LEUVEN'S SUSTAINABLE MODAL SHIFT

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PROJECT GOAL

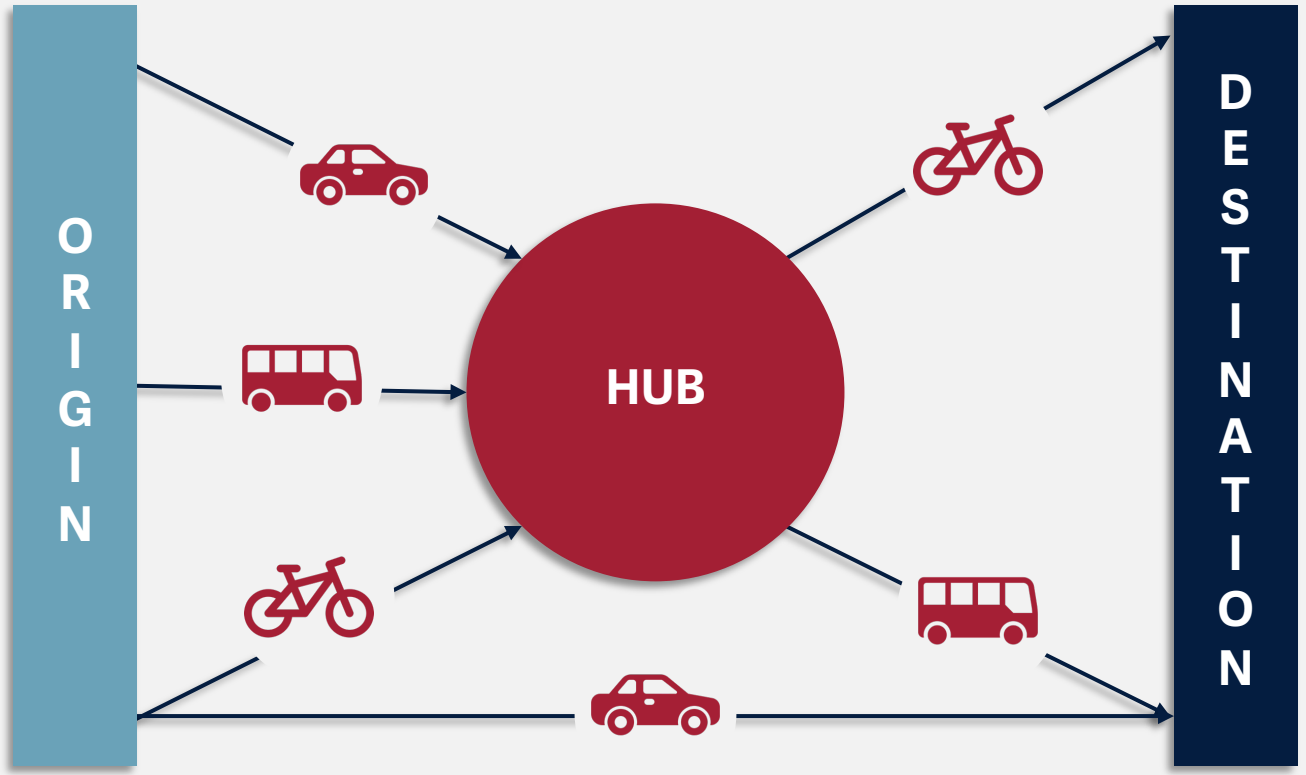
WE ARE OPTIMIZING THE LOCATIONS OF MOBILITY HUBS FOR THE BELGIAN CITY OF LEUVEN

LEUVEN'S GOALS

1. Become a **climate-neutral** municipality
2. Shift towards **sustainable transport system**
3. Strongly **reduce traffic congestions** due to private cars

Create mobility hubs throughout the city

EXAMPLE: HUBS ENABLE MODE CHANGES



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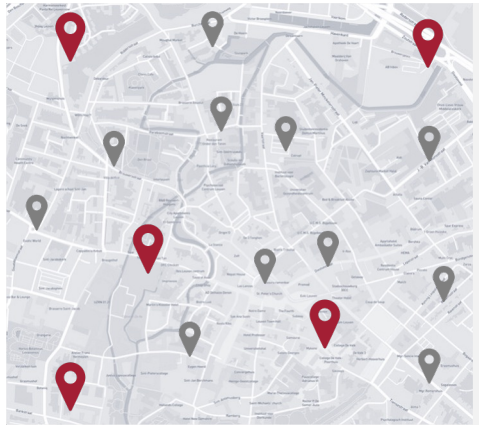
OPTIMIZATION MODEL

