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CONNECTA

Technical Assistance for the Deployment of Smart and Sustainable Mobility in the Western Balkans

Component 2: Development of a strategic framework for the deployment of e-charging infrastructure in the Western Balkans

Methodological approach: Capacity and locations for e-charging

CONNECTA-TRA-CRM-REG-MOB-07

Workshop No. 2

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www.connecta-info.eu

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Contents

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Introductory Facts

- Sustainability in transport is a requirement in the modern era.
- Need to …

  …**drastically reduce** GHG emissions and pollutants in the WB.

  …**disengage** from costly (imported) fossil fuel in the transportation sector.
- Electric vehicles ("EV"s) promoted worldwide as a sustainable alternative
- Anticipated **rapid increase** in EV ownership and usage in the next decade.
- Ambitious EV penetration targets in Europe and the WB.

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Introductory Facts

However…

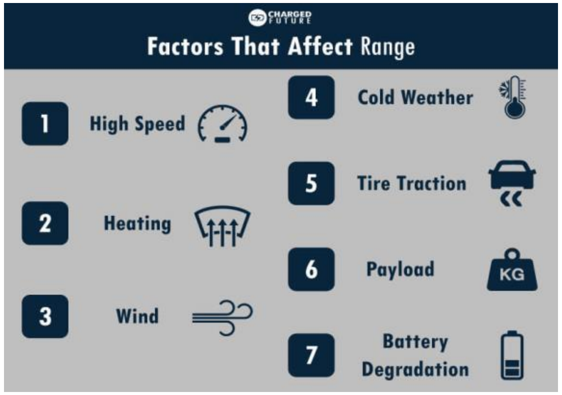
- EV technology is still not 100% mature…
- EV power consumption highly dependent upon several factors.
- Despite technology improvements, "range" is still an issue.
- Unlike fossil fuel refueling, recharging takes time…

Efficient charger location planning for…

✓ ensuring proper EV circulation.

✓ persuading people in adopting EV technologies.

✓ obtaining travel time savings.



Source: Charged Future

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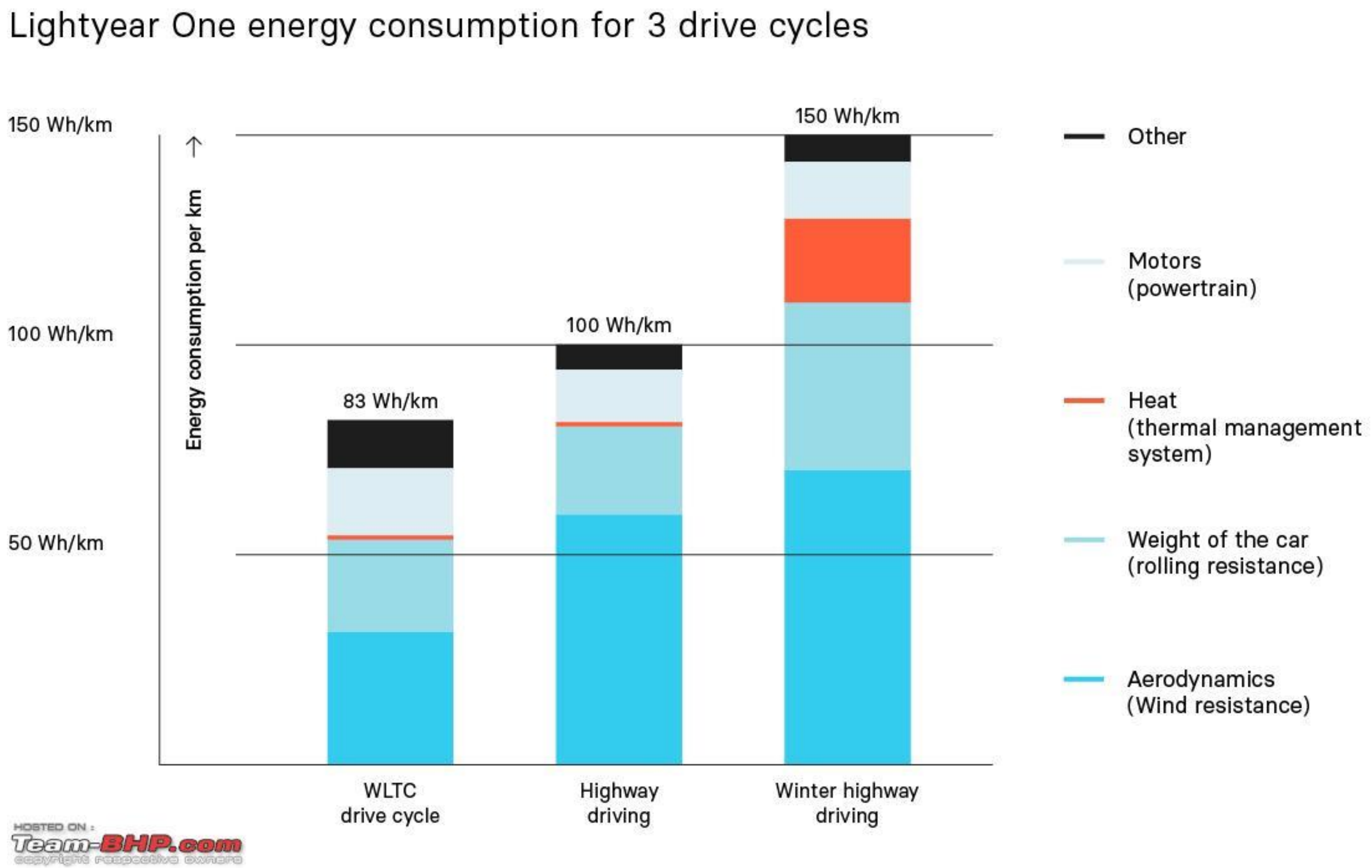
Introductory Facts



