Future visions for electric vehicle deployment in Denmark: stakeholder based scenario development.

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Future visions for electric vehicle deployment in Denmark: stakeholder based scenario development

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Context

Fossil-free Denmark by 2050

Electrification of vehicle fleet necessary; also biggest challenge

- *What are the implications for the electricity grid and other energy and transport infrastructure?*
- *What are the implications for modal choice and travel time budgets?*
- *What are the policy relevant scenarios for the future?*

COMETS

CO-Management of Energy and Transport Systems

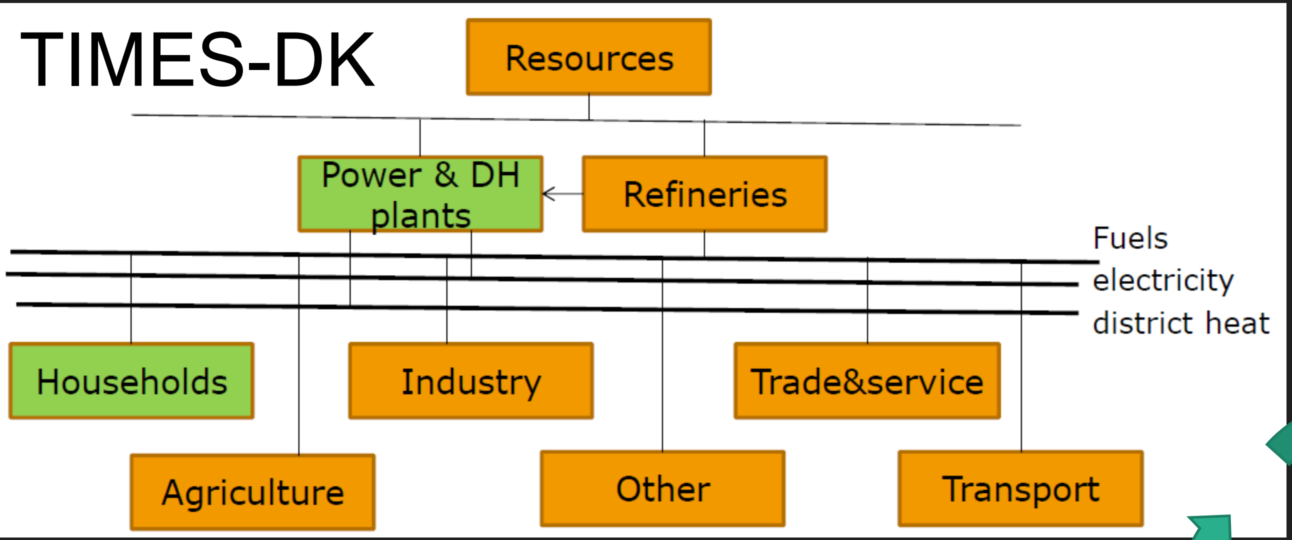
www.cometsproject.dk

- TIMES-DK linear optimization model of Danish energy system
- Transport in TIMES-DK: Optimization of tech and fuel to meet end-use passenger-km demand; modes are exogenous (i.e. shares of buse[...] fixed)
- Goal: Expand TIMES-DK to incorporate
  - Modal choice (travel time budget /investment, speed, trip purpose)
  - Infrastructure capacity and requirements

Factors to consider: unanswered modeling questions

- Travel Time Investment (TTI): Investing in bus infrastructure (lanes, number of busses) reduces the waiting time and travel time for busses, which has societal value.
- Demand segmentations: Discomfort costs are different depending by the demand segments. The overall land travel demand should be split to calculate different costs for different segments.
- Value of Time (VoT): Is VoT mode specific? VoT reflects the income of people taking the mode, but also depends also on the length of the trip.
- Trip vs tours: Distinguish between trips and tours. A tour (urban to rural travel) is constrained to the same transport means on

Soft-link between TIMES & LTM (method proposed in COMETS)



