University of Antwerp
TPR | Research Group Transport and Regional Economics

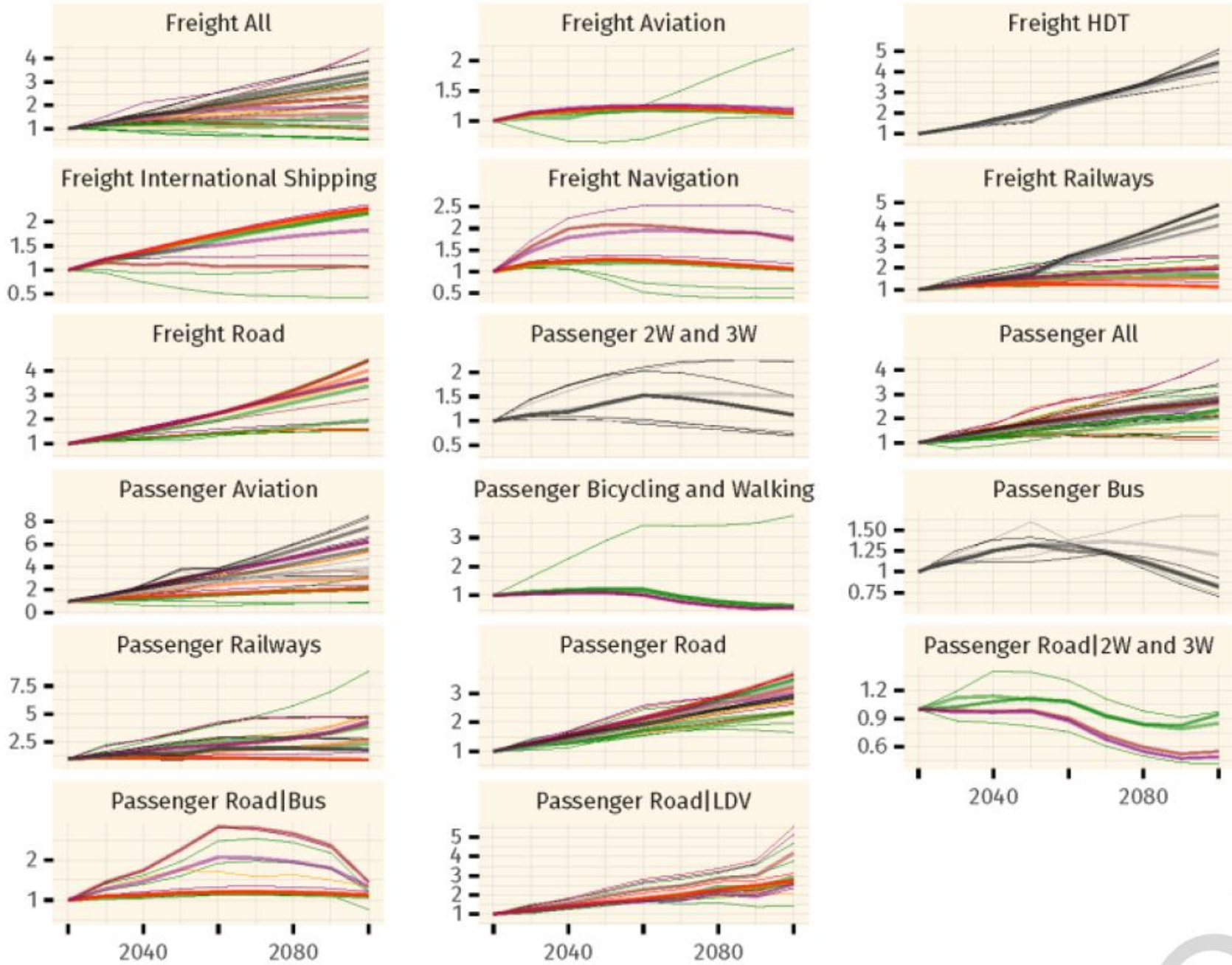
Mobility of the future

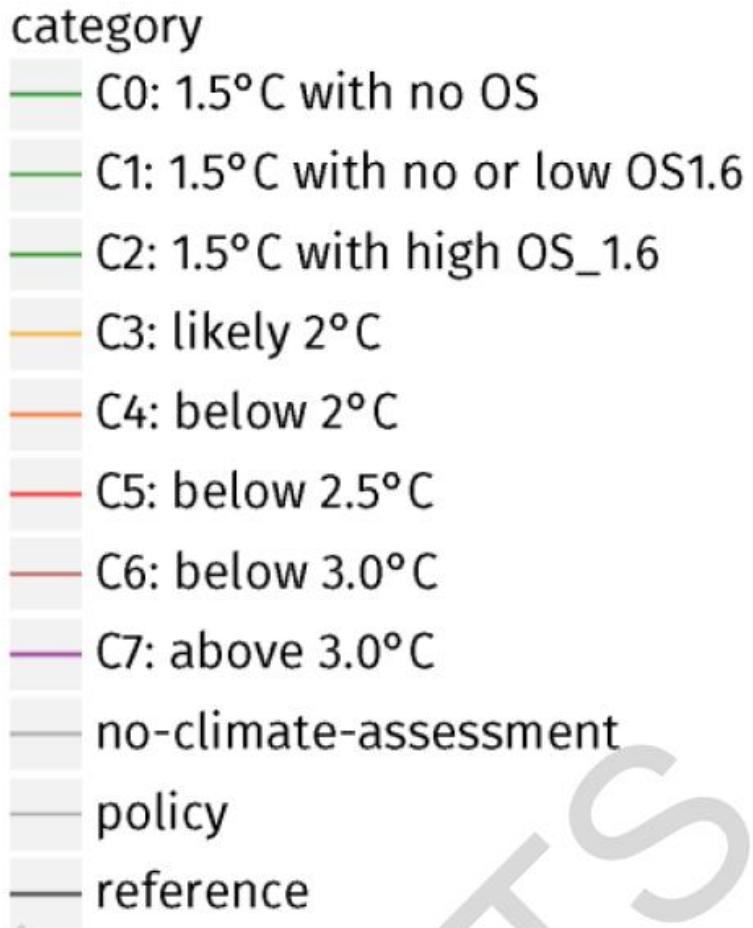
Prof. Thierry Vanelslander
University of Antwerp

Situation with respect to decarbonisation

- Global freight transport, measured in tonne-kilometres (tkm), grew by 68% between 2000 and 2015 and is projected to grow 3.3 times by 2050 (ITF 2019)
- Heavy-duty vehicles (HDVs) make a disproportionate contribution to air pollution, relative to their global numbers, because of their substantial emissions of particulate matter and of black carbon with high short-term warming potentials (Anenberg et al. 2019)
- Climate change impacts such as extremely high temperatures, intense rainfall leading to flooding, more intense winds and/or storms, and sea level rise can seriously impact transport infrastructure, operations, and mobility for road, rail, shipping, and aviation.