Source: Lightyear One

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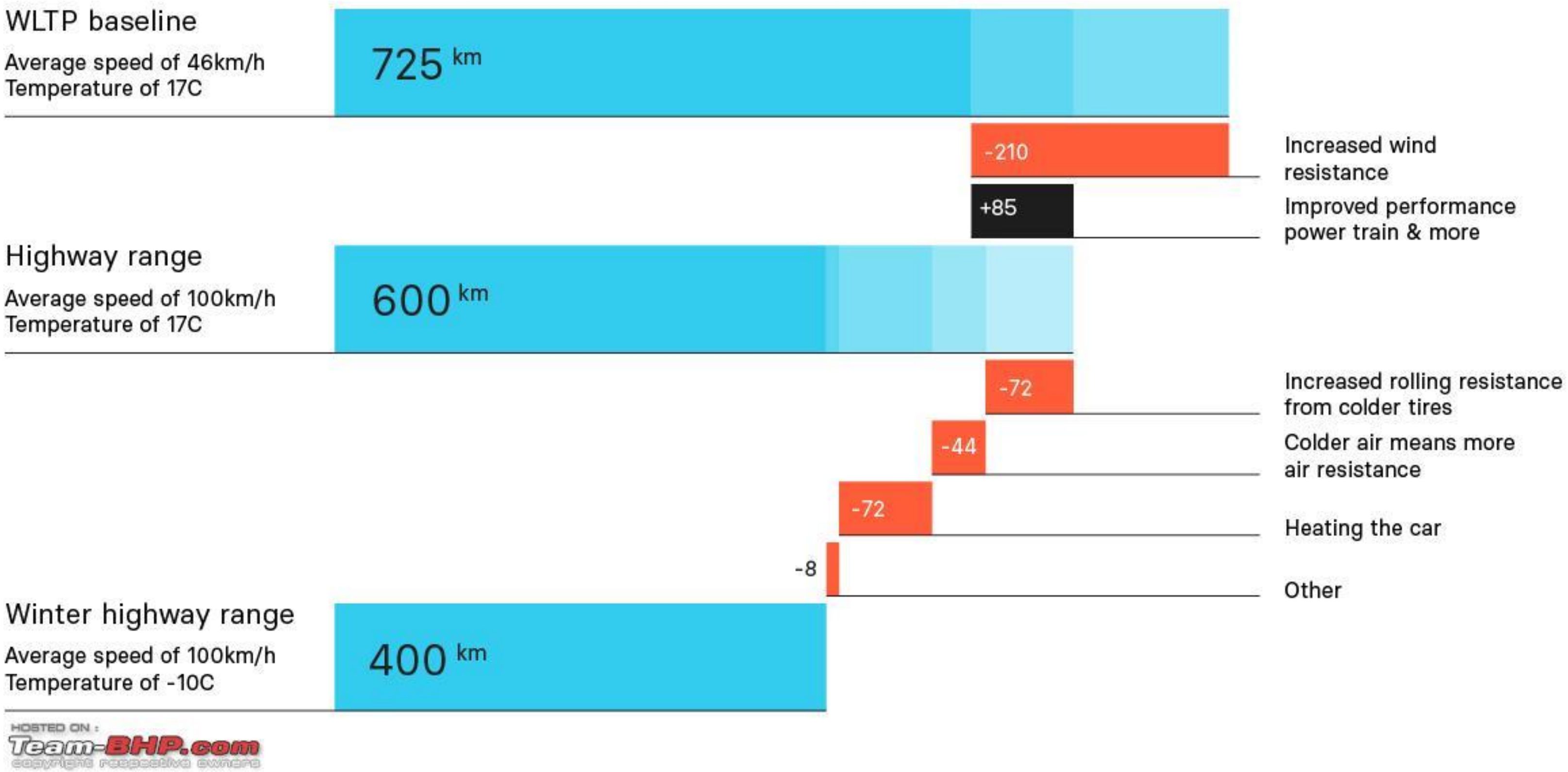
Introductory Facts