TIMES-DK → LTM: Optimal fuel and technology mix, travel cost by mode

LTM → TIMES-DK: Modal choice, short and long distance travel demand

LTM: Landstrafikmodellen

But…

- LTM does not allow setting CO_2 caps: emission reduction scenarios in TIMES-DK would be inconsistent with LTM; LTM not sensitive to fuel price
- LTM is highly geographically disaggregated geographically (trips for each household). When aggregating to TIMES-DK, LTM output loses meaning and a lot of biases appear, especially in iterative analysis

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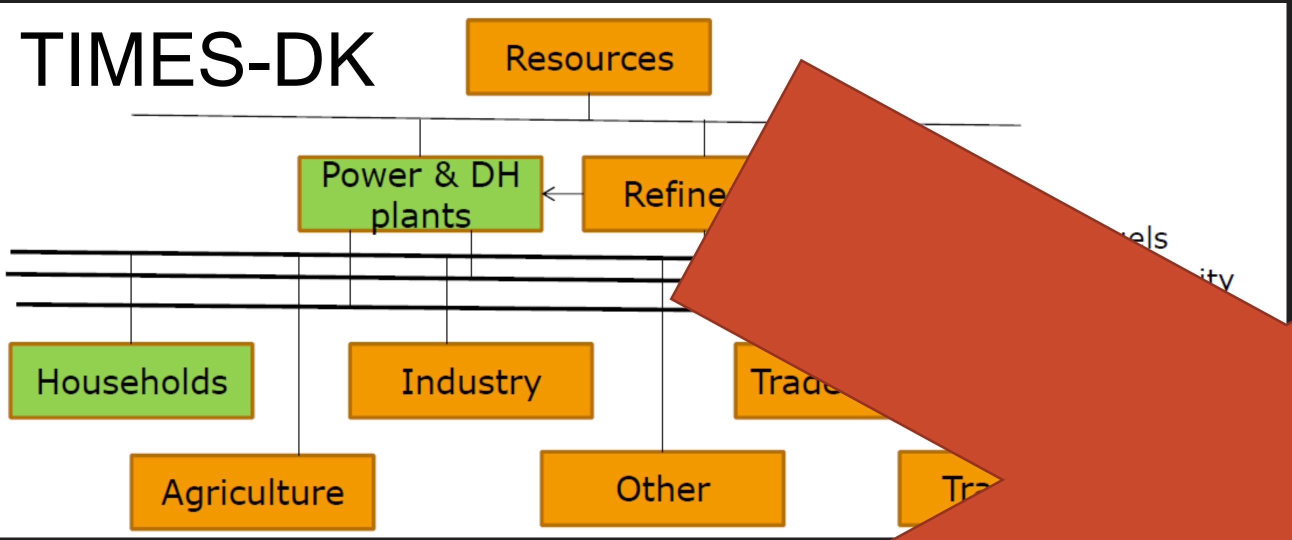

