MIT Portugal

# Development of

# a Multi-Criteria evaluation framework

# for alternative light-duty vehicles technologies


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**Co-Supervisor: Prof. Jorge Pinho de Sousa**
**Co-Supervisor: Steve Connors (MIT EI)**

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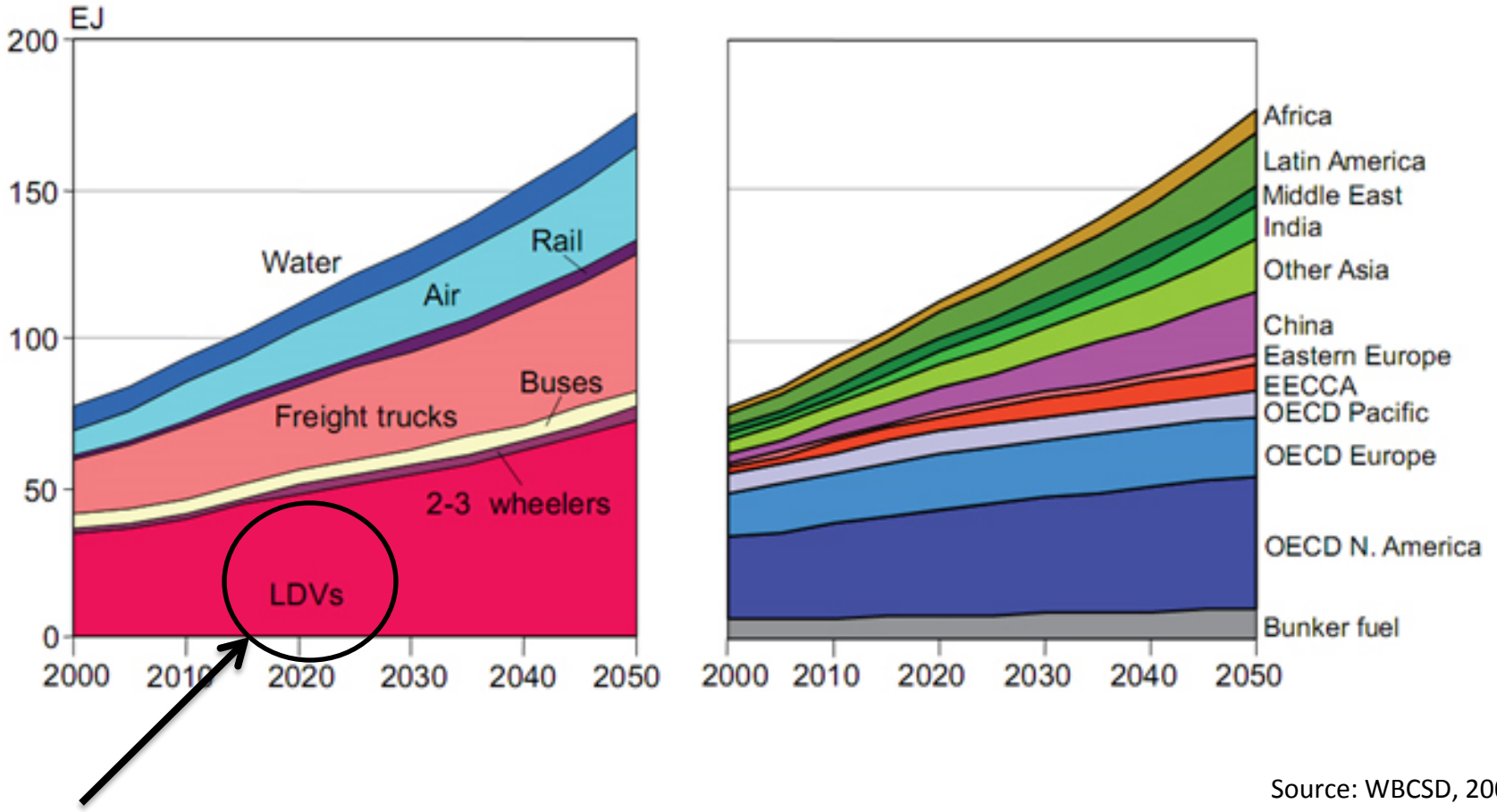
# Global Projections for Transportation Energy Use by mode and region, 2000-2050




Source: WBCSD, 2004.

