Using Electric Vehicles for Commercial Urban Transports

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INFORMS Annual Meeting 2018
DTU Management Engineering
Electro-mobility for Urban Logistics

EUFAL
ELECTRIC URBAN FREIGHT AND LOGISTICS
This project is funded by the European Union

Optimization
Planning
Demo
Trends in Electric Vehicle Adoption

Manufacturing Costs Are—and Are Expected to Continue—Falling

https://www.ucsusa.org/clean-vehicles/electric-vehicles/electric-cars-battery-life-materials-cost#.W8hUemgqy2w
Trends in Electric Vehicle Adoption

Global Electric-Car Revolution Set to Take Off
China set to lead EV market

Gradual integration

- Mixed ICV + EV fleet composition
- Mix of electric vehicles – bikes, tricycles, cars, etc.

Source: Bloomberg New Energy Finance

https://www.weforum.org/agenda/2018/05/china-surge-electric-vehicle-sales/
Research and Implementation - Status

- Review paper on goods distribution with EV’s by Pelletier, Jabali and Laporte (2016):
  - EV’s gaining popularity, mostly within passenger transport (cars)
  - Rather limited experiences with real use of EV’s for goods transport
  - Uncertainties wrt. to cost, driving range, payload, reliability and availability => expected operational costs
  - Deployment of EV’s should not be seen as a measure to cut costs but rather to explore and prepare for the expected future developments
Electro-mobility for Urban Logistics

Electro-mobility – Potential and Challenges

- **Advantages**: Reduces emissions and noise, cheaper operationally
- **Restrictions**: Electric range and recharging time
- **Energy loads**: Kinetic (depending on mass, distance, gradient, acceleration, speed), resistance (rolling friction, drag), **heating or cooling**

Inner-city / Urban logistics - Opportunities

- Short distances between locations
- Incentive to reduce pollution and noise
- Maneuverability of small street vehicles
Case Study: Electrician routing for MT Højgaard

Fleet electrification
- Sustainability vs. business competitiveness
- Driver selection for electric vehicles
- Mixed ICV + EV fleet composition

Features
- Urban logistics
- Compatibility of electrician with customer request
- Spatio-temporal uncertainty of demand occurrence

Questions
- Replace how many ICVs with EVs?
- Total cost of ownership?
- Seasonal variation of operational costs?
- Optimize the mixed fleet operation problem?
Case Study:
Blood Sample Collection for Region Hovedstaden

- Blood sample collection from private physicians
- Temperature control
- Tight time windows
- Fleet mix optimization
- Electric bikes, tricycles, and cars
- Optimized mix for city logistics?
Proposed Framework

- **Strategic level**
  - Fleet mix – distribution of EV’s versus ICV’s

- **Operational level**
  - Distribution planning / Vehicle Routing
MFEVRPTWCC – Operational Problem

MFEVRPTWCC

• Mixed Fleet
• Electric

• Vehicle Routing Problem with
  – Time Windows and
  – Compatibility Constraints
Simulation Problem – Strategic Level

Demand occurrence

Spatio-temporal uncertainty

Energy consumption

Seasonal variation

Driver effect

Created in AnyLogic using OpenStreetMap
Mixed Fleet Composition Problem

Simulation Problem

MFEVRPTWCC

deterministic demands

ALNS

INSTANCE GENERATION

STRATEGIC

DECOMPOSITION

Operational

Strategic
Mixed Fleet Composition (MFC) Problem

\[
\min_{\text{acquiring, \ } T \ \text{routes}} \ (\text{acquisition cost}) + \sum_{t=1}^{T} \mathbb{E}[C_t(\text{route}_t, \omega)]
\]

\[
C_t(\text{route}_t, \omega) = EVRPTWCC_t(\omega),
\]

**Total cost of ownership - TCO**

- Purchase
- Maintenance and fuel
- “Green cost”
Potential next steps for determining MFC

Scenario Decomposition  Multi-objective optimization  Integrated approach
Thank you!