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…fikmodellen

A story-and-simulation (SAS) approach

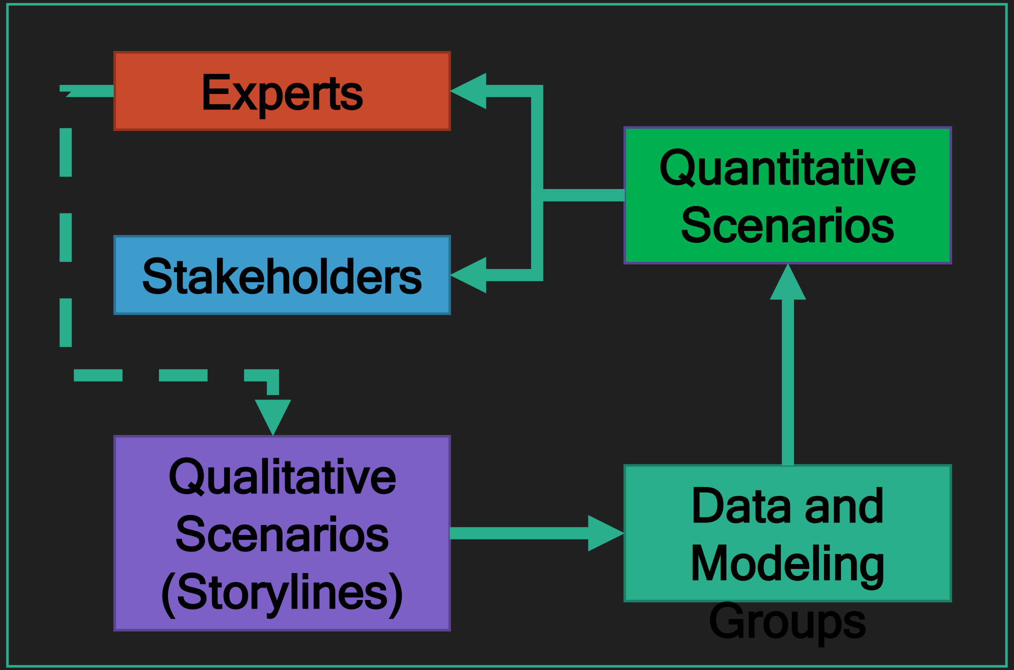
Stakeholder panel

- Discuss driving forces and uncertainties
- Develop qualitative storylines

Experts (data & modeling groups)

- translate the qualitative information into quantitative model input
- underpin qualitative analysis by quantitative modeling as feedback

Iteration (Stakeholders and experts) refine storylines and quantification until a set of compelling, plausible and relevant stories and simulations about the future is reached



Based on European Environment Agency (2007) *Land-Use Scenarios for Europe: Qualitative and Quantitative Analysis on a European Scale*.