# Research Questions

- What are the main alternative fuel/technologies for LDVs, their characteristics and main uncertainties?
- How to choose and (successfully support) the **preferred alternative fuel/technology drivetrains**, (assuming these options are at market competitive level)?
- How to incorporate uncertainties on the decisions regarding transportation infrastructures and technology development?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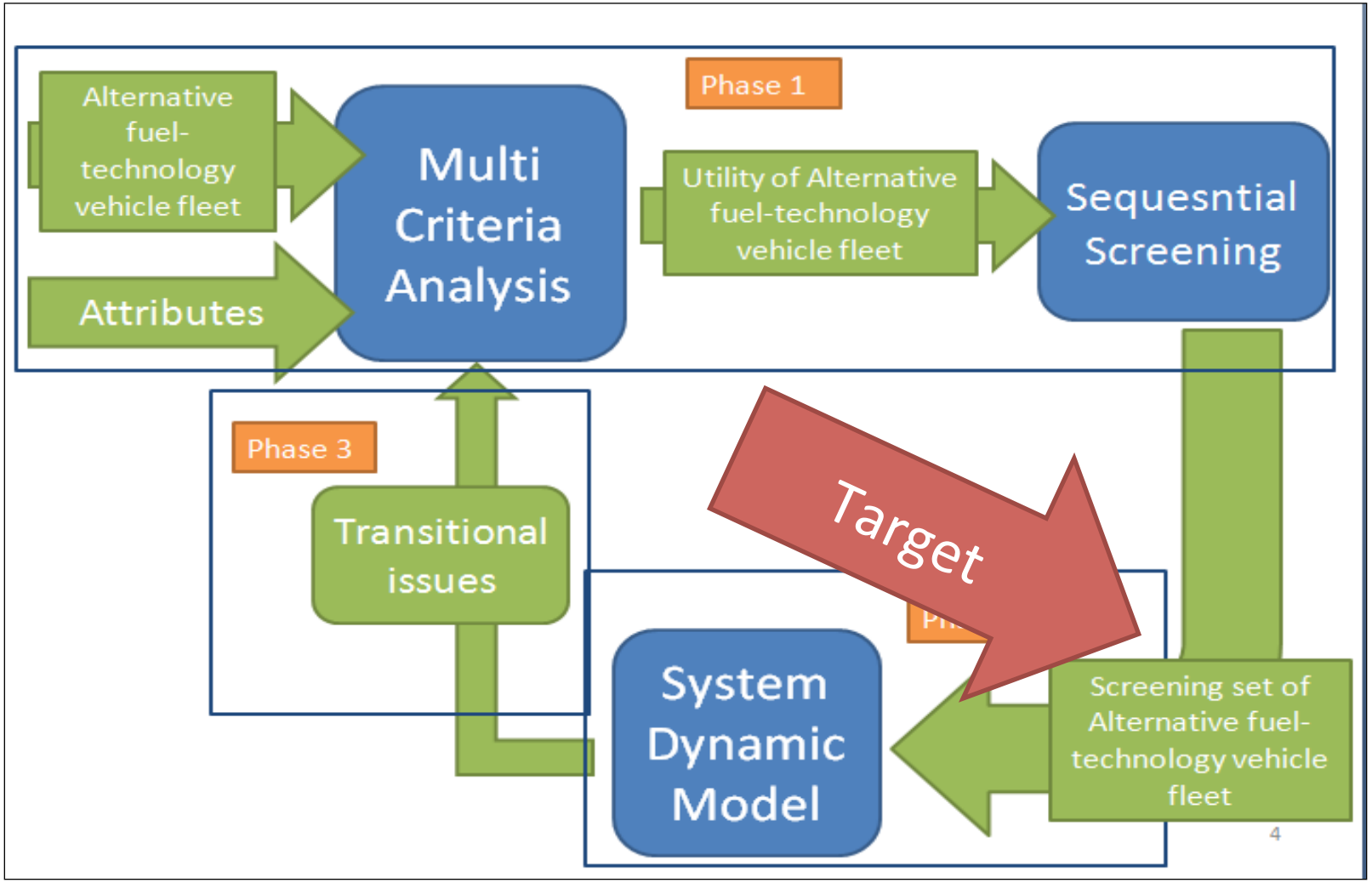
# Research Phases



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# Multi-Criteria Evaluation Process



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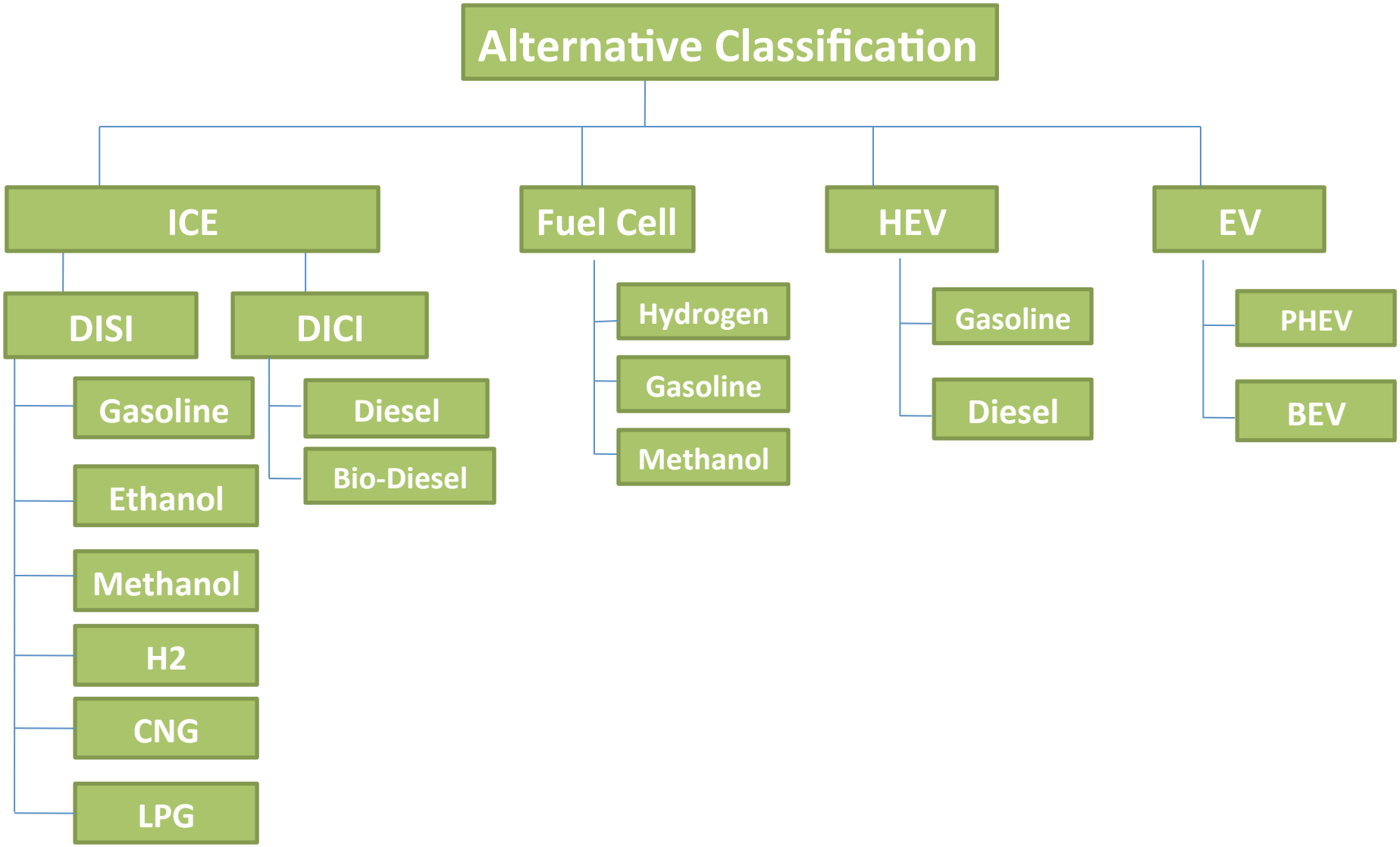


