiality

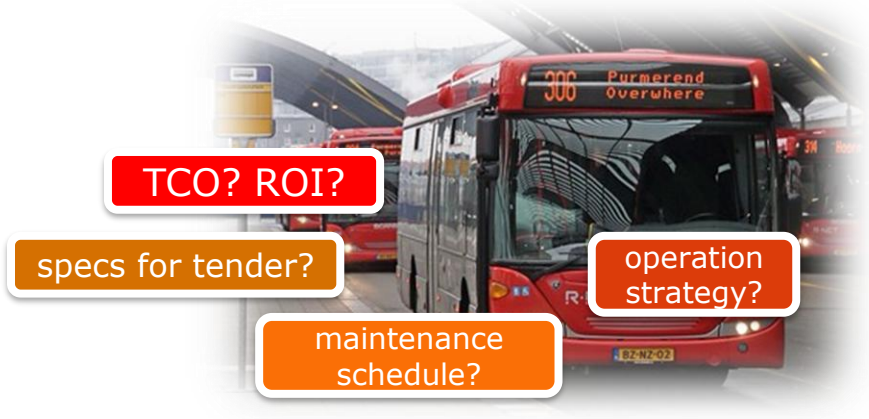
✓ AVL independently performs all modelling and analysis tasks ✓engineering expertise

✓ Company A receives "only" the simulation results; full data confidentiality is ensured ✓turnkey service

Company A

Company B

Example 3) Optimized Fleet Operation



Tool for Scheduled Fleets (e.g. Bus…) Simulation

- Estimation of **energy consumption** of any vehicles with operating schedules available in GPTS format (standard with bus operators) or GPS data
  - Actually covering H2-HEV and BEV powertrains

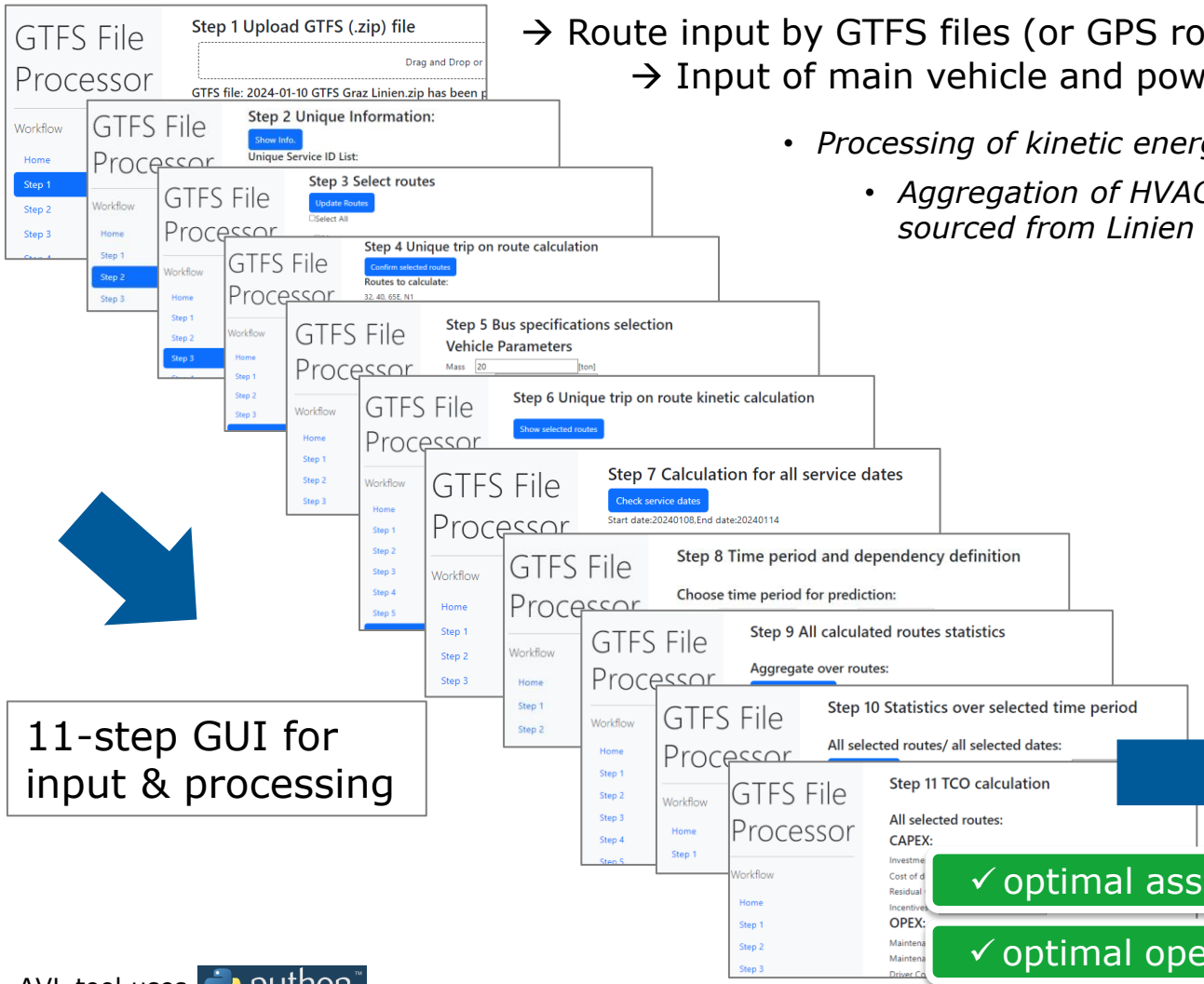
- Energy & charging / re-fueling **requirements** come from the kinetic movement of the vehicle and the modelled efforts for HVAC and passenger load (for this, data analytics of real public transport recordings are used)