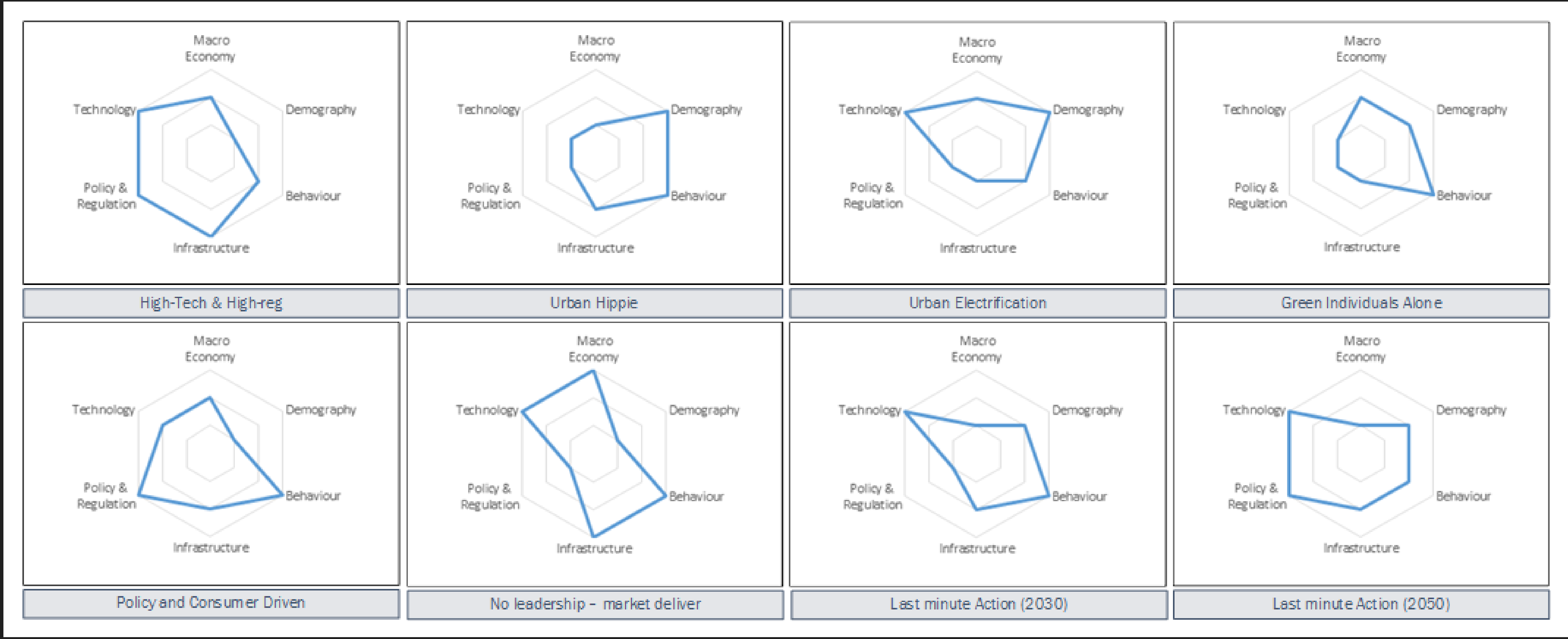
Meiken Hansen

Stakeholder / Expert workshop, Sept. 2016

- Brainstorm in in groups of 3 on driving forces for transport sector, and present PostIt notes
- Cluster the driving forces (around 20)
- Place green dots on the clusters with highest **impact** (8 votes each)
- Place red dots on the clusters with highest **uncertainty** (8 votes each)
- Agree on the most important 5 clusters (key drivers)
- Create scenarios based on key drivers (ca 10 minutes)
  - Groups develop scenario based on (low, medium, high) values of the five key drivers
  - Write a narrative (story) for each scenario in the form of bullet points