Transport activity by mode — World [Index, 2020 level = 1.0] (fig_6-AR6_snapshot-norm)





Situation (2)

- Available evidence suggests that transport-related CO_2 emissions would need to be restricted to about 2 to 3 Gt in 2050 (1.5°C scenario-1.5DS, B2DS), or about 70 to 80% below 2015 levels, to meet the goals set in the Paris Agreement.
- Avoid - Shift - Improve
- Infrastructure - Pricing - Regulation

Infrastructure

- Urban form
- Autonomous vehicles
- Battery-electric (LIB) vehicles (Electronic Road Systems?)
- Hydrogen (ammonia or menthanol) fuel cells?
- Large-scale investments in low-carbon transport infrastructure
- (Biofuel and hydrogen)
- Intersectoral deployment
- Critical minerals, resource availability

Pricing

- R&D support
- Investment support
- Charging for external costs, mode shift

Regulation

- Urban behaviour
- Vehicle and fuel efficiency standards
- Supportive planning policy, building regulations
- Emission reporting
- ‘Poseidon’ rules
- Design standards
- LNG/CNG, biofuels, Ammonia, synthetic fuels: mainly for long-distance transport modes
- Labour rights, non-climate impacts

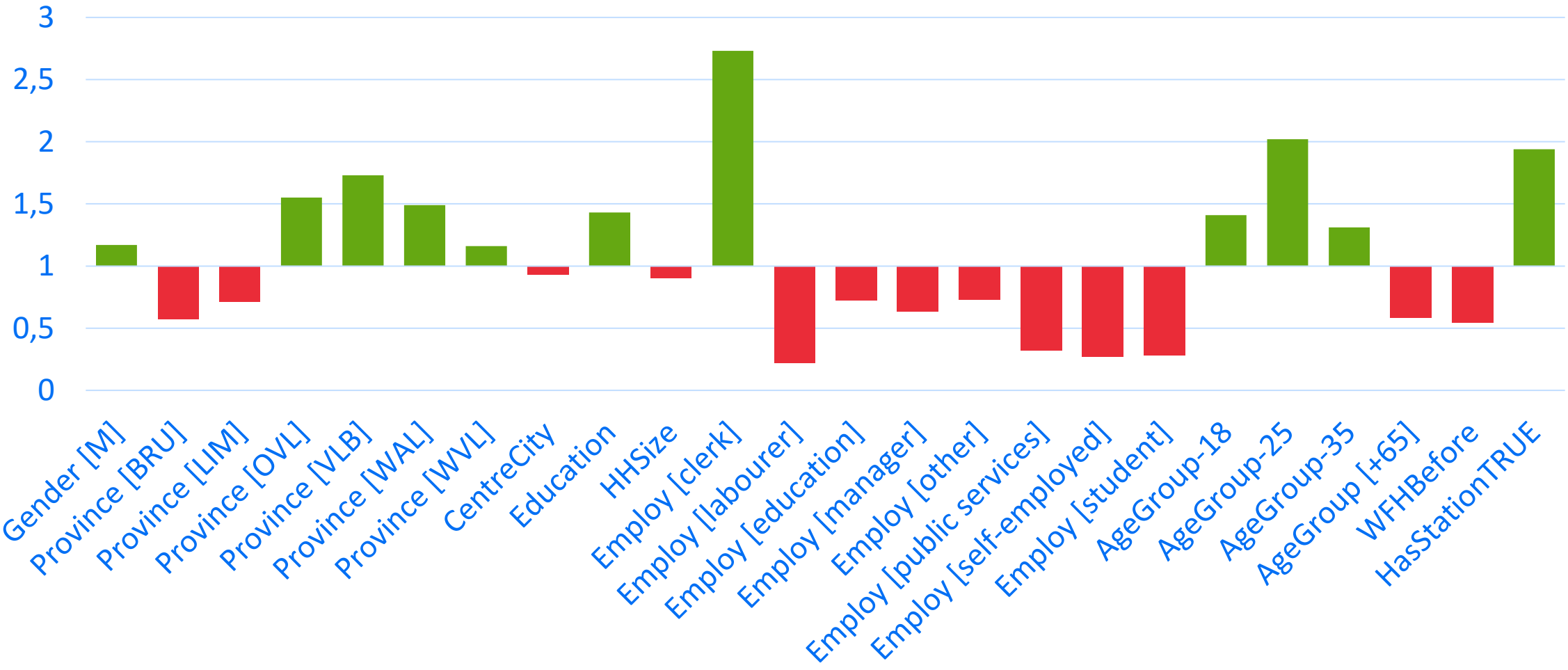
Conclusion on decarbonisation

- A substantial package of measures needed
- No unique recipe, but clear differences in performance
- No exact science: human behaviour
- Consistency and follow-up
- Decarbonisation will need to go hand in hand with ‘classical’ characteristics.

University of Antwerp
TPR | Research Group Transport and Regional Economics

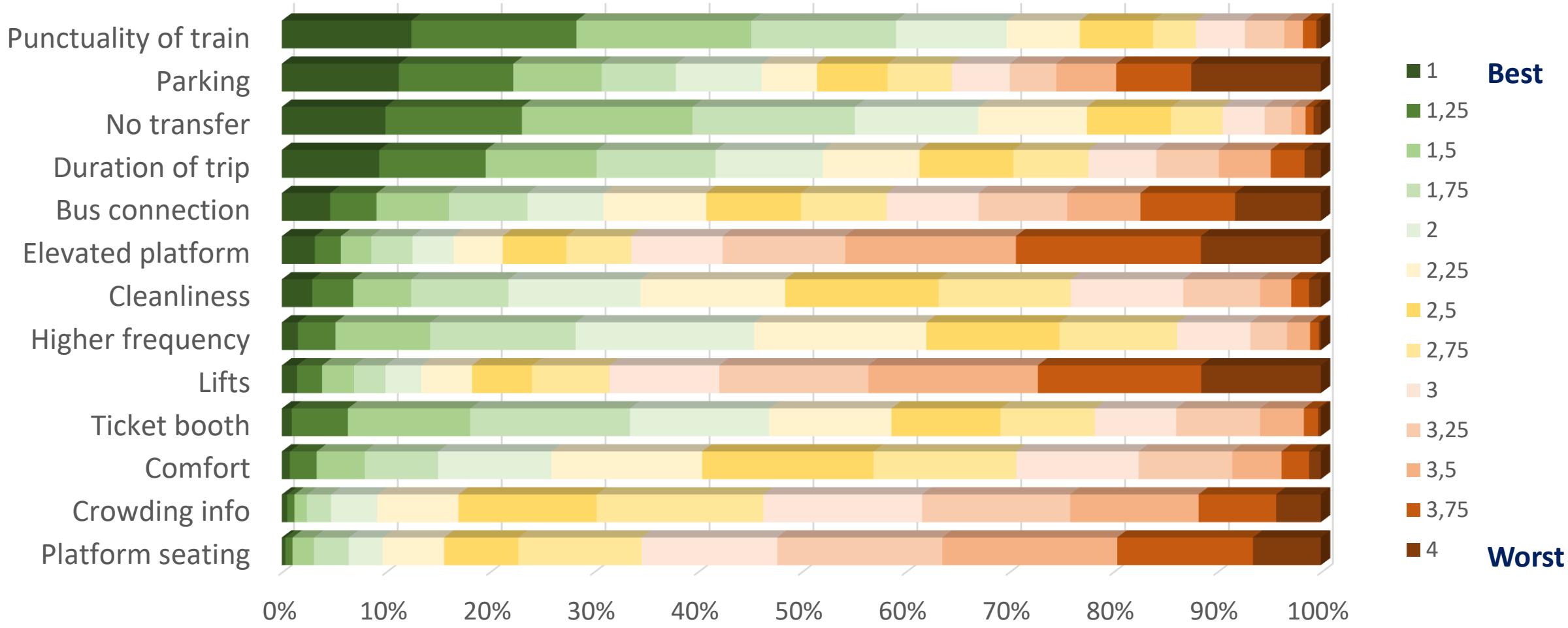
People transport

Who are the train drivers today?