ICE: Internal Combustion Engine, DISI; Direct Injection Spark Ignition engine , DICI: Direct injection compression ignition engine, Hybrid-PISI, Hybrid-DICI, Fuel Cell with/without reformer, PHEV; Plug-in Hybrid, and BEV; Battery Electric Vehicle

# Attribute Classification

**User**

1- Acceptance
- -Economy
  - - Initial Cost ($)
  - - Fuel Cost ($/year)
  - -M&R Cost ($/year)
- -Performance
  - -Acceleration
  - -Range
  - -Safety
  - -Reliabaility

2- Risk of Technology Maturity

3- Transition Cost

4- Emission to Atmosphere
- - Air Polution (g/km)
- - Global GHG Emissions (g/km)
  - -WTT
  - -TTW
  - -M&D

5- Availability of Fuel Supply
- -Energy Security

**Policy Maker**

# Decision Making Approach

Decision Variable is the

*Share of*

*each specific alternative Fuel-Technology Vehicle*

*in LDV Fleet (not annual sale)*

*at 2030!*



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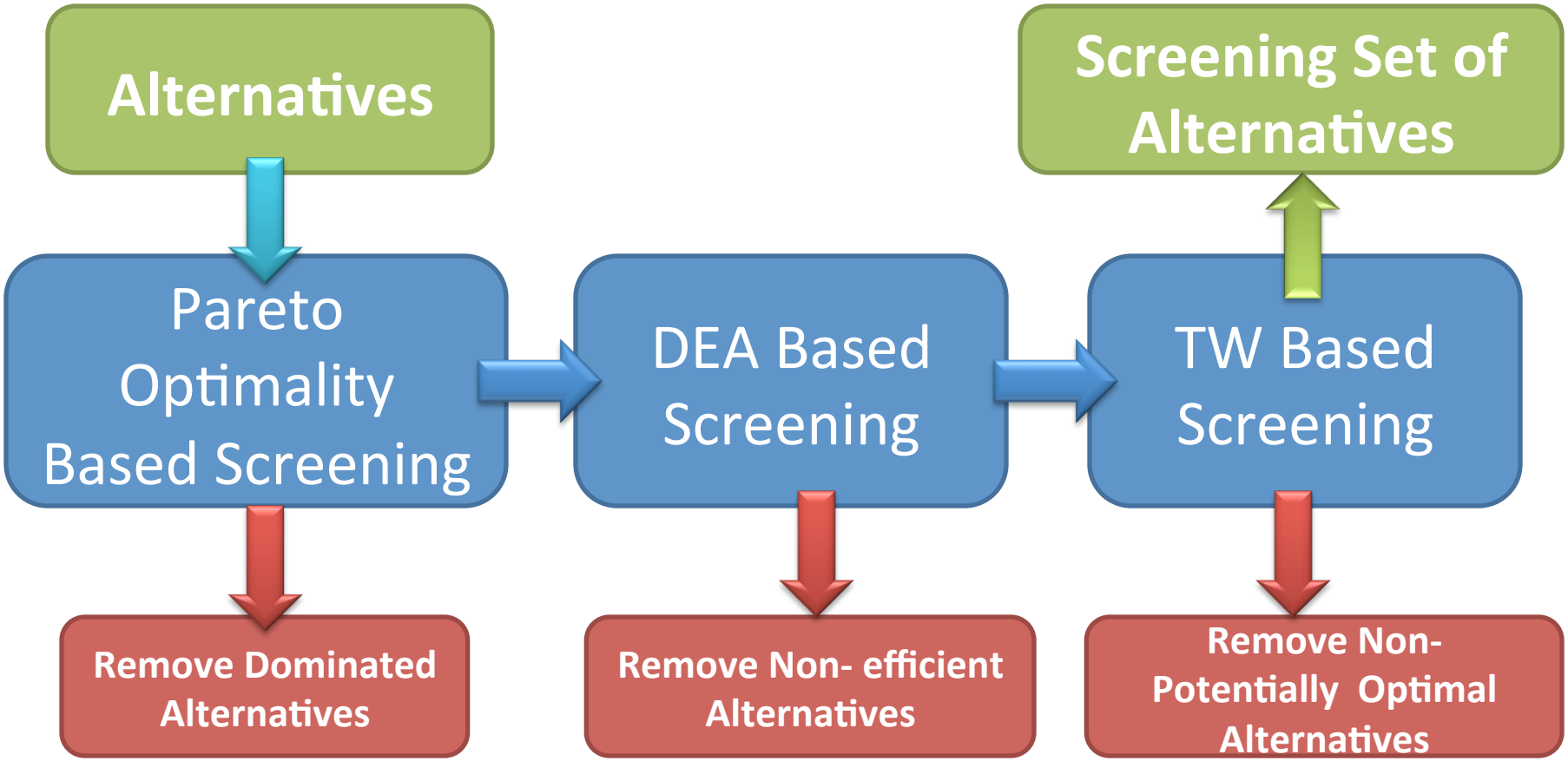
# Sequential Screening