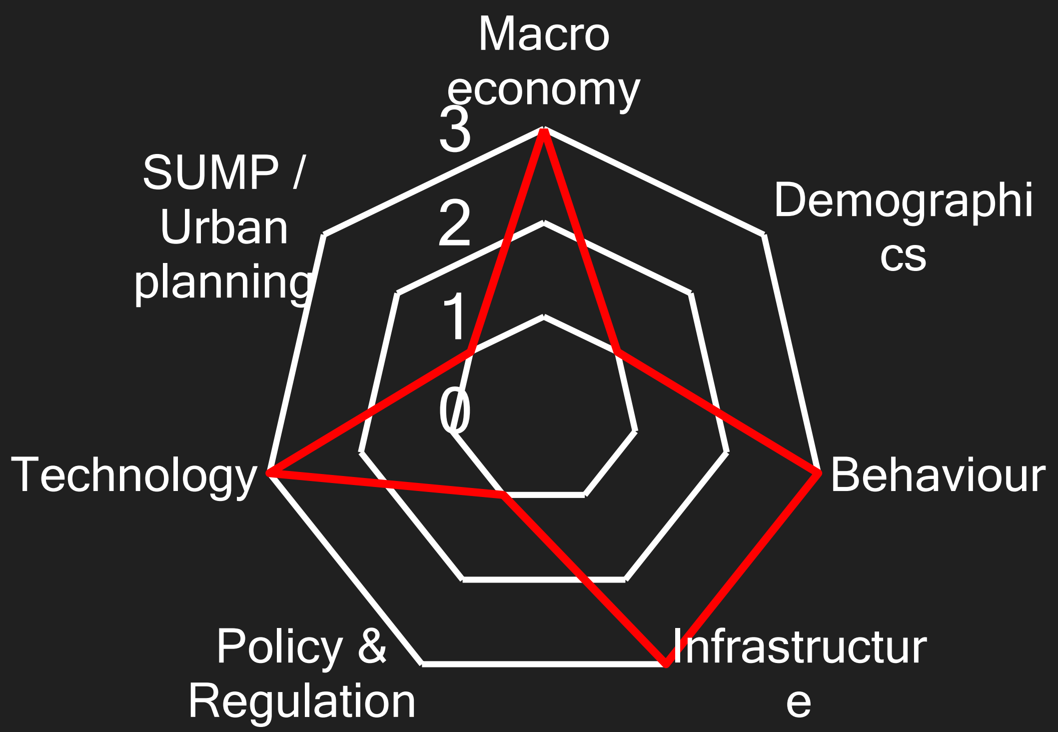
Meiken Hansen

Scenario storylines from expert workshop



Giada Venturini

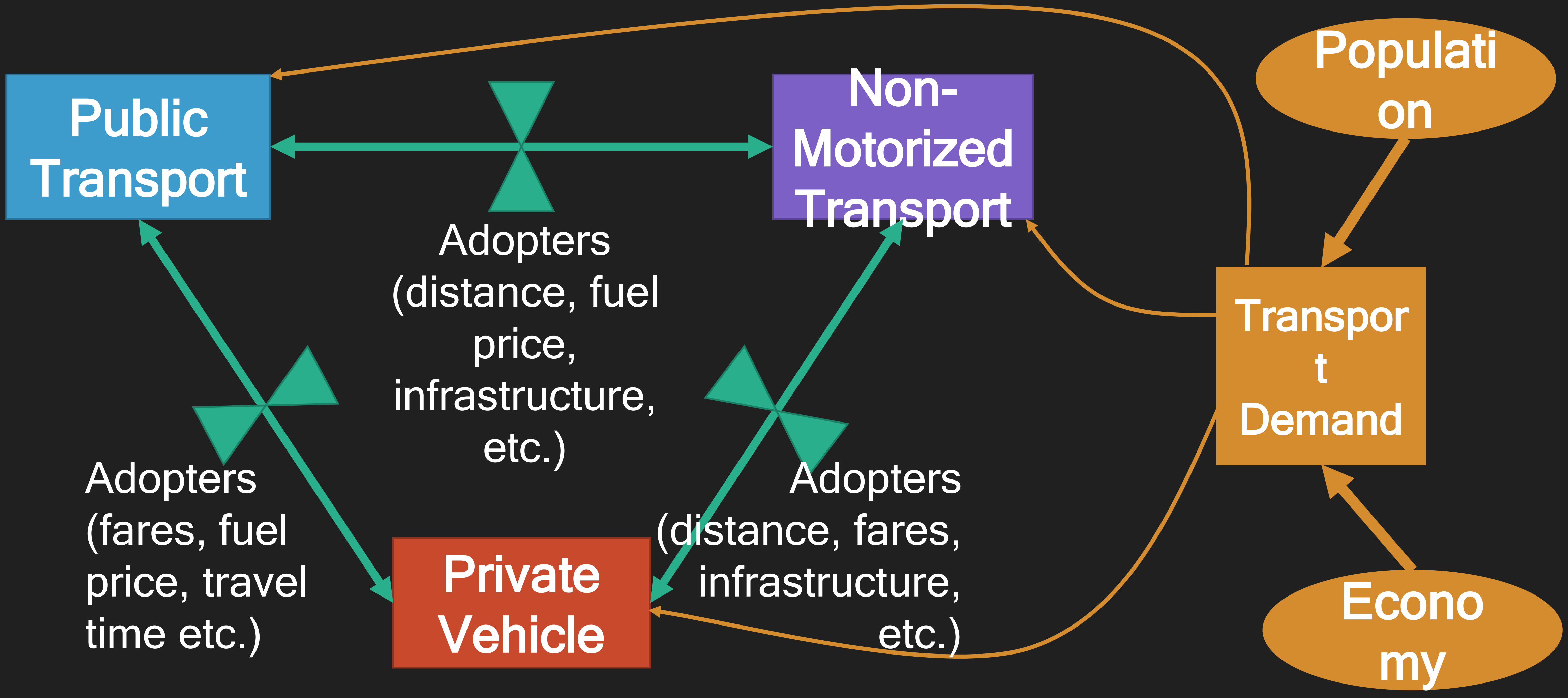
Example Narrative from Stakeholders: "No leadership - market delivered"



- Minimal or no national & international political leadership
- No Sustainable Urban Management Plan (SUMP)
- High degree of technological development & innovation in power production, charging and batteries
- Private development of infrastructure
- High economic and environmental consciousness behavior
- High oil prices