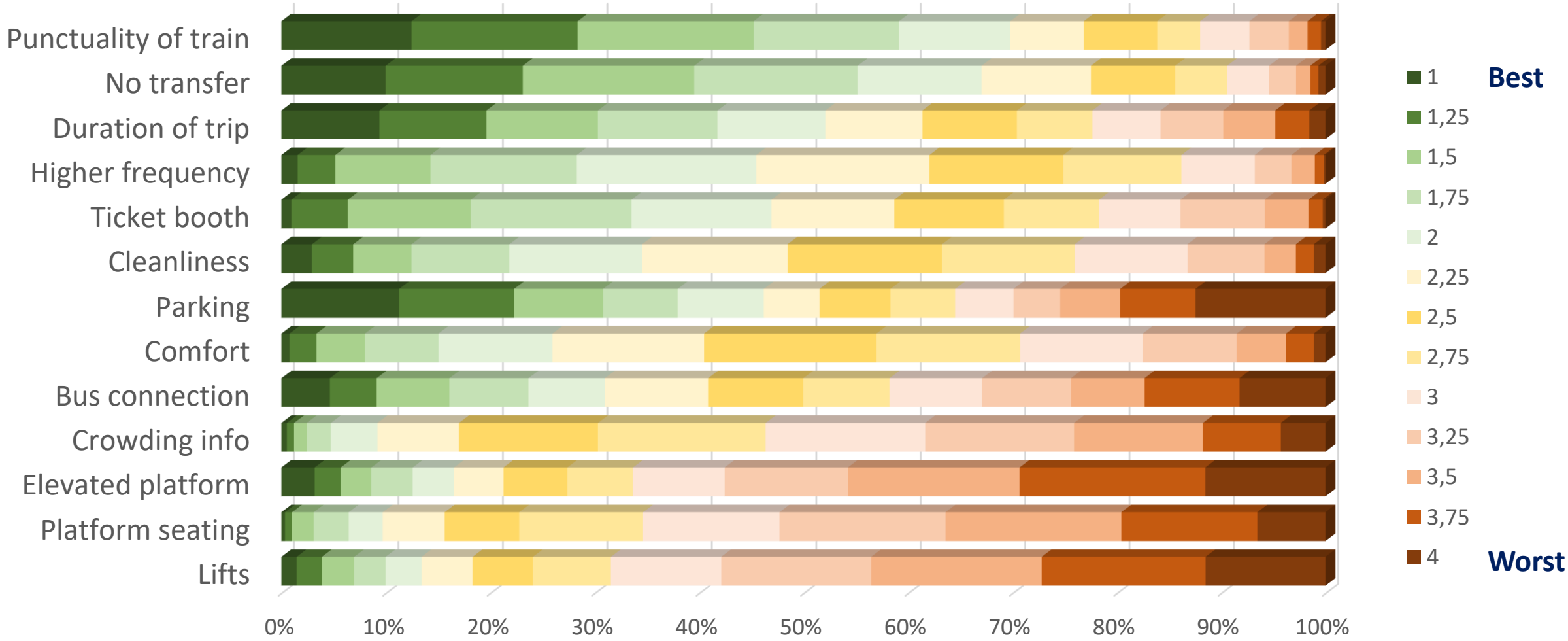
Source: Own composition based on The big corona study (2020)

Criteria, based on MOST important feature



Source: Own composition

Criteria, based on AVERAGE score



Source: Own composition

University of Antwerp
TPR | Research Group Transport and Regional Economics

Freight transport

1. Choice drivers

- Survey held among a wide sample of shippers and freight forwarders
- Focus on port hinterland mode choices

Results

- **Importance of factors**

	Reliability	Flexibility	Loss/Damage	Frequency	Cost	Transport time	Customer service	Environment
Importance	4,8	3,95	4,6	3,85	4,1	3,6	4,35	2,5

- **Performance on factors**

Performance road	reliability	flexibility	loss/damage	frequency	cost	transport time	customer service	environment
	3,85	4,35	3,75	4,40	3,45	4,10	4,00	2,30
Performance intermodal	reliability	flexibility	loss/damage	frequency	cost	transport time	customer service	environment
	3,80	3,25	4,10	3,40	3,95	3,20	3,65	3,95

- **Mixed picture: intermodal (rail / barge) performs well on certain important criteria (blue), but weak on others (red).**

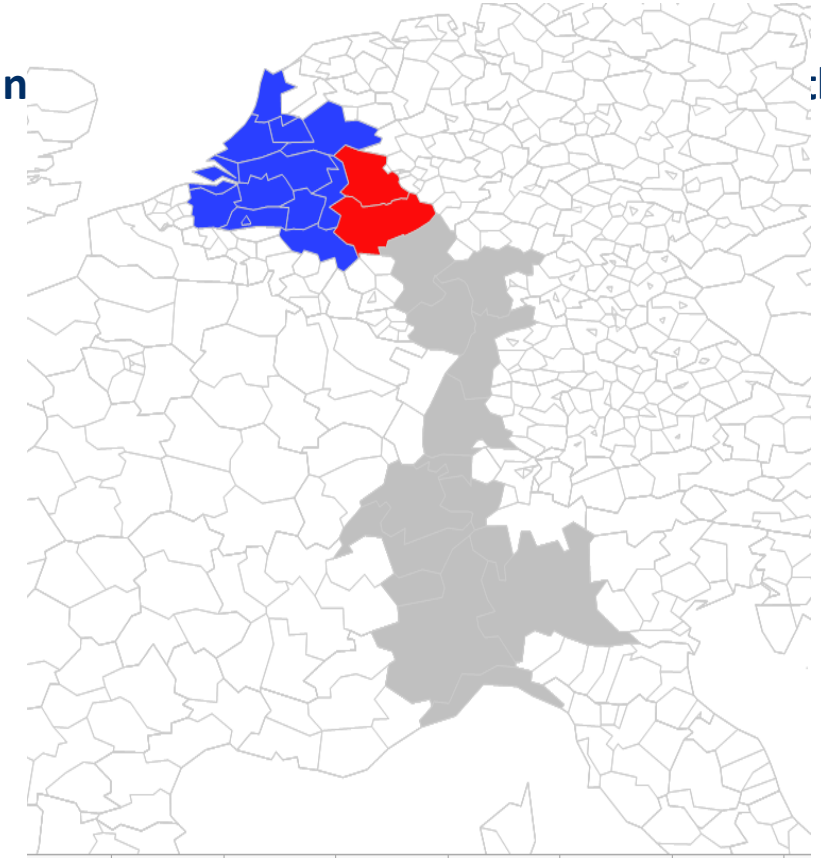
2. Impacts of policy measures

- Long-distance freight transport
- Focus on containers
- Indicators to assess alternative scenarios against a baseline scenario (business as usual) to study the mode shift and emission reduction potential: tonne.km, TEU.km, veh.km, CO_2 emissions
- Two scenarios: BAU and Pro Rail

The setting

- **Rhine-Alpine (RALP) from Rotterdam via Duisburg and Basle to Genova and the southern branch of the RFC.**

- **One of the two main freight corridors crossing Germany an :h-Rhine Westphalia (NRW)**