THE MULTI-OBJECTIVE MIXED-INTEGER MODEL MINIMIZES BOTH CO2 EMISSIONS AND TRAVEL TIME

Decision Variables



1. Activation of optimal hubs from subset of candidates ❱ 103 binary variables

2. Expected flow by mode depending on activated hubs ❱ 30m continuous variables

Objective Function

Minimize Total **CO2** emissions $+ \gamma \times$ Total travel **time**

γ: willingness to accept higher travel times for lower emissions

Con-straints

- Maximum hub number
- Balanced flow
- Demand satisfaction
- Bike/parking availability

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MAIN RESULT

By making a 30-minute Leuven commute **5** minutes longer, we can save the CO_2 emissions of **6300** car trips per day.

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CONSERVATIVE SCENARIO

By leaving Leuven travel times practically **unchanged**, we can save the **CO_2 emissions** of **1050** car trips **per day.**

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MANAGERIAL RECOMMENDATIONS

INSTALLING 20 HUBS WILL SAVE THE CO2 EMISSIONS OF AROUND 600 CARS PER DAY

RECOMMENDATIONS

1

Install 20 hubs at the locations proposed by the model

- Reduced emissions of 7,500 kg CO_2 per day
- 20 hubs yield the best CO2/time trade-off for a medium-high budget

2

Expand bike sharing and car parking at hub locations:

- Every hub requires a bike sharing station (e.g., Bluebike)
- Expand parking opportunities at hubs to enable “park and ride“

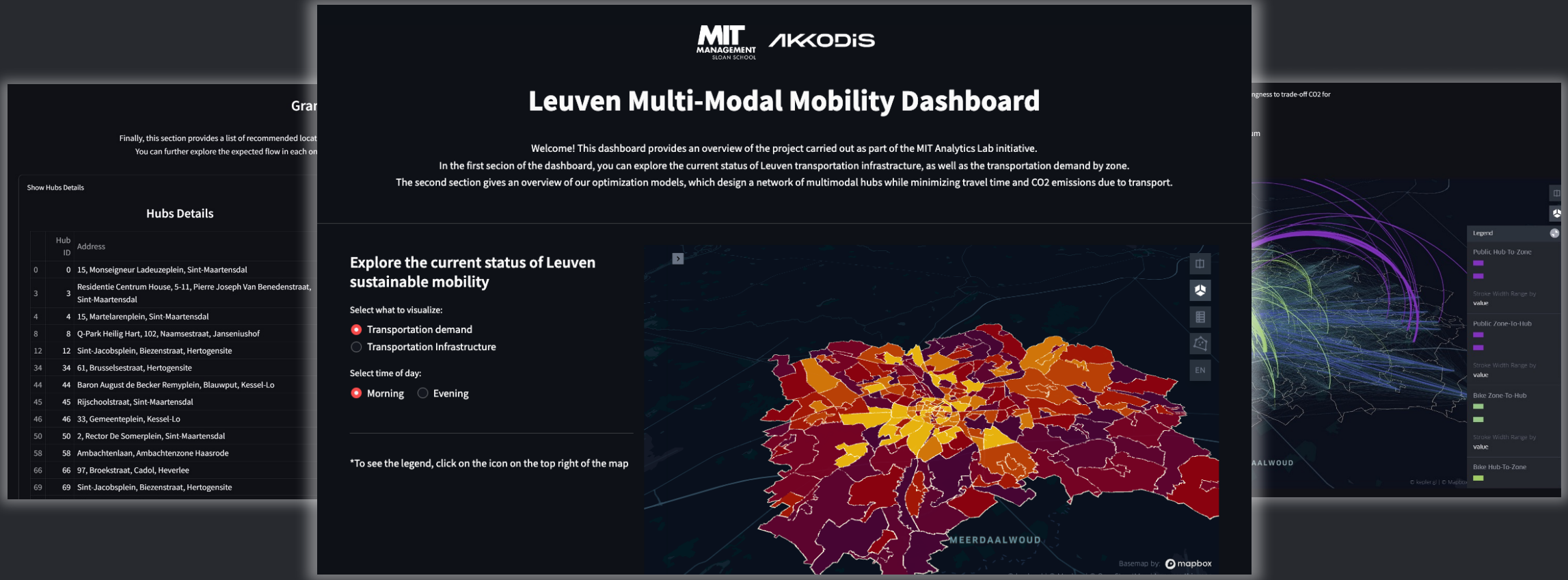
3

Incentivize hub usage

- Examples: reduced cost of travel when using hub, ad campaign
- CO_2 reduction depends on system acceptance by citizens