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# Scenario

## Key Factors

**Annual Trip distance: 15000 Km**

**Discount rate: 8%**

**GHG Damage Cost: 20 Euro/tonne-CO2 Eq**

**Portugal**

**Population at 2030 (PNAC Report)**

Low Growth: 10930 (*1000 inhabitants)

High Growth: 11379 (*1000 inhabitants)

**No of Passenger Vehicle at 2030**

Low Growth: 5365 (*1000 vehicle)

High Growth: 5617 (*1000 vehicle)

**Base Scenario**

# Base Scenario
# Prefered set of alterantives for Portugal

| | DISI-Ethanol | DICI-Biodiesel | FCWR-Gasoline | FCWR-Methanol | HEV-PISI-Gasoline | PHEV | BEV |
|---|---|---|---|---|---|---|---|
| Alternative 1 | | | | | 100% | | |
| Alternative 2 | 50% | | | | 50% | | |
| Alternative 3 | | | | 50% | 50% | | |
| Alternative 4 | 33% | | | 33% | 33% | | |
| Alternative 5 | 33% | | | 33% | | | 33% |
| Alternative 6 | 25% | 25% | | 25% | 25% | | |
| Alternative 7 | 25% | | 25% | 25% | 25% | | |
| Alternative 8 | 25% | | | 25% | 25% | 25% | |

***Share of each specific alternative Fuel-Technology Vehicle in LDV fleet at 2030!***


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# Sensitivity Analysis

**Integrated Scenario analysis**

1- Power Generation: 35% Renewable vs 70% Renewable

2- Share of biofuel availability: Base-25% vs 10% vs 5%

3- Hydrogen Production: 50% from electrolysis vs 100%

4- Gasoline Price: 21 $/GJ (1.4 $/liter) to 43 $/GJ (2.1 $/liter)

5- GHG Damage Cost: 20 Euro/tone-Co2-Eq vs 50 Euro/tone-Co2-Eq

6- Annual Average Travel: 15000 Km vs 12000 km

96 Scenarios!



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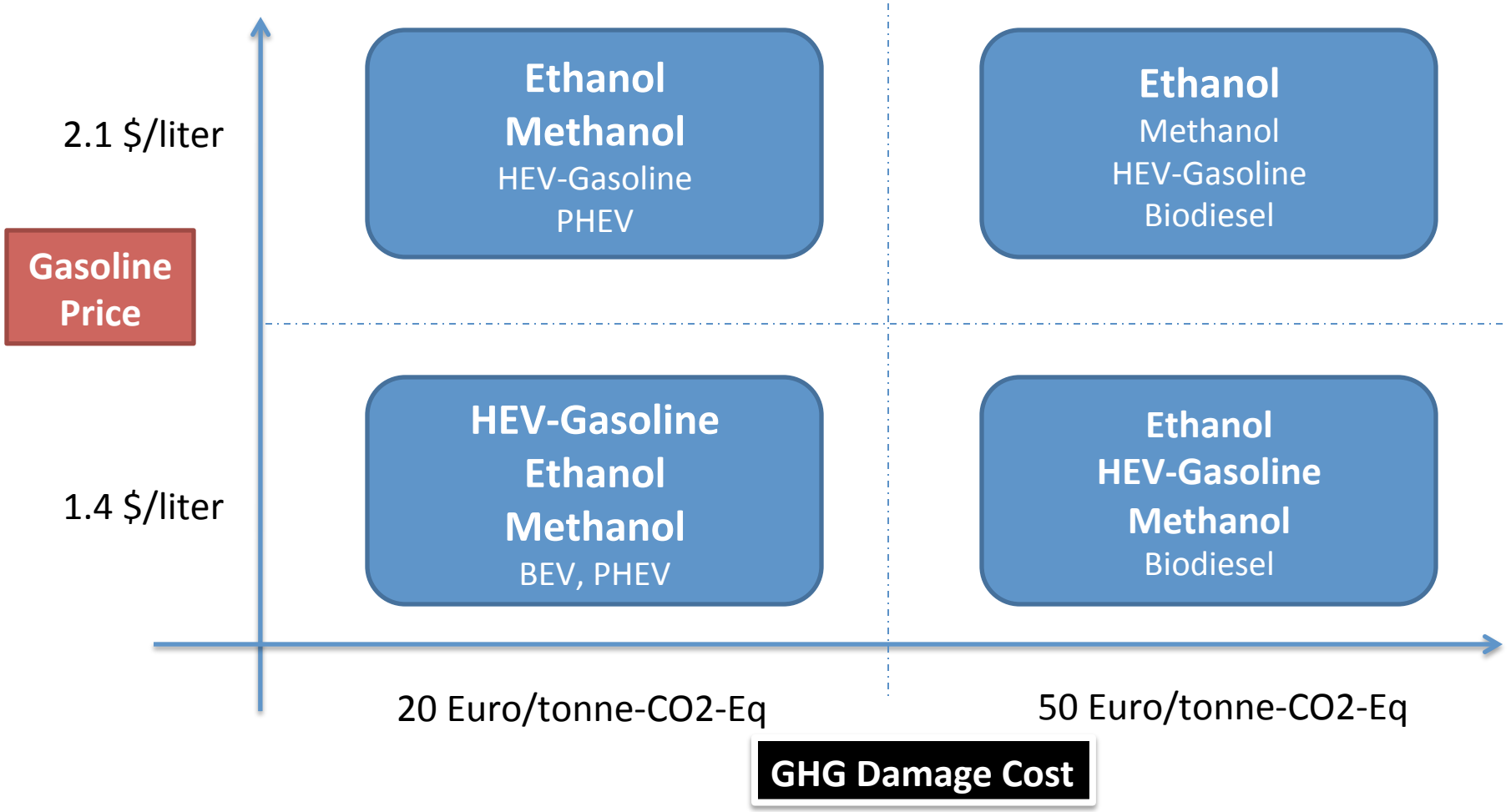
# Merit of Alternative Technology for Portugal



# Phase 2:
# Transition Analysis of Alternative Fuel Vehicles

Essence of System Thinking!