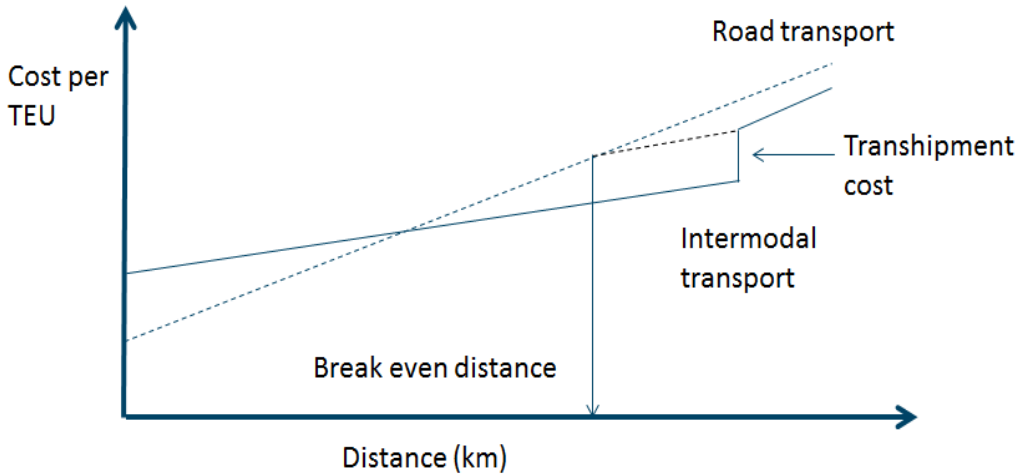
The procedure

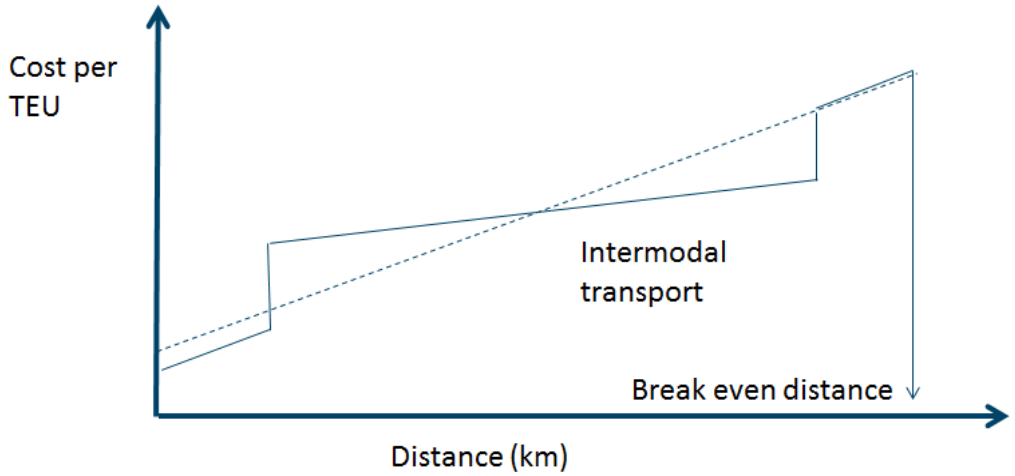
- **For each corridor, an O-D matrix is set up containing the total outgoing and incoming cargo flows for each zone (NUTS-2) including the cargo flows between the different zones.**
- **For each freight corridor there are different types of cargo flows:**

  - Destination in NRW (yellow)
  - Origin in NRW (blue)
  - Transit through (green)
  - Internal NRW flows (red)

	BE25	BE23	BE21	BE22	BE24	BE10	BE33	NL34	NL33	NL32	NL31	NL22	NL41	NL42	DEA1	DEA2	DEB1	DEB3	DE71	DE12	DE13	CH03	CH02	CH01	CH06	CH07	ITC2	ITC4	ITC1	ITC3
BE25															9,270	9,075	1,845	1,429	2,563	2,867	3,008	372	284	268	146	15	37	4,320	2,000	37
BE23															11,492	11,572	2,268	1,771	3,331	3,863	3,772	355	390	355	184	18	39	4,890	2,432	205
BE21															20,513	20,075	4,185	3,329	6,562	6,586	6,781	903	582	688	309	35	77	9,399	3,966	392
BE22															8,208	8,377	1,819	1,243	2,357	2,583	2,802	262	181	194	91	10	29	2,864	1,252	113
BE24															3,626	3,468	703	528	1,026	1,097	1,144	134	98	100	50	6	11	1,570	669	57
BE10															970	1,015	237	151	262	250	249	20	14	15	8	0	2	251	118	10
BE33															7,997	8,037	1,714	1,538	2,220	2,553	2,790	239	212	185	99	9	30	3,108	1,547	125
NL34															9,118	7,043	1,396	1,278	1,853	2,248	2,406	267	202	187	104	13	10	1,202	516	38
NL33															38,688	31,125	6,794	7,510	10,625	10,485	11,332	1,679	1,183	1,269	633	69	49	7,139	2,781	221
NL32															12,217	9,730	2,094	1,758	3,039	3,142	3,474	467	346	348	173	21	16	2,253	903	66
NL31															5,866	4,849	1,064	923	1,580	1,591	1,729	232	172	181	91	11	33	1,093	444	33
NL22															22,176	17,709	3,810	3,188	5,668	5,821	6,560	791	584	602	305	38	28	3,995	1,617	120
NL41															39,207	32,275	6,632	6,470	9,752	10,525	11,314	1,346	1,050	1,075	559	65	51	6,978	2,960	222
NL42															25,780	21,737	4,535	3,881	6,364	7,003	7,536	823	622	635	334	44	29	3,786	1,570	117
DEA1	12,768	13,958	29,614	13,462	6,706	2,465	9,470	9,075	43,000	13,779	9,742	38,404	55,524	42,330	2,735,948	614,806	74,444	6,237	20,367	2,951	277	6,801	5,032	3,249	2,213	238	190	19,703	8,606	758
DEA2	11,240	11,895	25,853	11,588	5,774	2,178	7,986	5,590	26,900	8,445	6,233	23,117	34,956	28,979	568,742	2,265,333	167,895	17,346	41,838	6,363	609	5,431	4,052	2,726	1,768	172	139	13,151	6,113	491
DEB1	2,661	3,004	6,157	3,053	1,449	560	2,105	1,648	7,439	2,384	1,766	6,442	9,360	7,941	74,843	194,353														
DEB3	1,770	1,671	4,333	1,612	843	345	1,387	940	5,278	1,452	1,236	4,139	6,455	5,161	4,125	14,232														
DE71	2,298	2,608	5,721	2,346	1,288	427	1,577	1,143	6,516	1,852	1,513	5,045	7,611	5,717	11,190	34,196														
DE12	3,741	4,227	8,716	3,496	1,877	650	2,673	1,632	8,876	2,636	2,102	7,401	11,466	8,461	1,134	3,987														
DE13	4,341	4,855	10,231	4,283	2,134	738	3,294	1,948	9,912	2,994	2,284	8,607	12,470	9,620	50	219														
CH03	698	784	1,613	484	405	107	330	132	804	193	156	589	795	509	4,189	3,780														
CH02	462	588	1,023	308	257	91	274	101	540	135	107	362	571	368	2,520	2,319														
CH01	453	512	1,037	303	266	74	217	73	470	108	92	297	464	289	1,566	1,497														
CH06	388	553	849	266	217	80	254	77	400	102	82	278	432	273	1,993	1,873														
CH07	77	124	154	47	44	22	63	12	64	14	13	42	67	42	291	261														
ITC2	15	14	30	10	5	2	7	2	7	2	2	5	9	7	51	55														
ITC4	2,687	2,259	5,369	1,637	1,047	449	1,759	760	4,617	1,106	979	3,124	4,500	2,775	14,934	12,828														
ITC1	1,745	1,646	3,393	1,044	638	292	1,124	318	1,678	452	374	1,221	1,839	1,160	7,650	7,399														
ITC3	246	187	444	121	80	37	145	58	340	83	70	234	360	218	1,170	955														