Figure 2 — Lightyear One range under different scenarios



Source: Lightyear One

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Overview

- E-charging station location planning (or placement) affected by several factors.
- Investment costs should be justified – minimized.
- Demand along corridors (and its variation) sets priorities.
- Service in e-charging station should be adequate
  - ✓ Delays for re-charging should be low.
- Range constraints should be considered.
- Electric power availability should be ensured.

A limited number of well-placed e-charging stations can provide adequate coverage to a large network

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Planning Scope, Objectives and Constraints

- **Planning Scope**
  - ✓ Decide upon the **most prominent** e-charging station locations (location – allocation)
  - ✓ **Roughly** estimate number of chargers per e-charging station (sizing)
- **Objectives**
  - ✓ Maximize traffic served by locations (location allocation)
  - ✓ Minimize investment costs (location allocation)
  - ✓ Maximize service quality (sizing)
- **Constraints**
  - ✓ Range
  - ✓ Travel behavior
  - ✓ Power supply availability
  - ✓ Location specific constraints (for example already deployed facilities)

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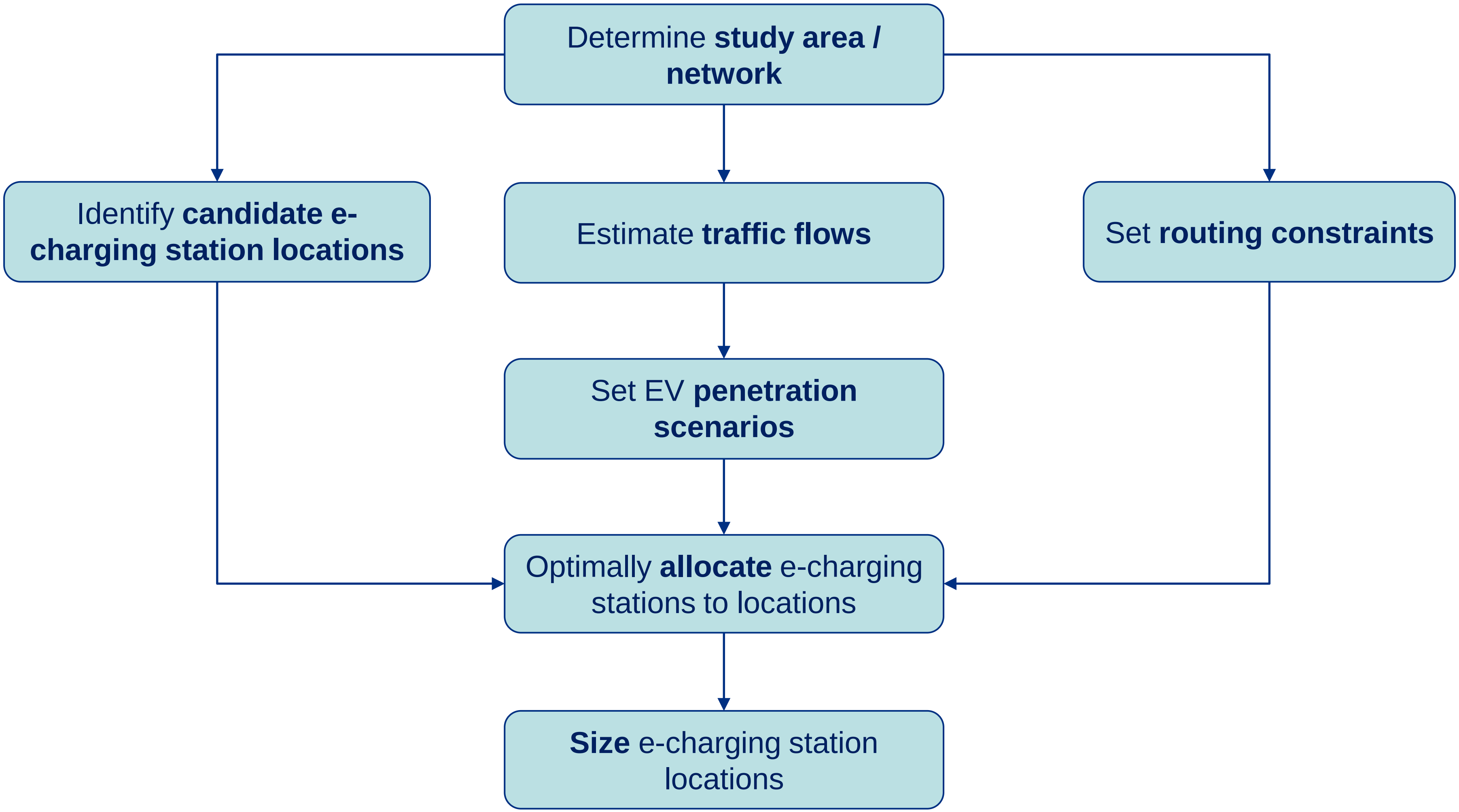
Methodological Framework



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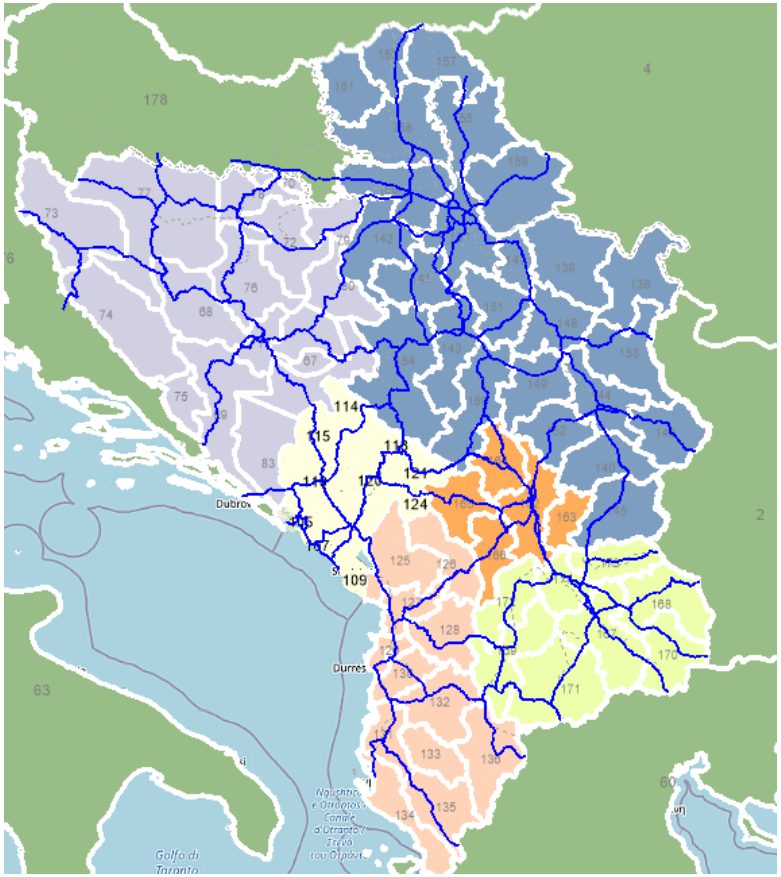
Details: Study Area