DASHBOARD

PLAY WITH PARAMETER COMBINATIONS AND ANALYZE RESULTS IN THE DASHBOARD



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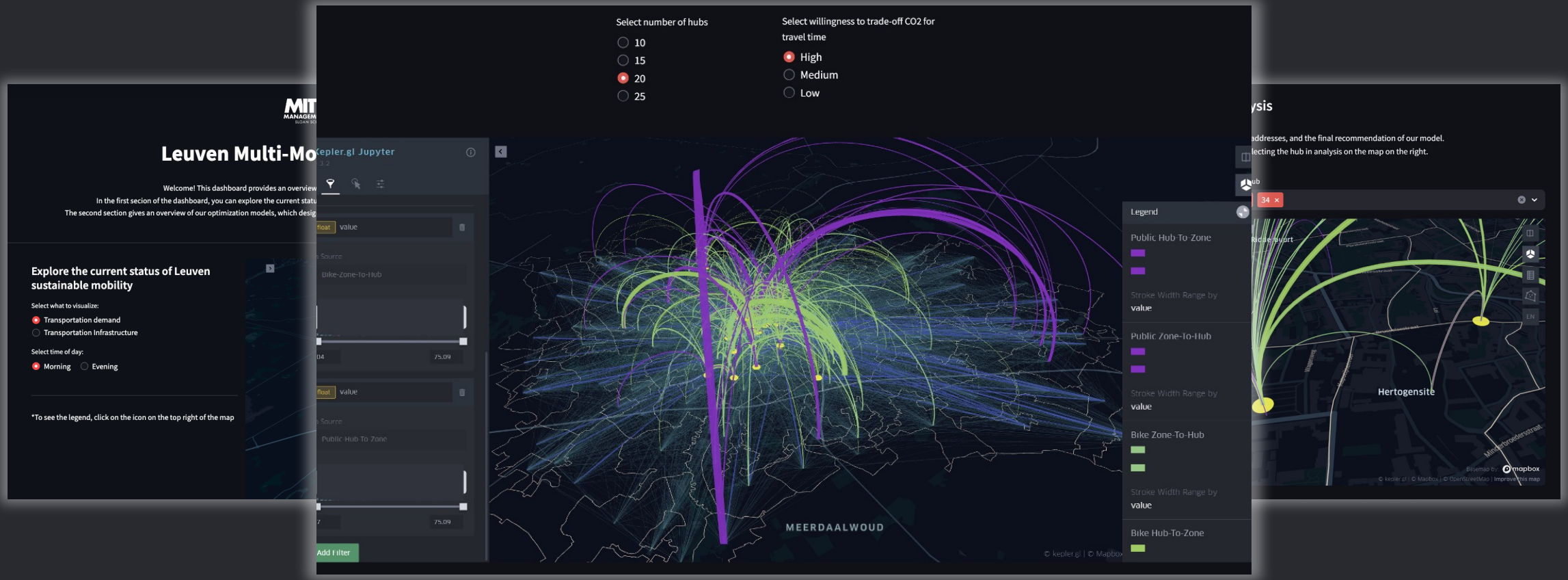

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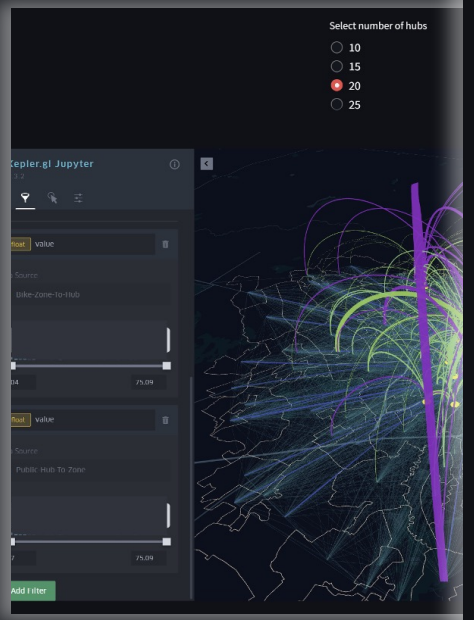


Granular Analysis

Finally, this section provides a list of recommended locations (hubs), their addresses, and the final recommendation of our model.
You can further explore the expected flow in each one of the hub by selecting the hub in analysis on the map on the right.