- **Maritime flows (left) + continental flows (right)**





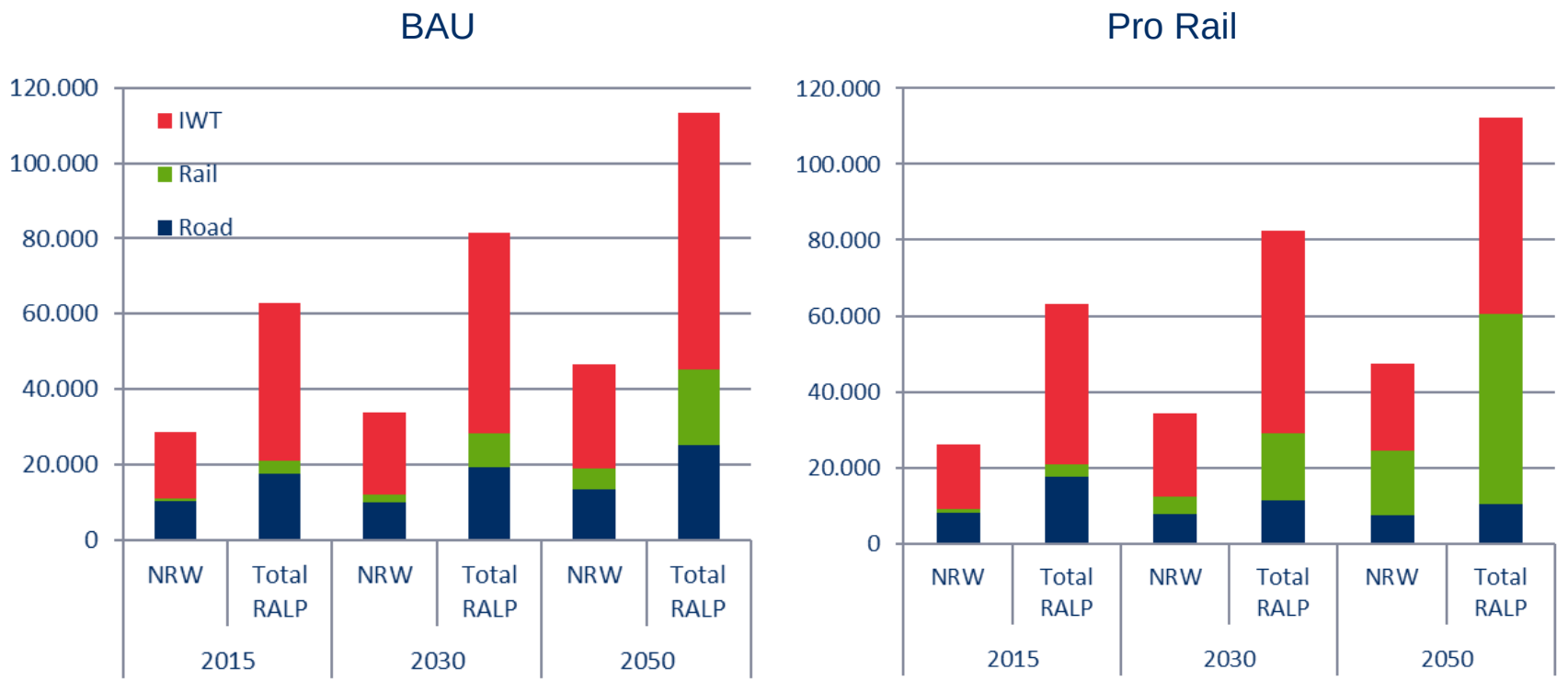
The BAU scenario

Cost Category	Railways	Road haulage
Load factors	Corridor extension to 740m trains; European wagon management and cargo trading platforms	Without longer trucks, only slight improvement possible in loaded hauls and use of truckload space.
	+45 %	+10 %
Infrastructure	Policy plans: halving rail track access charges	No major change to current pricing practices on European motorways
	-20 %	+/-0 %
Rolling stock	Soft removal of regulatory barriers but additional administrative hurdles; better management of wagon fleet	Stop trials with longer and heavier vehicles; some field tests with electrified motorways; more expensive trucks (+20 %), constant maintenance costs
	-25 %	9%
Energy costs	Full electrification (-10 % primary energy demand) and improved energy efficiency through driver assistance (-5 %).	Modest improvement in logistics planning, better aerodynamics (-21 %), driver-assistance systems.
	-12 %	-26%
Labour costs	More or less stable for drivers; decrease for local workers due to automation of terminals and track works.	Competition for truck drivers by higher wages and stronger enforcement of social legislation (driving and rest times, etc.) drives personnel costs up.
	-20 %	+/-0 %
Administrative costs	Productivity increases mainly in administrative structures (+25%); some extra management costs.	Advanced use of IT technologies and networking (-20%); formation of larger haulage companies
	-25 %	-20 %
Total generalised costs	Dominant drivers: rolling stock and energy costs.	Dominant drivers: driver and fuel costs
	-25 %	-19 %

The Pro Rail scenario

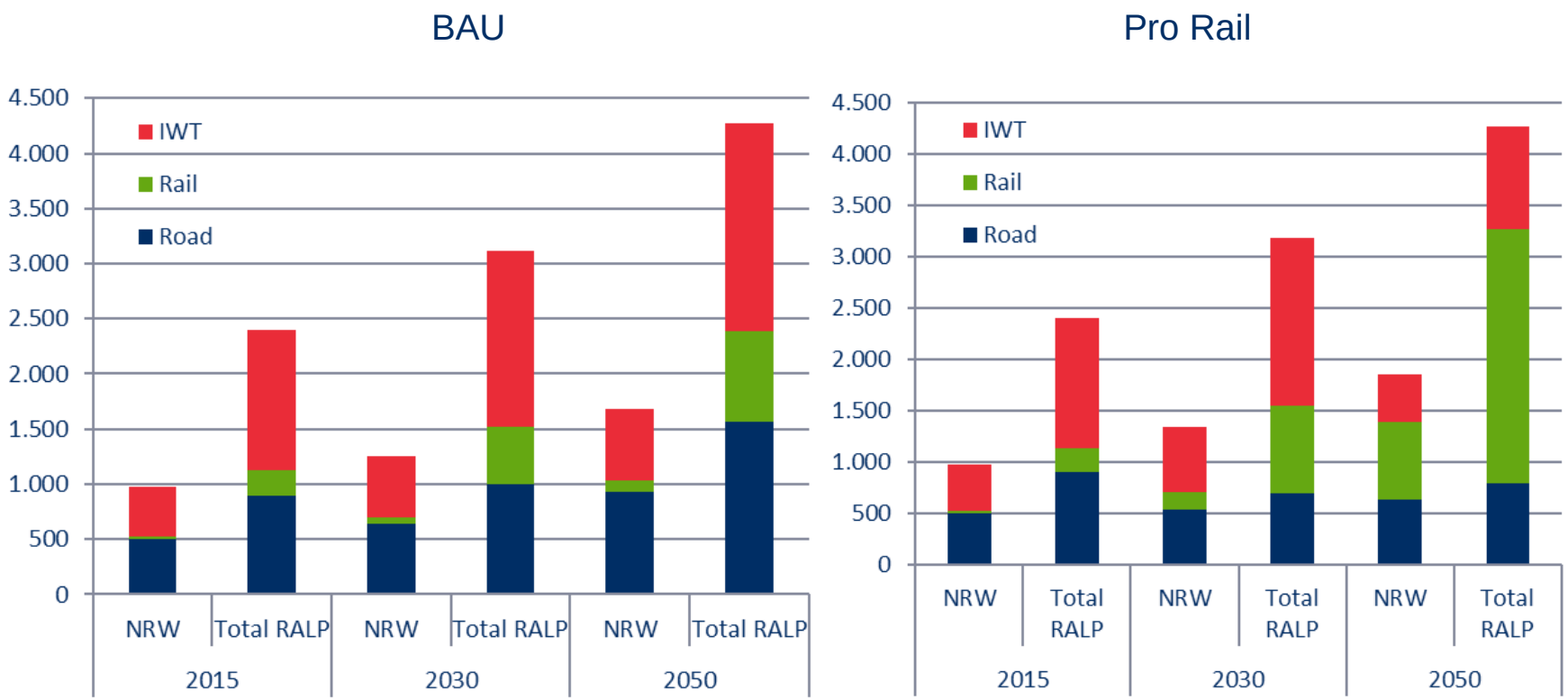
Cost Category	Railways	Road haulage
Load factors	Up to 1500m trains; equal speeds; ETCS level 3; European wagon and cargo management	Without longer trucks, only slight improvement possible in loaded hauls and use of truckload space.
	+209 %	+10 %
Infrastructure	Halving of track access charges by 2030 and marginal cost pricing by 2050	Full cost pricing including surcharges on HGV motorway user tariffs for rail projects
	-75 %	+200 %
Rolling stock	Strong decline in licencing and operating costs for locomotives, modular wagon systems, longer trains and European wagon management	Stricter environmental and safety requirements (capital costs +50 %); multiple fuels and more complex engines; higher environmental taxes and charges
	-60 %	+52%
Energy costs	Engine control. Driver assistance systems and aerodynamics.	Modest improvement in logistics planning, better aerodynamics (-21 %), driver-assistance systems.
	-35 %	-26%
Labour costs	Automation and standardisation, but also more labour-intensive customer demand; strong unions.	Wide restriction of automation; strict enforcement wage levels and of social legislation
	-68 %	+10 %
Administrative costs	Common use of highly efficient IT solutions for management, horizontal cooperation, Big Data and deep learning	Advanced use of IT technologies and networking (-20%); formation of larger haulage companies
	-70 %	-20 %
Total generalised costs	Extremely deep cuts across all cost categories; main driver is train utilization and wagonloads.	Main drivers for increasing costs are infrastructure charges and rolling stock regulations
	-66 %	+25 %