- Indicative extension to the TEN-T Core/Comprehensive Road Network to the Western Balkans



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Details: Candidate Charger Locations

Prepare a set of candidate locations for e-charging station placement

In detail:

- Find existing e-charging stations or planned ones
- Identify potential new locations for e-charging stations near the core and comprehensive TEN-T road network
  - Service /rest areas.
  - Gas stations.
  - Intersections / interchanges
  - Other potential locations (e.g. parking facilities in neighboring urban areas, shopping malls).
- Determine possible power supply constraints (if any).
- Identify possible space constraints in locations (where possible).

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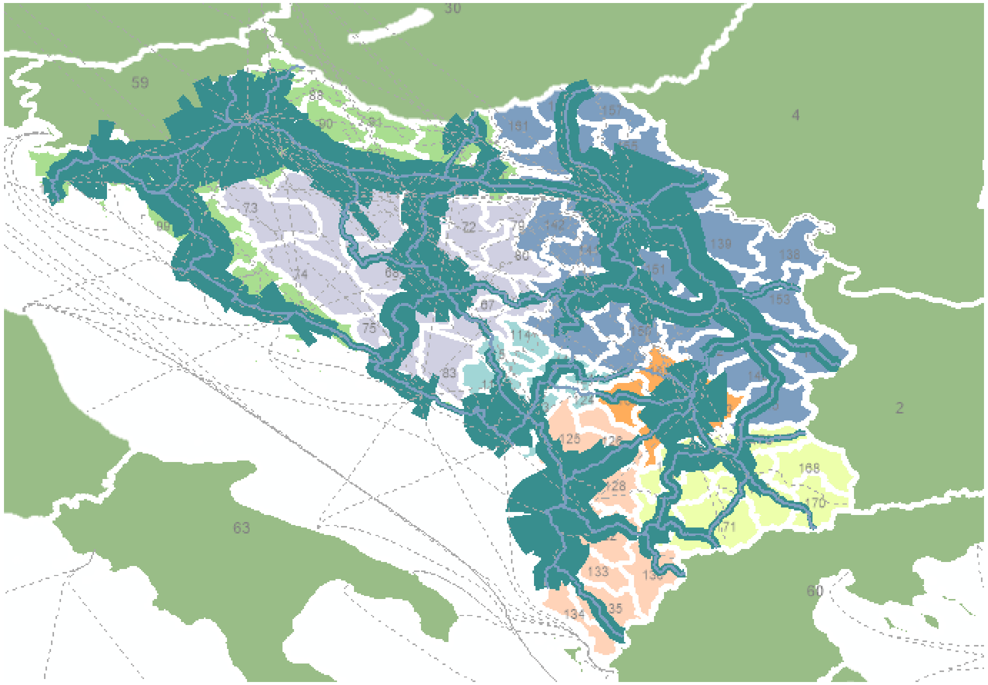
Details: Traffic Flows

Estimate traffic flows along the core and comprehensive TEN-T network

In detail:

- Set target years for traffic flow estimation (2030/2040/2050)
- Use macroscopic traffic model to estimate traffic flows in road segments



Details: Routing Constraints

Determine range constraints in road travel paths between origins and destinations

In detail:

- Assume **maximum EV range** according to the literature
  - (conservative assumption according to prevailing weather conditions)
- Derive **shortest paths** between origins and destinations of the core and comprehensive network (using the transportation model).
  - Shortest path (all-or-nothing assignment) is acceptable for intercity travel as an assumption.
- Identify **needs** (constraints) for intermediate recharging for each paths.