Meiken Hansen

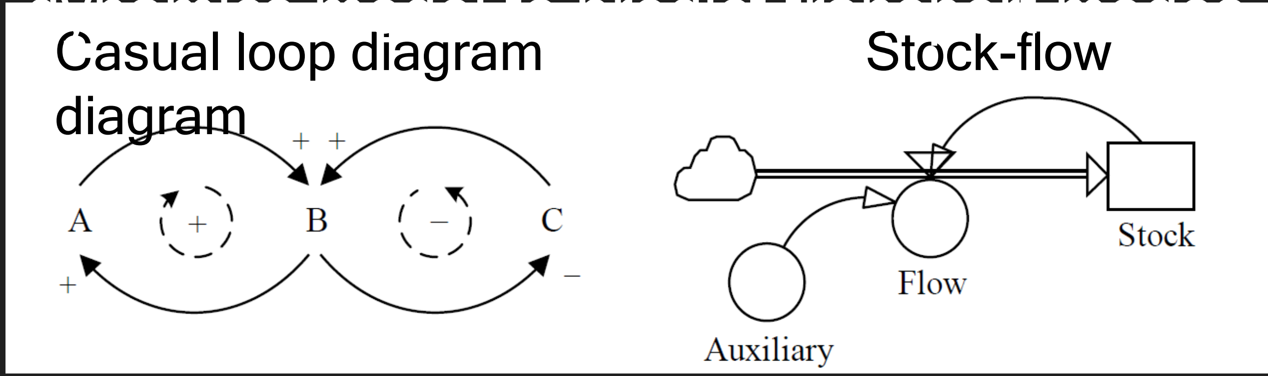
Modal Choice and Human Behavior



Georgios Nikou

Modal Choice and Human Behavior: System Dynamics

Goal: to understand motivations behind modal choice, and create a system



Potential validation through stakeholder interviews

Compare with an Agent Based Model

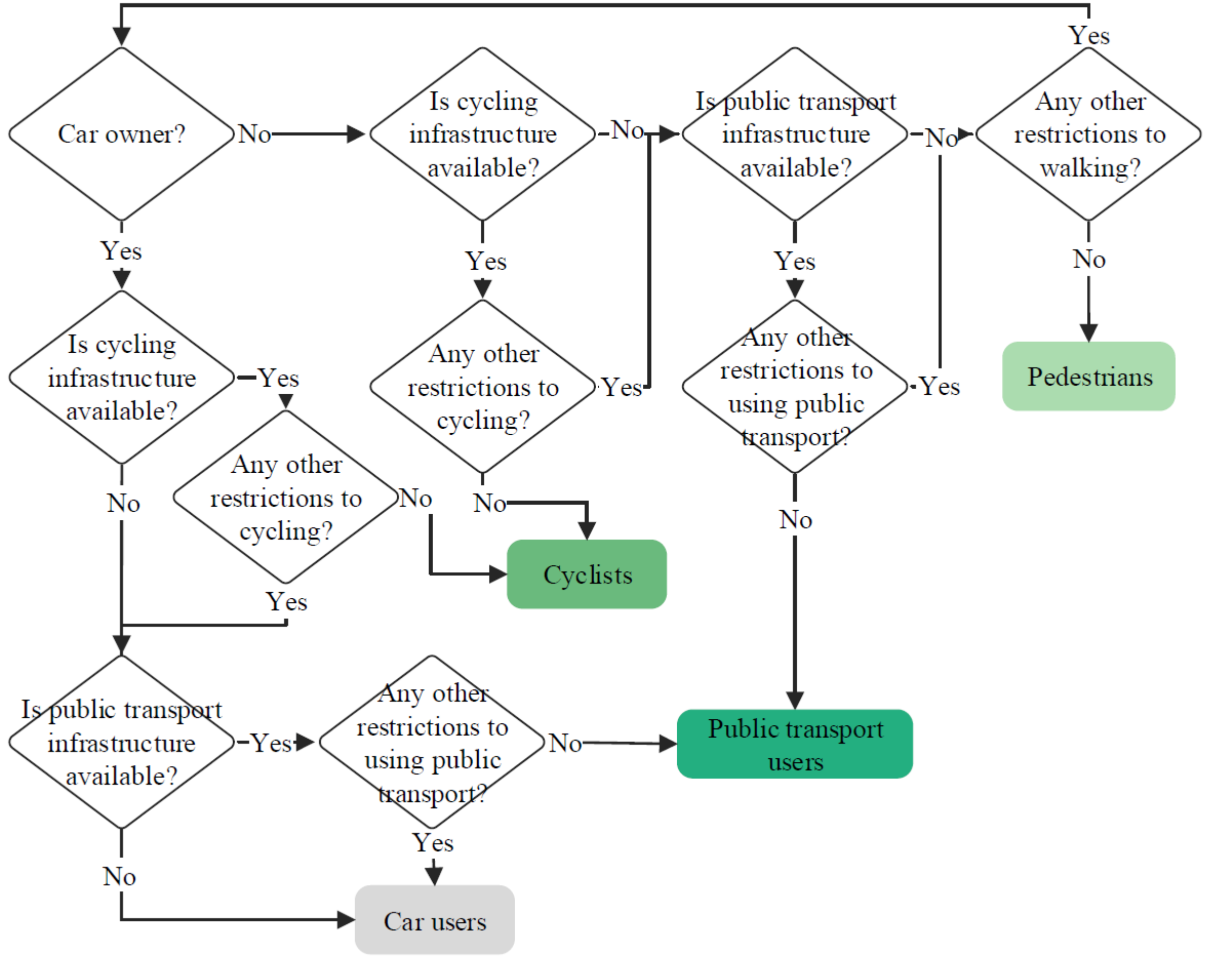