Results ton.km



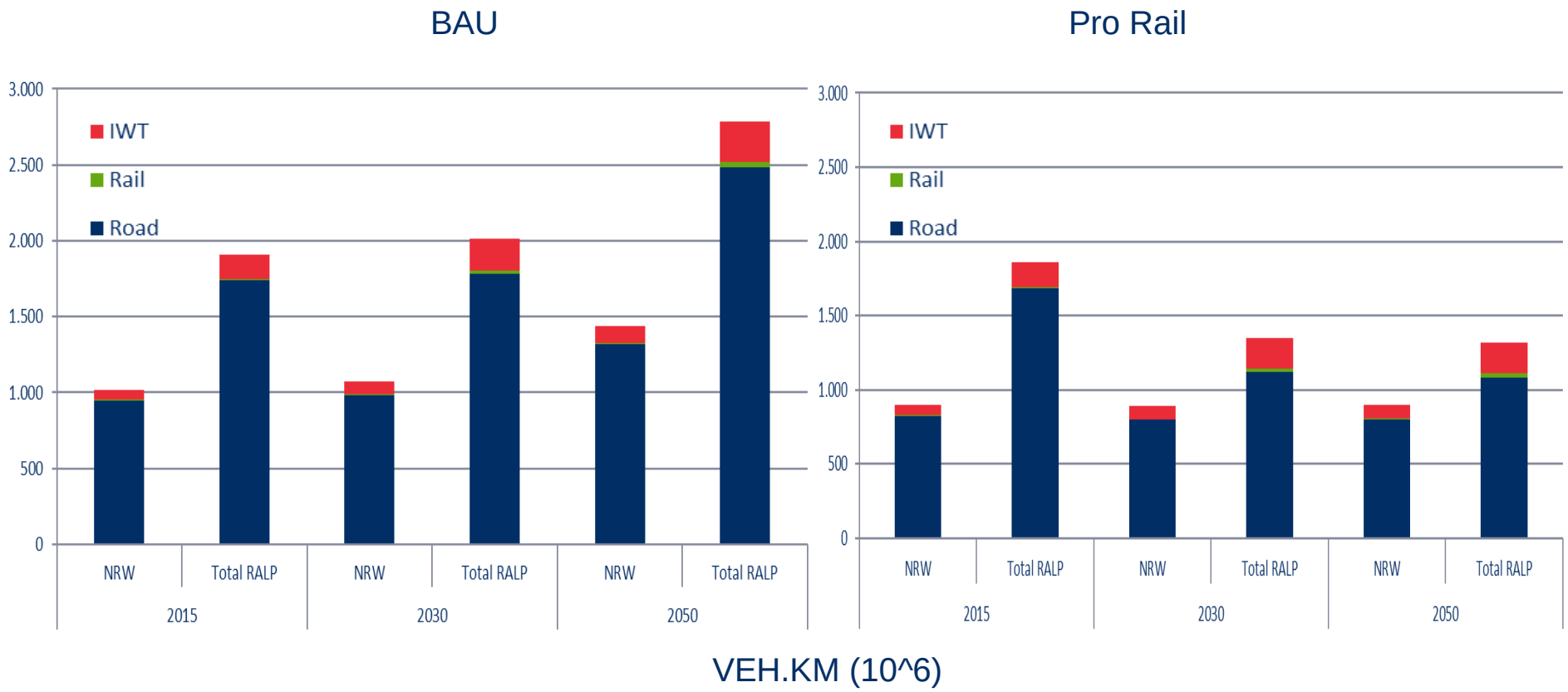
TON.KM (10^6)