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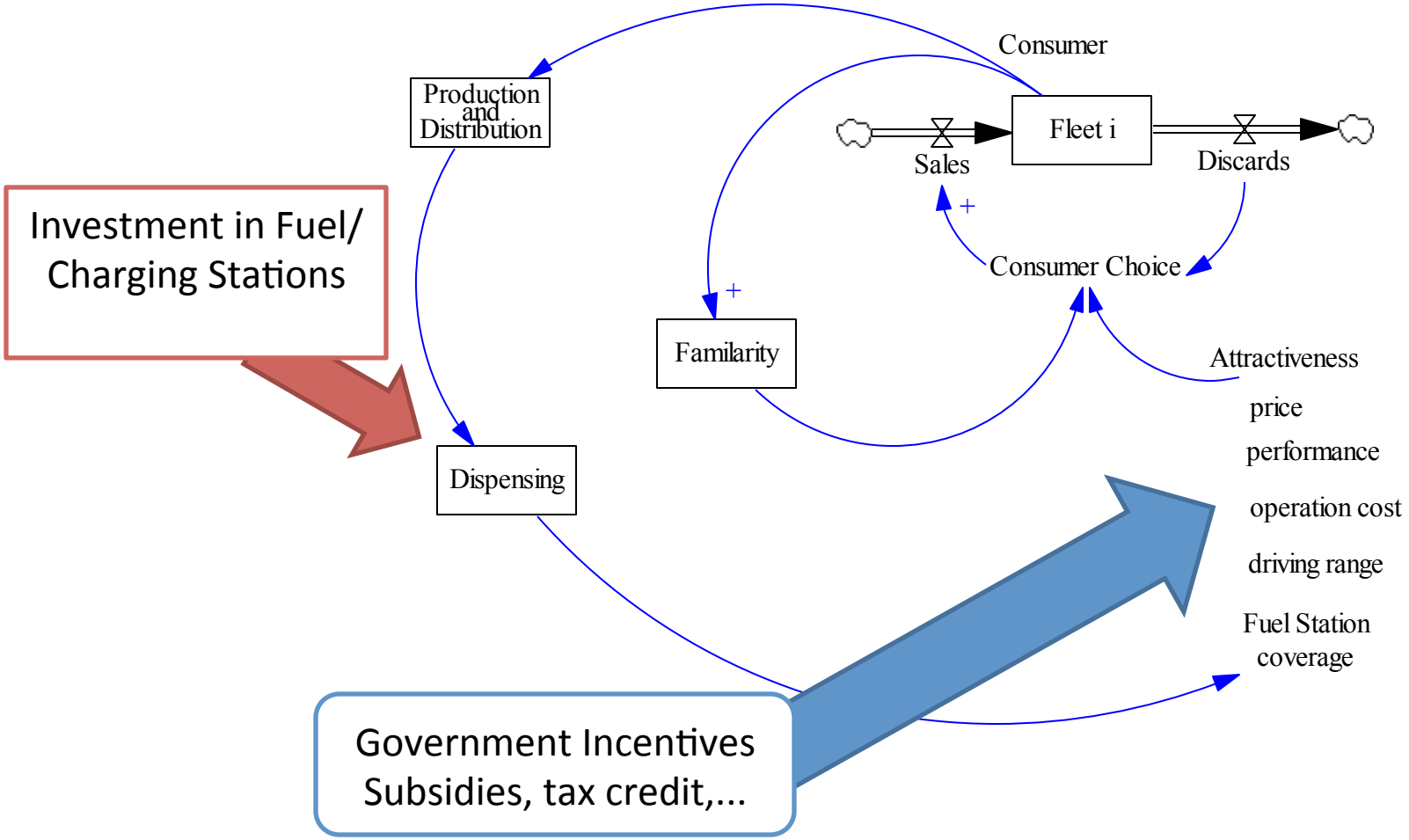
# System Dynamic Model






Adopted from Struben, 2008

# Potential application in Azores

- Application of Multi-Criteria Decision Making Tool for each island
  - Identifying the Prefered technology
  - Investigate the impacts on Energy Saving and Emissions

