Disruptive Innovations for Sustainable Freight Transport

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7% of global GHG emissions caused by logistics

75% of transportations via road

20% of trucks are driving empty around Europe

50% average truck load

Transport increase through:
- E-commerce
- Individualized small scale deliveries
- Economic growth

To reach 2°C scenario by 2050, global transport emissions need to be reduced by 20%

For 1.5°C, 70% reduction

New technologies and business model innovations are needed to decrease global GHG emissions

Stern (2008); European Environmental Agency (2001); Kersten et al. (2017); European Union (2017)
Multi-rounded real-time Delphi method

Innovation selection based on pre-survey and literature review

(1) Assessment
(2) Real-time feedback
(3) Possibility for re-assessment

Expert - Pool

Start

Analysis of quantitative and qualitative results

End

t = 6 weeks

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## Surveyed innovations

<table>
<thead>
<tr>
<th></th>
<th>Innovative Solution</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Battery electric trucks</td>
<td>(up to 40 tons) for deliveries up to 500 km (310 miles)</td>
</tr>
<tr>
<td>2</td>
<td>Biofuel trucks</td>
<td>for long-haul deliveries (more than 500 km / 310 miles)</td>
</tr>
<tr>
<td>3</td>
<td>Catenary technology</td>
<td>for heavy duty trucks (up to 40 tons) on highways</td>
</tr>
<tr>
<td>4</td>
<td>Truck Platooning</td>
<td>on highways for long distances (more than 500 km / 310 miles)</td>
</tr>
<tr>
<td>5</td>
<td>Self-driving trucks</td>
<td>for extra-urban traffic</td>
</tr>
<tr>
<td>6</td>
<td>Pipeline supply networks</td>
<td>for long distance freight transport (more than 500 km / 310 miles)</td>
</tr>
<tr>
<td>7</td>
<td>Drones</td>
<td>for last mile deliveries (up to 50 km / 32 miles) in urbanized areas</td>
</tr>
<tr>
<td>8</td>
<td>Digital freight matching platforms</td>
<td>for last mile deliveries in urbanized areas</td>
</tr>
<tr>
<td>9</td>
<td>Freight</td>
<td>is predominantly transported through a shared open intermodal transport network (Physical Internet)</td>
</tr>
<tr>
<td>10</td>
<td>Internet of Things</td>
<td>to connect vehicle within a fleet and optimize freight transportation</td>
</tr>
<tr>
<td>11</td>
<td>Modularized and standardized packaging</td>
<td>Worldwide (from cargo container sizes to tiny sizes)</td>
</tr>
<tr>
<td>12</td>
<td>Smart containers</td>
<td>elaborate the transportation route to their destination by themselves</td>
</tr>
<tr>
<td>13</td>
<td>Automated loading and unloading</td>
<td>Completely of transport vehicles through robotics or automated loading systems</td>
</tr>
<tr>
<td>14</td>
<td>Local 3D-printing</td>
<td>instead of transporting products</td>
</tr>
</tbody>
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Delphi study interface

- Option to see experts’ comments
- Own evaluation compared to group response
- Option to change own statements

Innovation: Battery electric trucks (up to 40 tonne) for deliveries up to 500 km (310 miles).
Status: The market share of battery electric trucks worldwide is currently 0.05% (2016) (in Germany: 0.14%). By now, mainly light and medium duty trucks with ranges of up to 300 km (186 miles) are in use.

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Questionnaire and respondents

1. When, if ever, do you sense there will be mass adoption of this potential innovation? Define “mass adoption” as at least 30% market penetration

2. Impact on sustainability (economical, environmental and social) (in case of occurrence)

3. Self-rated confidence in the assessment (Level of expertise in this innovation)

Respondents by Stakeholder

N=116

- Academics: 65 (56%)
- Industry: 26 (22%)
- Politics/Associations: 25 (22%)

Respondents by Region

- Europe: 61 (53%)
- Asia: 12 (10%)
- Africa: 4 (3%)
- Germany: 5 (4%)
- Australia: 31 (27%)
- North America: 2 (2%)
- South America: 1 (1%)

25 Countries

Number of comments: 877
## Results

<table>
<thead>
<tr>
<th>Thesis</th>
<th>Time of occurrence</th>
<th>Impact on sustainability</th>
</tr>
</thead>
<tbody>
<tr>
<td>3D-printing</td>
<td>Next 5 years</td>
<td></td>
</tr>
<tr>
<td>Transport network</td>
<td>Next 10 years</td>
<td></td>
</tr>
<tr>
<td>Battery electric trucks</td>
<td>Next 25 years</td>
<td></td>
</tr>
<tr>
<td>Pipeline supply networks</td>
<td>More than 25 years</td>
<td></td>
</tr>
<tr>
<td>Digital freight matching</td>
<td>Never</td>
<td></td>
</tr>
<tr>
<td>Catenary trucks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internet of Things</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standardized packaging</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drones</td>
<td></td>
<td></td>
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<tr>
<td>Self-driving loading</td>
<td></td>
<td></td>
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<tr>
<td>Biofuel trucks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Platooning</td>
<td></td>
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</tbody>
</table>

**Impact on sustainability:**
- 3.7
- 3.0
- 2.7

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Results

Clustering of innovations depending on rated time of occurrence and Impact

“Focus Innovations”
- Digital freight matching
- Battery electric trucks
- Internet of Things
  - Short – medium term
  - High impact

“Wildcards”
- Transport network
- 3D-printing
  - Medium – long term
  - Very high impact

“Supporting/ Enabling Technologies”
- Standardized packaging
- Self-driving trucks
- Smart containers
- Automated loading
- Platooning
  - Medium term
  - Medium impact

“Doubts”
- Drones
- Catenary trucks
- Pipeline supply networks
- Biofuel trucks
  - Long term - Never

“Truck utilization is key to sustainable transportation”

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Digital freight matching

- **(E)** Governmental regulations can lead to an increase of adoption
- **(L)** Integrated data sharing and collaboration, Priority and liability issues

Internet of Things

- **(E)** Technology already in place within some fleets
- **(L)** High impact only across fleets and in combination with autonomous driving

"Truck utilization is key to sustainable transportation"

Results

Qualitative expert comments on focus innovations

"Truck utilization is key to sustainable transportation"

Transport network

(Physical Internet)

- **(E)** Digital platforms pace the way, Governmental regulations and incentives can lead to faster adoption
- **(L)** Horizontal collaboration and trust, Monopolistic

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Summary

Key findings of the study

- Implementation of innovations in transportation needs considerable time, due to long depreciation times of infrastructure and high costs.

- Business Model innovations (Transport Network, 3D-printing) \textit{will have higher impact on sustainability} than technological improvements of applied technologies (Self-driving trucks, Automated loading).

- Governmental regulations and incentives play a significant role for innovations in logistics.

- Propulsion technology of trucks will be diverse, depending on the application (Battery electric mainly for short and medium haul).
Thank you for your attention!

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