Results TEU.km

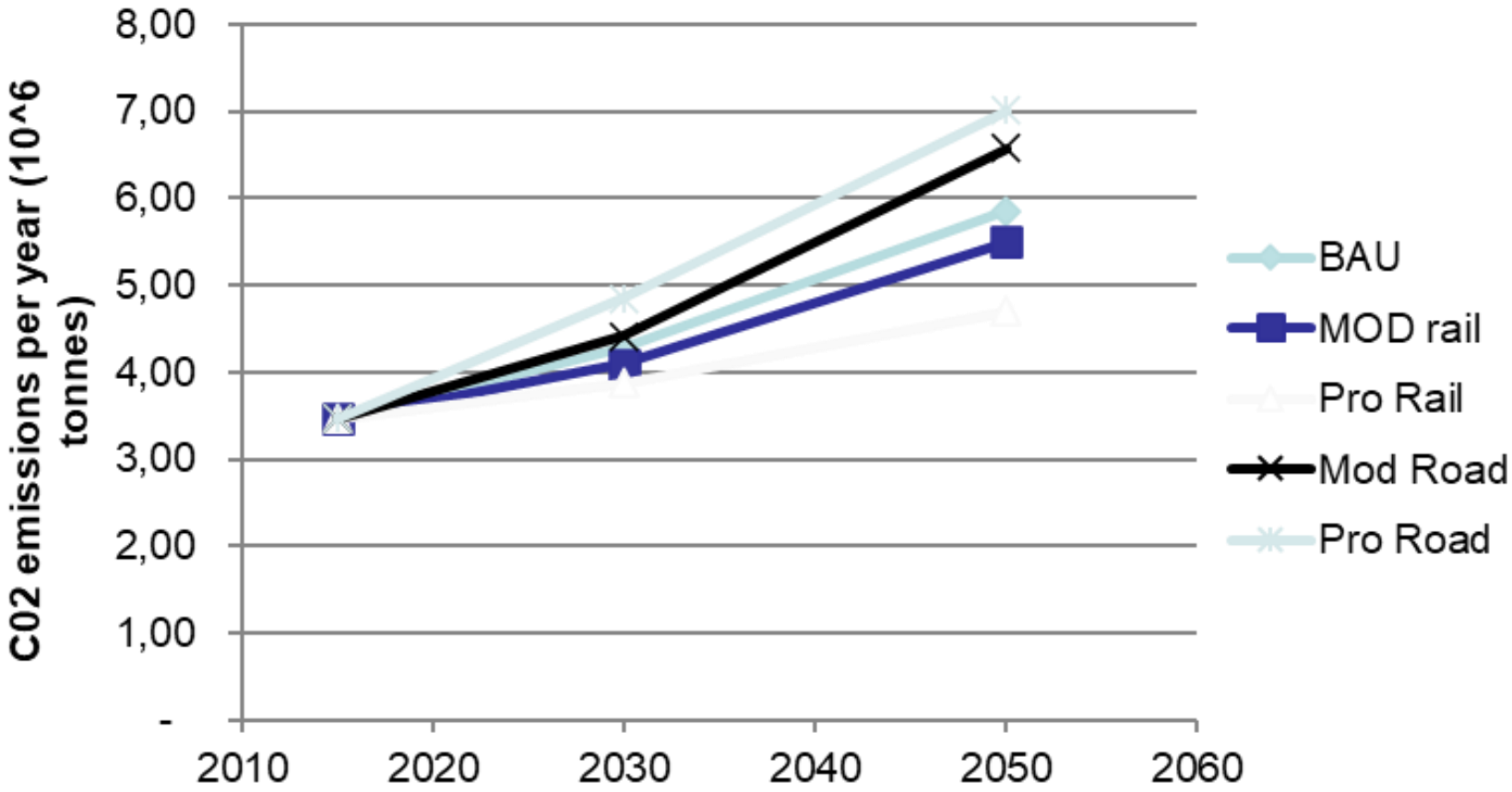


TEU.KM (10^6)

Results veh.km



Results CO_2 emissions



Conclusions on modal shift

- In all scenarios, there is a very large increase in TEU.km, tonne.km and veh.km both on the territory of NRW and on the corridor as a whole. This is caused by the increase in demand for freight transport (1.7% growth).

- With respect to the CO_2 emissions, there is an increase in the absolute volume for all calculated scenarios. The smallest increases are observed for the Pro Rail scenario for both freight corridors (+ 35% per year in 2015 for the RALP corridor and + 53% for the NSB corridor).

3. Road transport solutions?

- Electric road systems
- Network deployment
- International synergies
- Impacts for trucking sector
- Impacts for network operator
- Societal impacts: emission cost

ERS in practice: DE, A5 near Frankfurt Airport

Network deployment

ERS network size depending on investment level, m€

0 m€ = 0km

100 m€ = 69.0km

200 m€ = 148.0km

300 m€ = 224.0km

400 m€ = 305.0km

500 m€ = 376.0km

600 m€ = 459.0km

700 m€ = 535.0km

800 m€ = 611.0km

900 m€ = 692.0km

1000 m€ = 775.0km

1100 m€ = 862.0km

1200 m€ = 942.0km

1300 m€ = 1024.0km

1400 m€ = 1113.0km

1500 m€ = 1195.0km

1600 m€ = 1278.0km

1700 m€ = 1360.0km

1800 m€ = 1442.0km

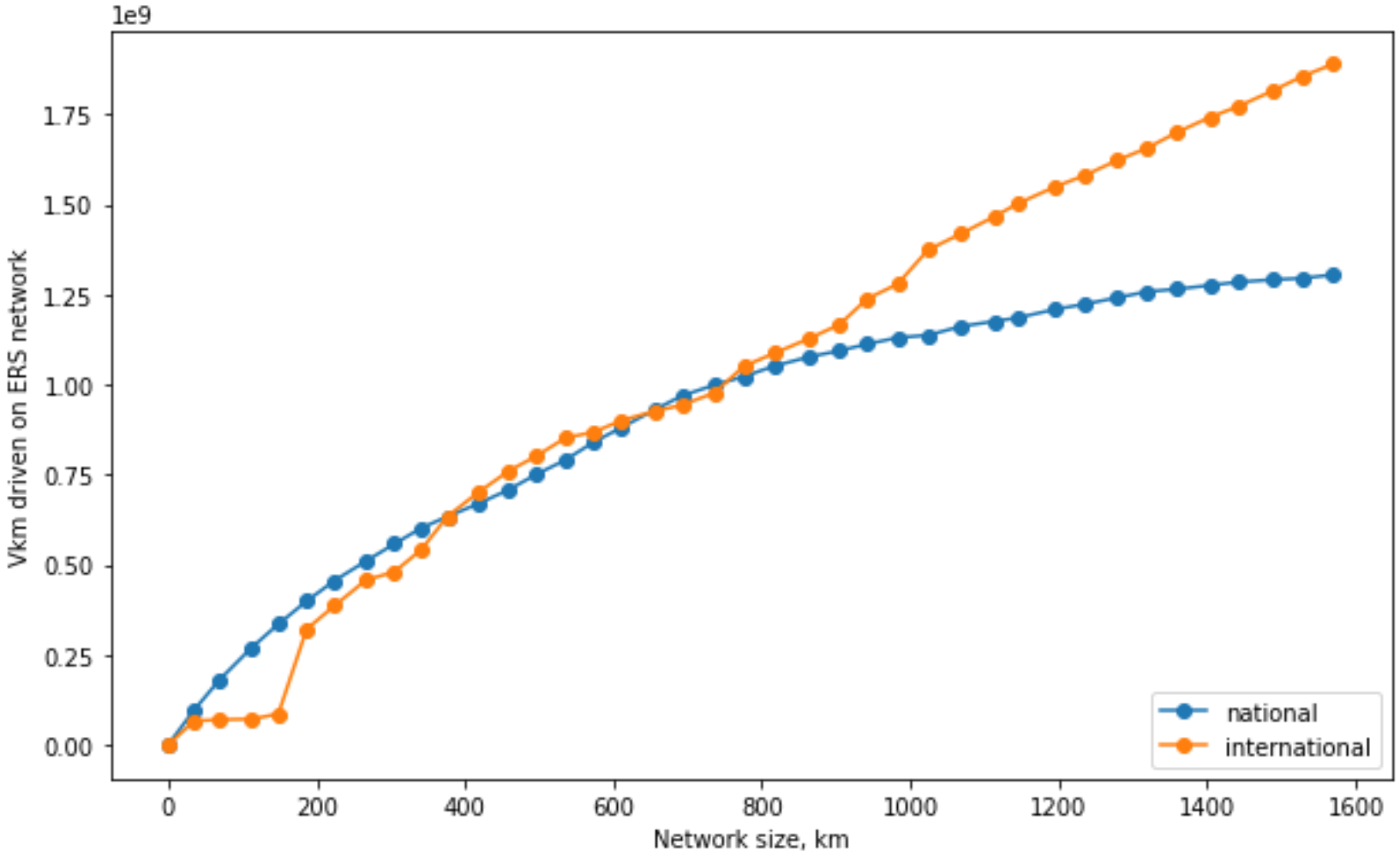
1900 m€ = 1529.0km

Takeaway:

With a modest investment of less than 2 billion €, which is less than 0.8 % of Flanders GDP, extensive coverage of more than 1.5 thousand km of the whole network could be achieved.