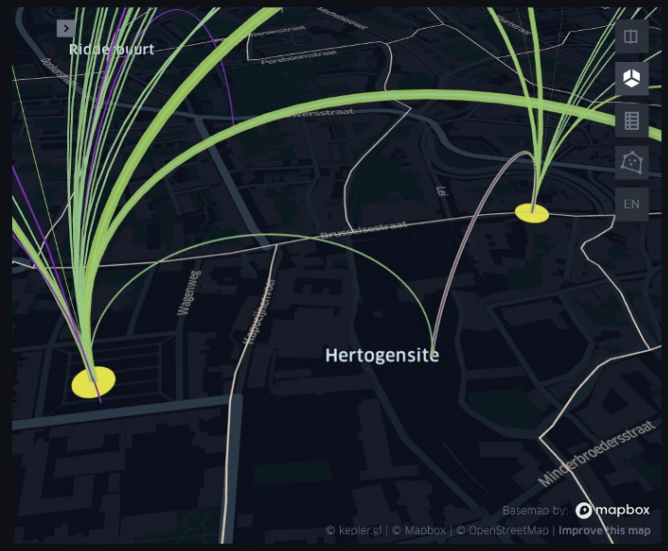
Show Hubs Details

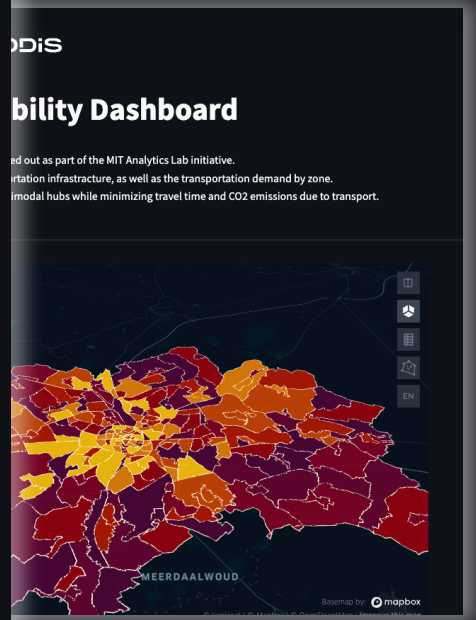
Hubs Details

	Hub ID	Address
0	0	15, Monseigneur Ladeuzeplein, Sint-Maartensdal
3	3	Residentie Centrum House, 5-11, Pierre Joseph Van Benedenstraat, Sint-Maartensdal
4	4	15, Martelarenplein, Sint-Maartensdal
8	8	Q-Park Heilig Hart, 102, Naamsestraat, Janseniushof
12	12	Sint-Jacobsplein, Biezenstraat, Hertogensite
34	34	61, Brusselsestraat, Hertogensite
44	44	Baron August de Becker Remyplein, Blauwput, Kessel-Lo
45	45	Rijschoolstraat, Sint-Maartensdal
46	46	33, Gemeenteplein, Kessel-Lo
50	50	2, Rector De Somerplein, Sint-Maartensdal
58	58	Ambachtenlaan, Ambachtenzone Haasrode
66	66	97, Broekstraat, Cadol, Heverlee
69	69	Sint-Jacobsplein, Biezenstraat, Hertogensite

Select a hub

12 × 34 ×





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THANK YOU!

Leuven's Sustainable Modal Shift

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MATHEMATICAL

THE MATHEMATICAL FORMULATION MODELS THE DIFFERENT SCENARIOS PRECISELY

FORMULATION

$$\min_{a_k} \quad E_{Total} + \gamma T_{Total}$$

where

$$E_{Total} = \sum_{i=1}^{Z}\sum_{j=1}^{Z} CD_{ij}E_{ij(Car)} + \sum_{i=1}^{Z}\sum_{k=1}^{K}\sum_{j=1}^{Z} CH_{ikj}E_{ik(Car)} + \sum_{i=1}^{Z}\sum_{k=1}^{K}\sum_{j=1}^{Z} PH_{ikj}E_{ik(Public)}$$
$$+ \sum_{i=1}^{Z}\sum_{k=1}^{K}\sum_{j=1}^{Z} PZ_{ikj}E_{kj(Public)}$$