# Thank you for your attention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# Extra



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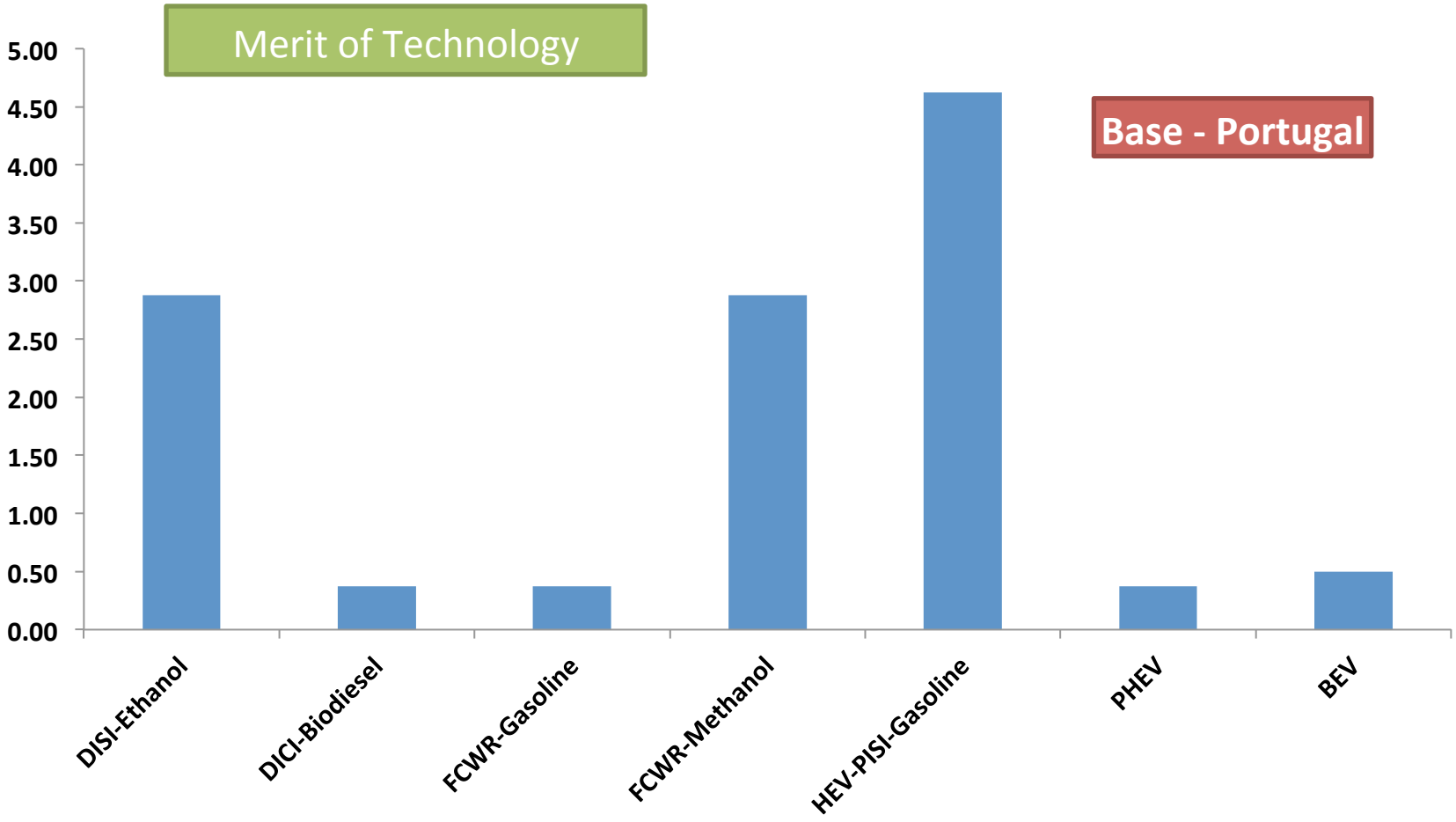
# Base Scenario - index for Prefered set of Alternatives for Portugal



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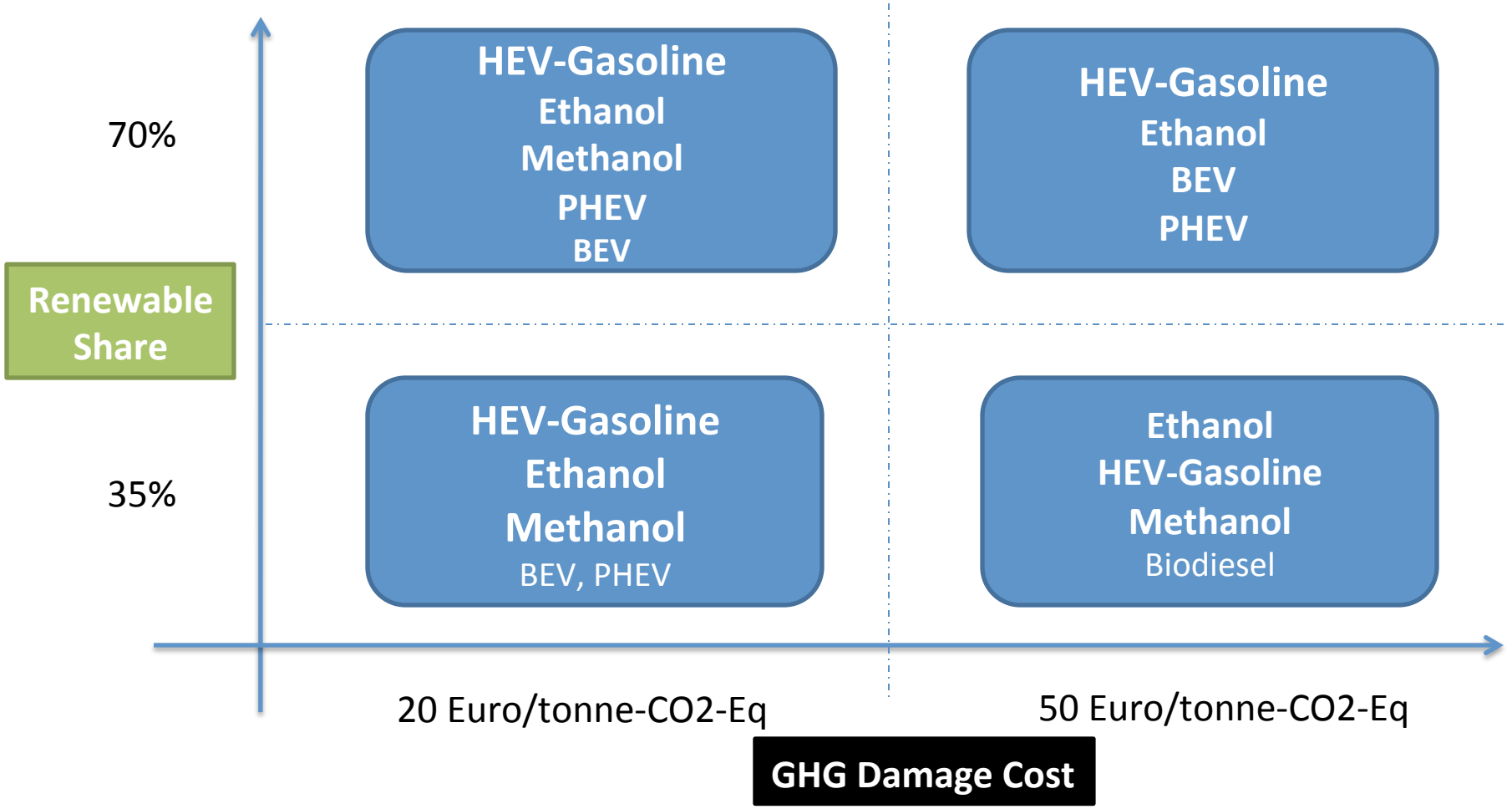
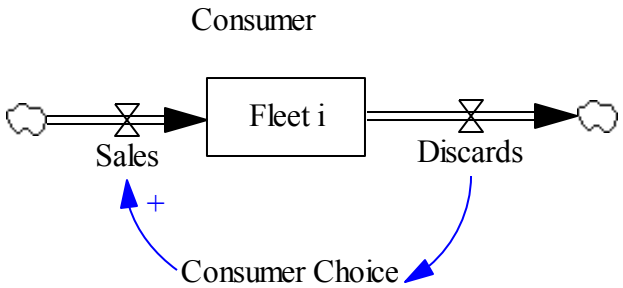
# Merit of Alternative Technology for Portugal (Cont)