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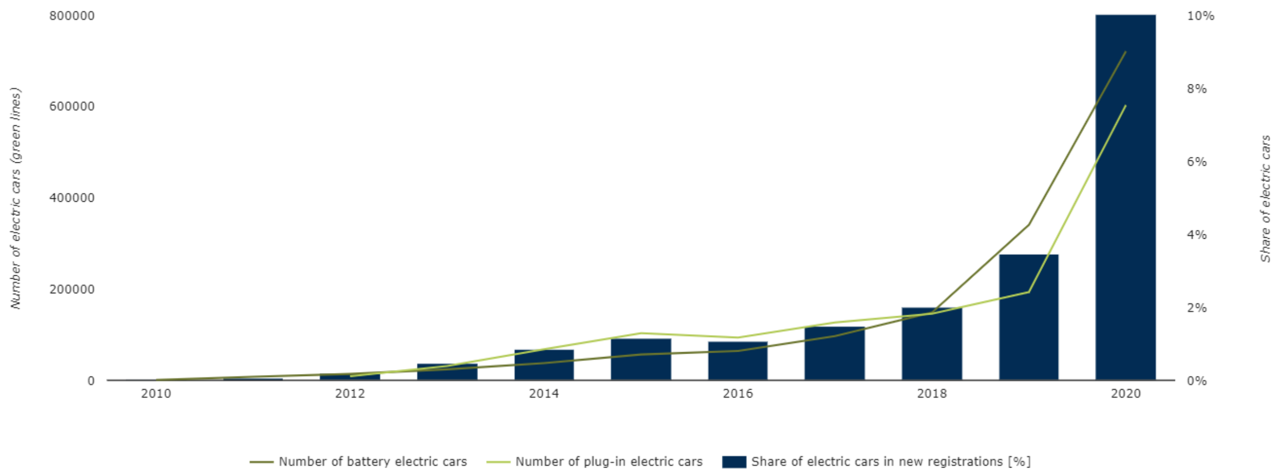
Details: EV Penetration Estimates

Estimate EV penetration in WB

- Follow a scenario planning approach
- Prepare scenarios of future EV penetration (years 2030/2040/2050)
  - **Decarbonization** scenario: According to targets set by the Sustainable and Smart Mobility Strategy to the Western Balkans, endorsed in 2021 by the Ministerial council of the TCT Secretariat'
  - **Do-something** scenario: Estimate an intermediate target.
  - Possibly differentiate by regional partner and out-of-region travel.
- Estimate share of EV flows per road network segment.



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Details: Optimal Location Allocation

Develop and apply location – allocation model

- Develop flow interception integer linear mathematical programming model*
  - **Objective function**: Flow maximization – cost minimization
  - **Constraints:** routes / range, location specific constraints.
- Apply the model for EV penetration scenarios
  - Obtain most prominent locations
- Perform **sensitivity analysis** in critical model parameters

$$\max Z = w_1 \cdot \left\| \sum_{i \in I, j \in \{0,1\}} h_{ij} \cdot x_{ij} \right\| - w_2 \cdot \left\| \sum_{i \in I, j \in \{0,1\}} f(y_{ij}) \cdot x_{ij} \right\|$$

$$x_{ij} \leq y_{ij} \forall \mathrm{i,j}$$

$$c(y_{ij}) \geq a \cdot h_{ij} \forall \mathrm{i,j}$$

$$\sum_{i \in I, j \in \{0,1\}} x_{ij} \leq p$$

$$\sum_{i \in I, j \in \{0,1\}} x_{ij} \geq n$$

$$y_{ij} \leq m \forall \mathrm{i,j}$$

$$s(y_{ij}) \leq S_{ij} \forall \mathrm{i,j}$$

$$x_{ij} \in \{0,1\}, y_{ij} \in N$$

*Konstantinou, T., Kepaptsoglou, K., & Kopelias, P. (2020). Mobile vehicle emission inspection service optimization: a flow intercepting location model and application. *Transportation Planning and Technology*, *43*(2), 174-187.

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Details: Charger Sizing per Location

Roughly determine number of chargers (charging booths) per e-charging station

- Use EV penetration and routing constraints to estimate typical daily demand for charging per location.
- Make assumptions for peak hour (normally 10%) and typical EV battery capacity.
- Identify **possible charger setups** (power supply per charger)
- Estimate **service rates** per charging booth
- Apply **M/M/n queuing theory** and estimate necessary chargers per location.
- Perform sensitivity analysis.

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Conclusions

- E-charging station location planning a complex decision analysis task.
- Two aspects: location allocation and sizing
- Planning objectives: Cost minimization, flow maximization
- Range and routing constraints should be considered
- Decisions highly dependent upon EV penetration scenarios.
- Need for extensive sensitivity analysis to validate results.

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Questions and Discussion

Any comments/suggestions?

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Thank you!

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