$$T_{Total} = \sum_{i=1}^{Z}\sum_{j=1}^{Z} CD_{ij}T_{ij(Car)} + \sum_{i=1}^{Z}\sum_{k=1}^{K}\sum_{j=1}^{Z} CH_{ikj}T_{ik(Car)} + \sum_{i=1}^{Z}\sum_{k=1}^{K}\sum_{j=1}^{Z} BH_{ikj}T_{ik(Bike)}$$
$$+ \sum_{i=1}^{Z}\sum_{k=1}^{K}\sum_{j=1}^{Z} BZ_{ikj}T_{kj(Bike)} + \sum_{i=1}^{Z}\sum_{k=1}^{K}\sum_{j=1}^{Z} PH_{ikj}T_{ik(Public)} + \sum_{i=1}^{Z}\sum_{k=1}^{K}\sum_{j=1}^{Z} PZ_{ikj}T_{kj(Public)}$$

s.t.

$$CH_{ikj} + BH_{ikj} + PH_{ikj} = BZ_{ikj} + PZ_{ikj} \qquad \forall i,j \in [Z], \forall k \in [K]$$

$$CD_{ij} + \sum_{k=1}^{K}(CH_{ikj} + BH_{ikj} + PH_{ikj}) = d_{ij} \qquad \forall i,j \in [Z]$$

$$BH_{ikj} \le M * CN_{ik(BH)} * \alpha_k \qquad \forall i,j \in [Z], \forall k \in [K]$$

$$PH_{ikj} \le M * CN_{ik(PH)} * \alpha_k \qquad \forall i,j \in [Z], \forall k \in [K]$$

$$PZ_{ikj} \le M * CN_{ij(PZ)} * \alpha_k \qquad \forall i,j \in [Z], \forall k \in [K]$$

$$BZ_{ikj} \le M * CN_{ij(BZ)} * \alpha_k \qquad \forall i,j \in [Z], \forall k \in [K]$$