Figure 4.7. An algorithm of passenger transport trip choice model incorporated in the system dynamics model

Mohammad

Car Sharing and Entrepreneurship Models

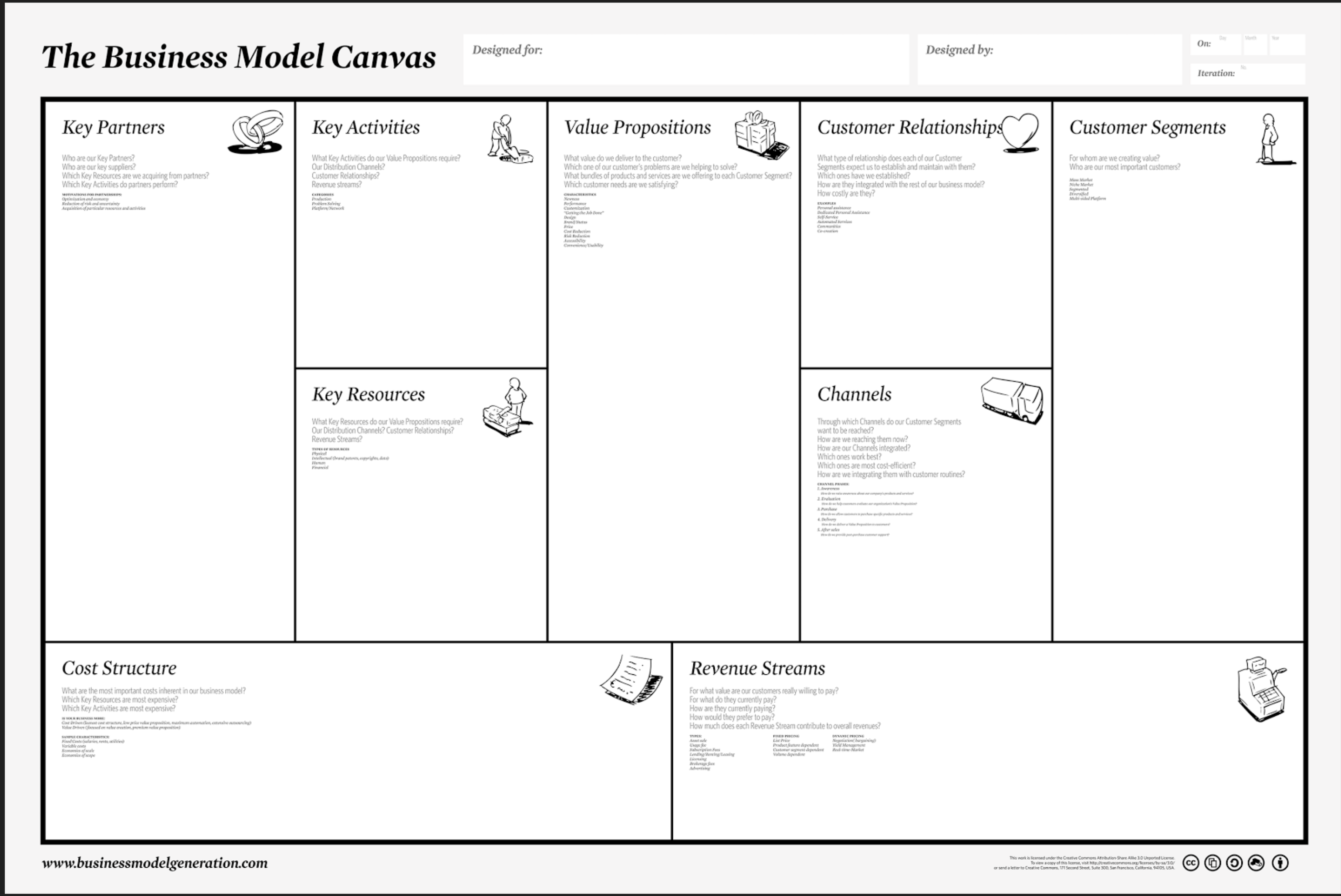
Ownership \ Flexibility	Round Trip	Station	Floating
Firm-to-Customer	Hertz Lyngby Delebil Tadaa!	NordSjaelland	DriveNow Green Mobility
Cooperative	Letsgo Albertslund delebil		
Peer to Peer	GoMore Snappcar		
Other	Arval		Spiri