# System Dynamic Model



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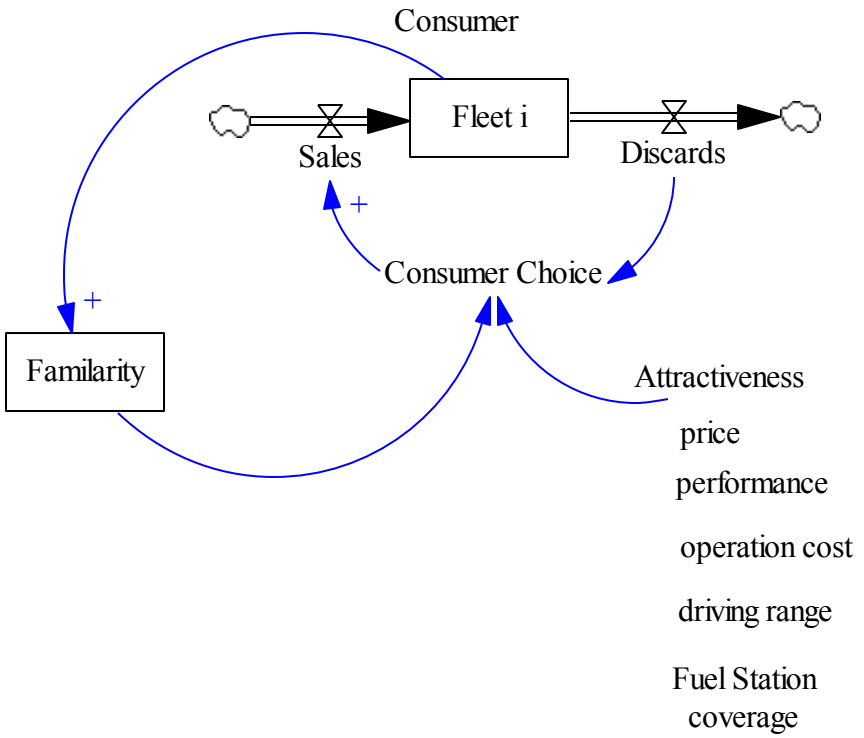
# System Dynamic Model

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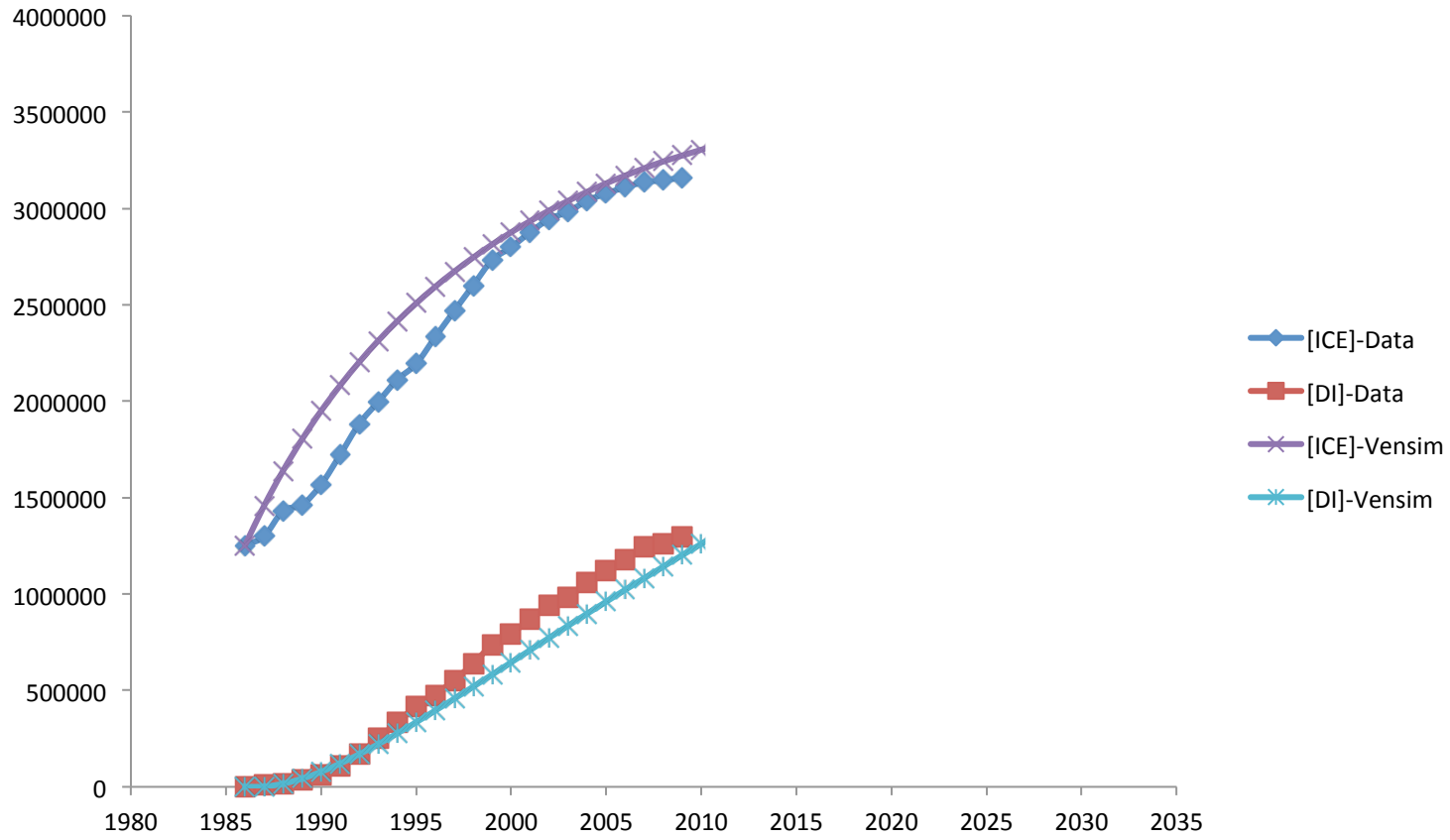
# Base Scenario – SD Model