$$CH_{ikj} \le M * \alpha_k \qquad \forall i,j \in [Z], \forall k \in [K]$$

$$\sum_{i=1}^{Z}\sum_{j=1}^{Z} BZ_{ikj} \le B_k \qquad \forall k \in [K]$$

$$\sum_{i=1}^{Z}\sum_{j=1}^{Z} PZ_{ikj} \le P_k \qquad \forall k \in [K]$$

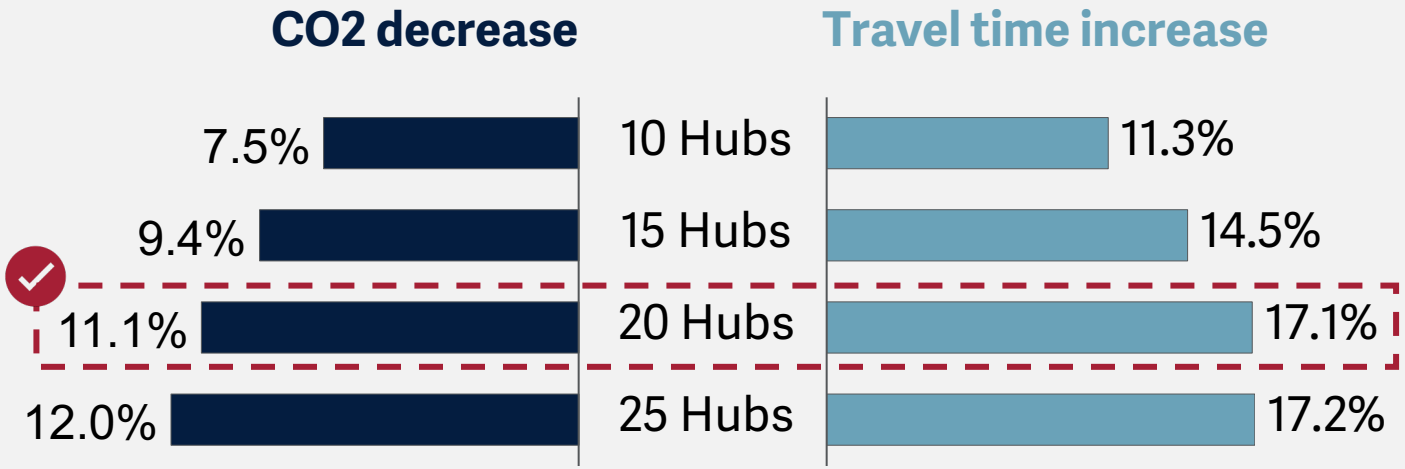
$$\sum_{k=1}^{K} \alpha_k \le MH$$

$$\alpha_k \in \{0,1\} \qquad \forall k \in [K]$$

$$CD_{ij}, CH_{ikj}, PH_{ikj}, BH_{ikj}, PZ_{ikj}, BZ_{ikj}, E_{Total}, T_{Total} \ge 0 \qquad \forall i,j \in [Z], \forall k \in [K]$$

INSTALLING 20 HUBS WILL YIELD A CO2 REDUCTION OF >11% FOR LEUVEN AND ITS CITIZENS

RESULTS BASED ON NUMBER OF HUBS



Assuming realistically high acceptance of higher travel times for lower CO_2 emissions ($\gamma = 0.86$).

RECOMMENDATIONS

1. **Install 20 hubs:** this combination of hubs yields the best CO2/time trade-off
2. **Expand bike sharing and car parking:** every hub requires a bike station
3. **Incentivize hub usage:** CO_2 reduction depends on system acceptance by citizens

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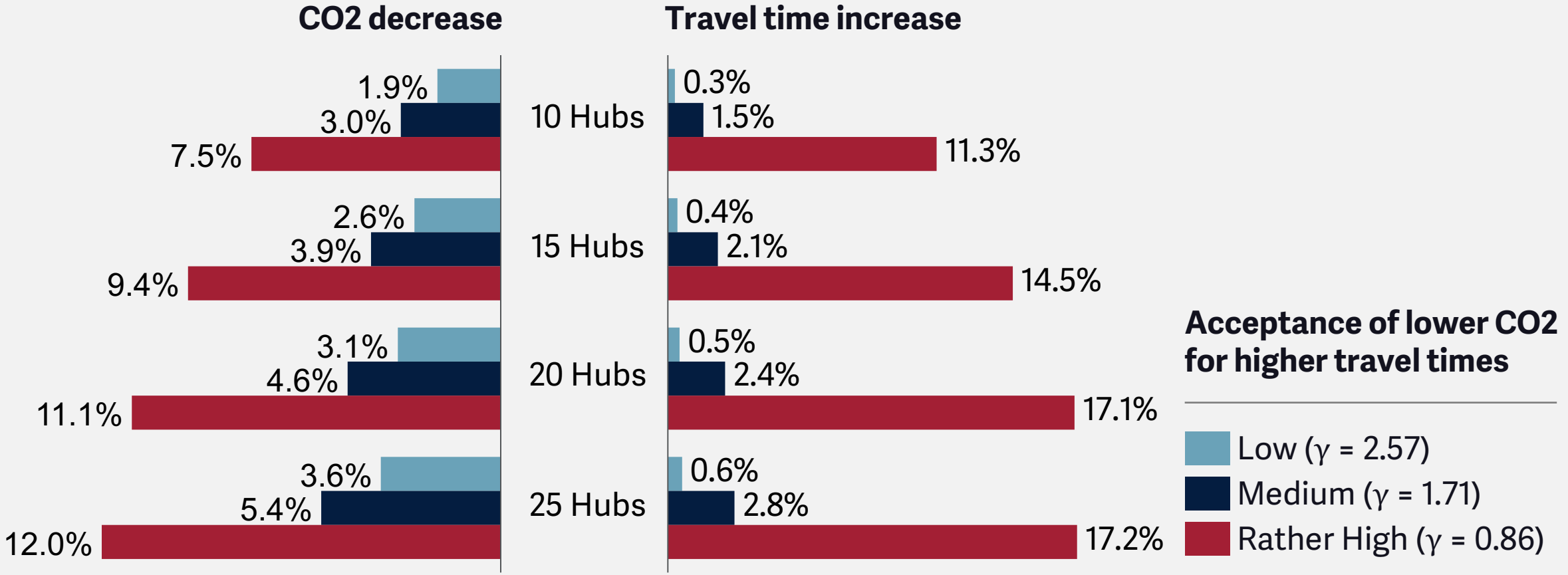
PARAMETRIZATION

THE RESULTS OF THE MODEL ARE MOST INFLUENCED BY THE TRADE-OFF AND MAXIMUM HUBS PARAMETERS



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