Elisa

Car Sharing and Entrepreneurship Models

- Business Model Canvas Comparison:
- Value Proposition (VP)
- Channels (CH)
- Revenue Streams (RS)
- Key Activities (KA)
- Customer Segments (CS)

- Future Potential: how are these related to ownership and flexibility?
- How does this affect modal choice scenarios?



Elisa

Game Changers: Autonomous Vehicles

SAE Level	SAE name	SAE narrative definition	Execution of steering and acceleration/ deceleration	Monitoring of driving environment	Fall-back performance of dynamic driving task	System capability (driving mode)
Human driver monitors the driving environment						
0	No Automation	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n.a.
1	Driver Assisted	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial Automation	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* performs all remaining aspects of the *dynamic driving task*	System	Human driver	Human driver	Some driving modes
Automated driving system ("system") monitors the driving environment						
3	Conditional Automation	the *driving mode*-specific performance by an *automated driving system* of all aspects of the *dynamic driving task* with the expectation that the *human driver* will respond appropriately to a request to intervene	System	System	Human driver	Some driving modes
4	High Automation	the *driving mode*-specific performance by an *automated driving system* of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a request to intervene	System	System	System	Some driving modes
5	Full Automation	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	All driving modes

Forecasts:

2018-2020: Nutonor
2018: Tesla
2018: NVIDIA (Leve
2019: Delphi & Mob
2019: VW
2019: Baidu
2020: GM
2020: Nissan (Level
2020: Toyota (Level
2020: Audi (Level 4)
2021: Ford (Level 5)
2021: BMW
2023: Tesla (Level 5
2040: IEEE 75% wil

http://www.driverless-future.com/?page_id=384

Disruptive Technological Development: Autonomous Cars

Motorways w. hard shoulder

Two-lane expressway

Mixed-use highway

Urban streets

Private roads and streets

Level 3

Level 4

Level 5

A Level 5 car has no steering wheel or pedals, so needs access to all streets

- The future scenarios: Privately owned vehicles vs. Mobility as a service
- What does it mean for public transport?
- What does it mean for non motorized transport?

Per Homann

Conclusions

- Major changes in the future!
  - Transport becomes electrified
  - Transport becomes a service
- Tech depends on social factors
- Difficult to model!
- Participatory scenari