- Time structure of demands of an „open number", i.e. PT of a whole city, of vehicles through the day, over weeks, month, year as results

- Input for vehicles: only basic „internet available" data required (input of deeper PT details feasible but not required)

➔ **Intention:** Not a „100% accuracy" tool, but good approximation in short time

Tool for Scheduled Fleets (e.g. Bus…) Simulation Kinetic and HVAC related Consumption, GUI & Postprocessing

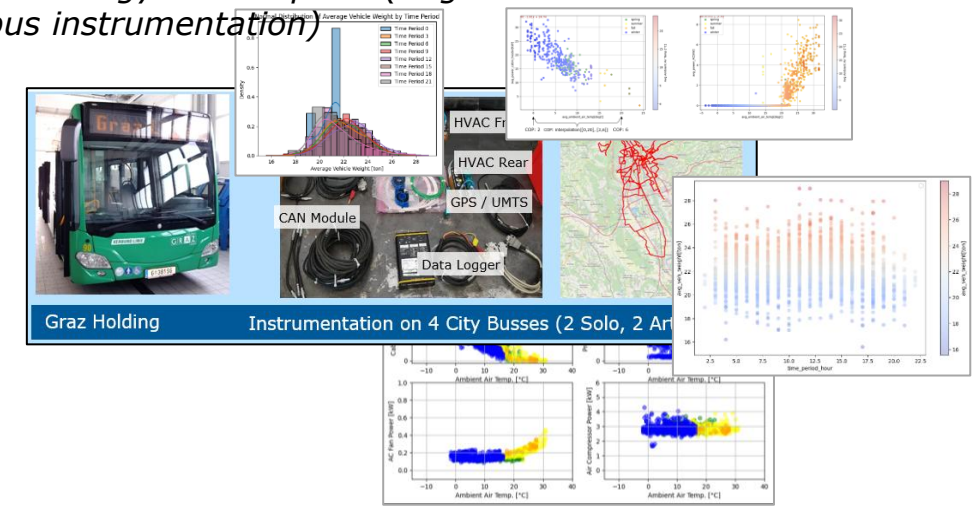


11-step GUI for input & processing

→ Route input by GTFS files (or GPS routing data)

→ Input of main vehicle and powertrain characteristic (catalog data, all relevant PT's)

- *Processing of kinetic energy consumption (using links for ambient, geo and traffic data)*
  - *Aggregation of HVAC-related energy consumption (large in-service data sourced from Linien Graz bus instrumentation)*



→ Simulation process & results

✓optimal asset specification

✓optimal operation strategy

✓optimal TCO over lifetime

AVL tool uses python™

Key Takeaways

- ➔ Energy transition is a societal challenge
- ➔ Simulation as key enabler
- ➔ Modeling and optimization require expertise
  - Integrated energy systems require solid, physics-based foundations
  - Thus, micro grid simulation enables projectability and bankability
  - Systems engineering principles – applied pragmatically – ensure robustness and reliability

Thank you!

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