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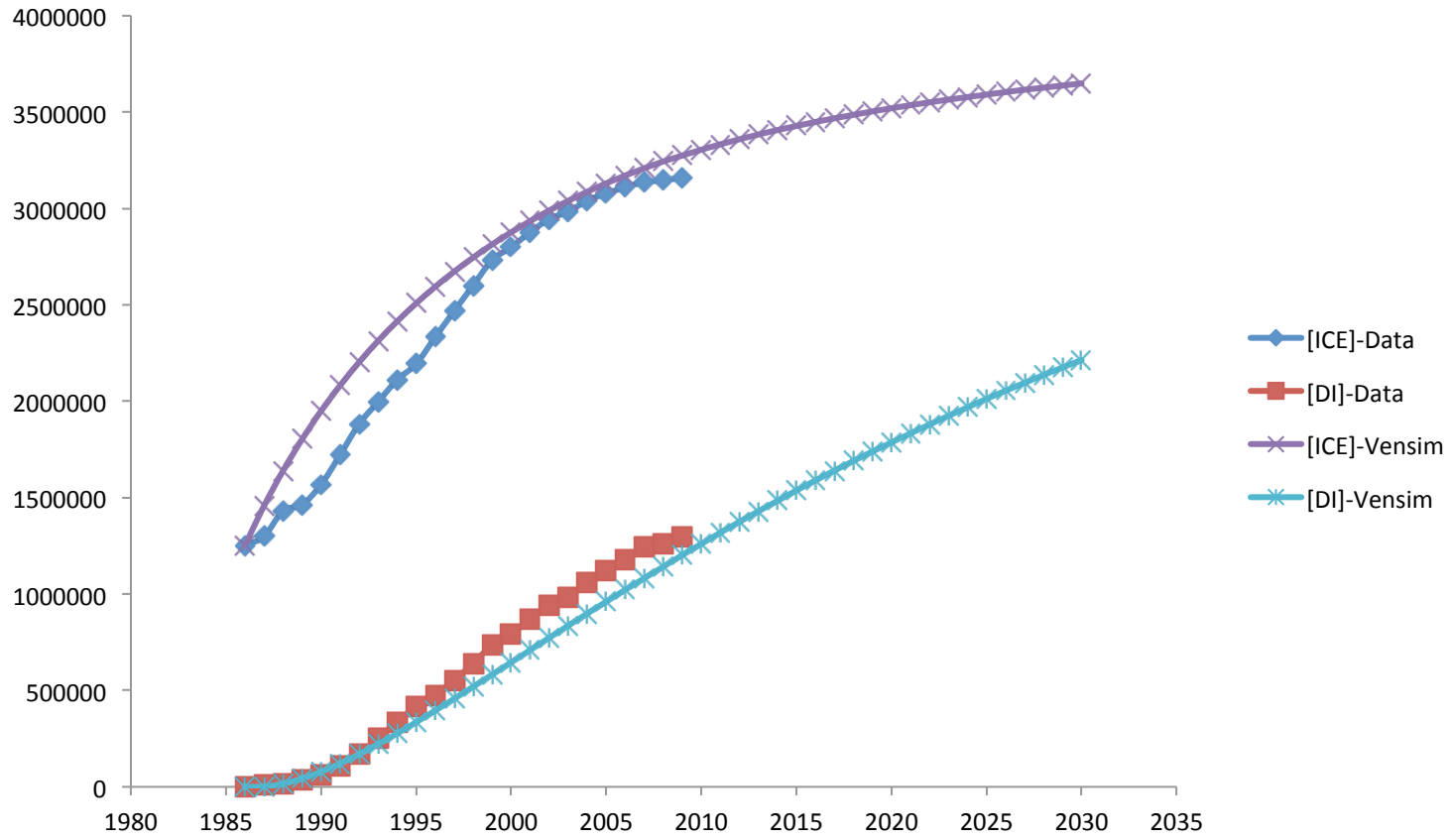
Adopted from Struben, 2008

# Base Scenario – SD Model (Continued)

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Adopted from Struben, 2008

# Conlusions

- Multi-Criteria Decision Making Tool
  - Charactristics

    Handy, Flexible and Robust
  - Achievements

    Significance of Multi-Attribute Comparison

    Importance of Transition Cost

    Introduction Phase:

    Critical for Manufacturer, Investors

    Heavily incentive based!

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