International synergies

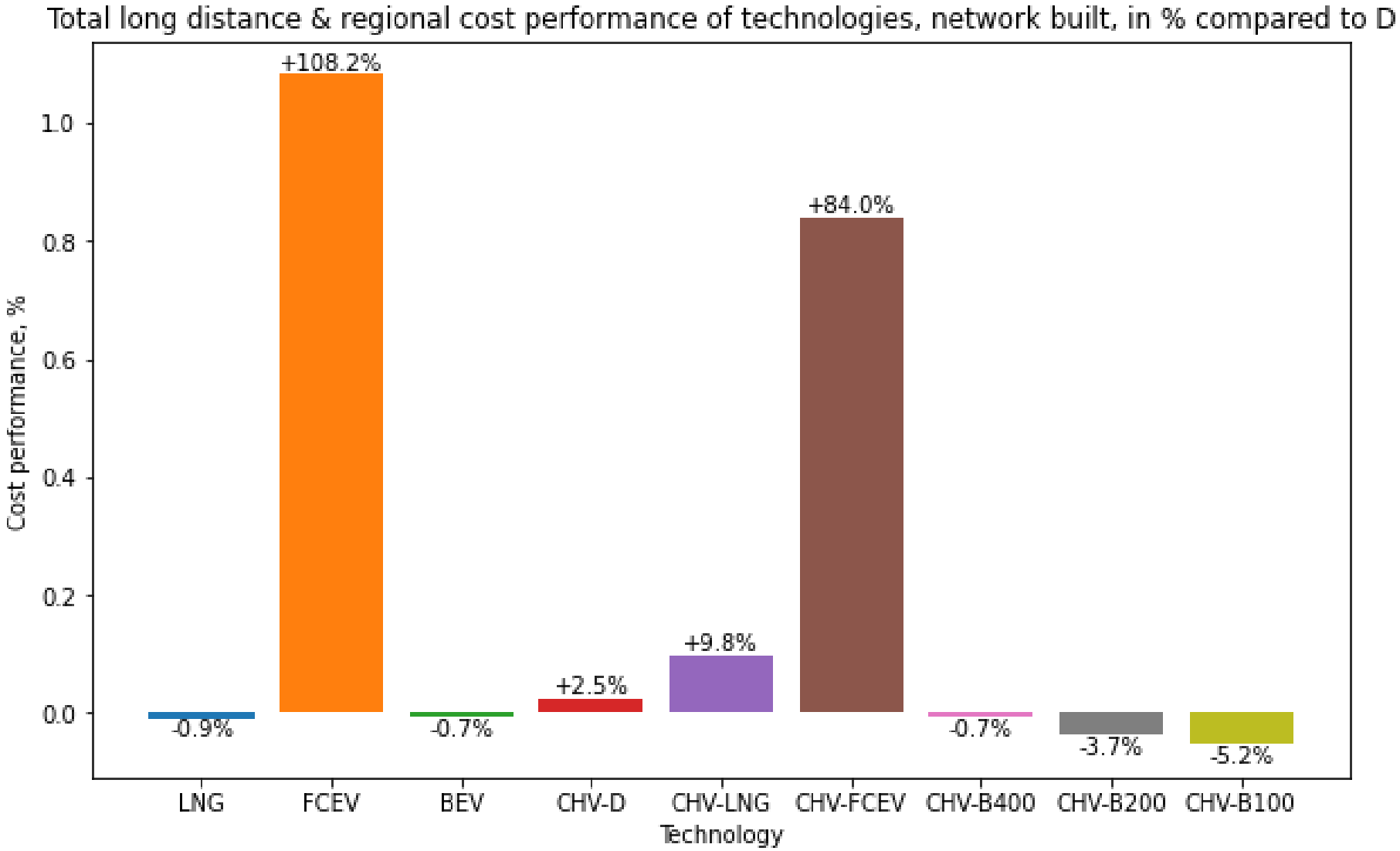
ERS network use depending on the network size, billion vkm



Takeaway:

Strong international synergies from international traffic can be expected. This ensures sustainability of the ERS operator. Synergies intensify with increase in network size.

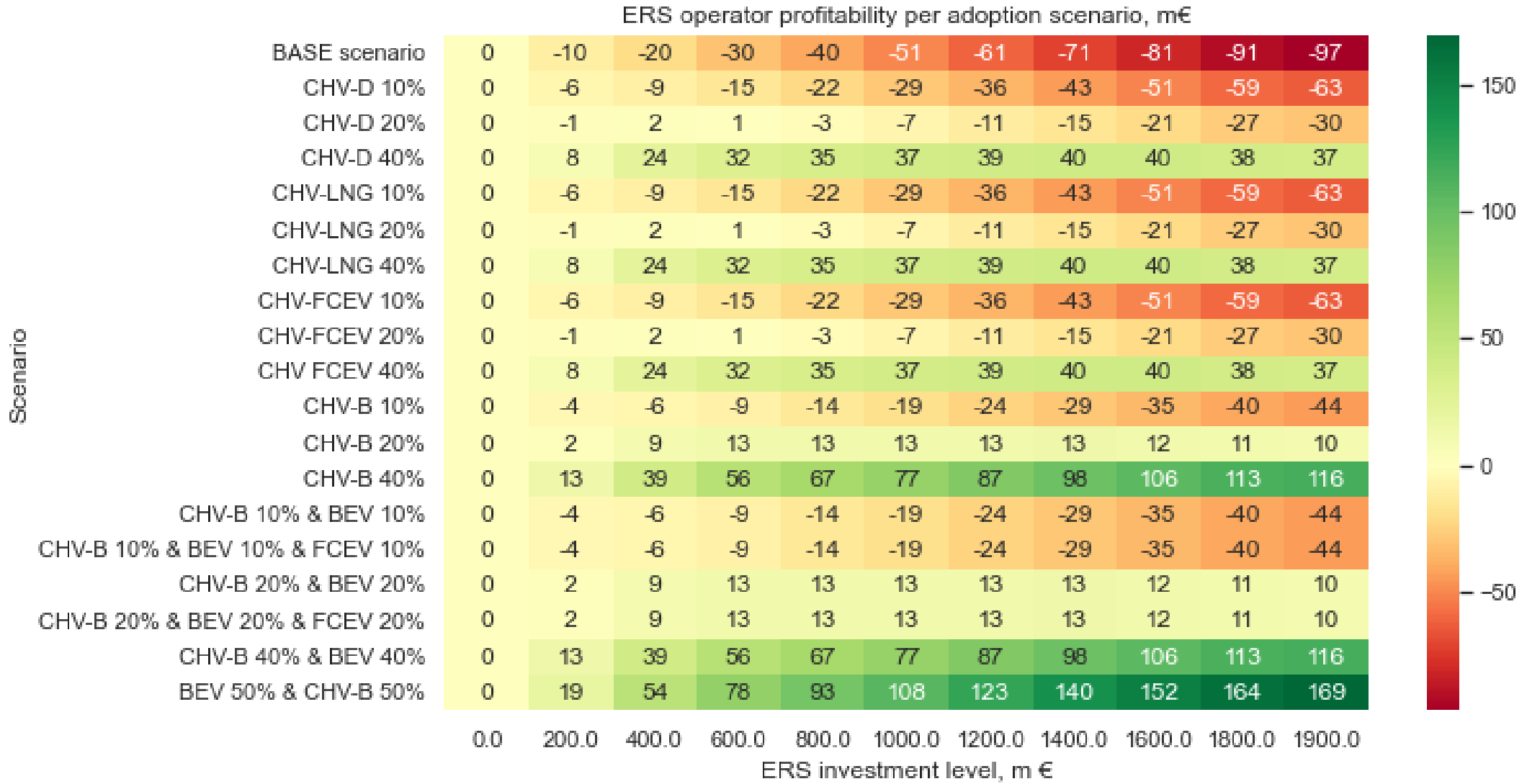
Impacts on trucking sector



Takeaways:

- It is possible to cost-effectively decarbonize road freight transport.
- Use of ERS allows using smaller batteries, which minimises required investment compared to BEVs.
- Operational patterns matter. To maximize ROI road transport operator should maximise ERS network use. With increase in ERS network use and size, the benefits to its users increase.

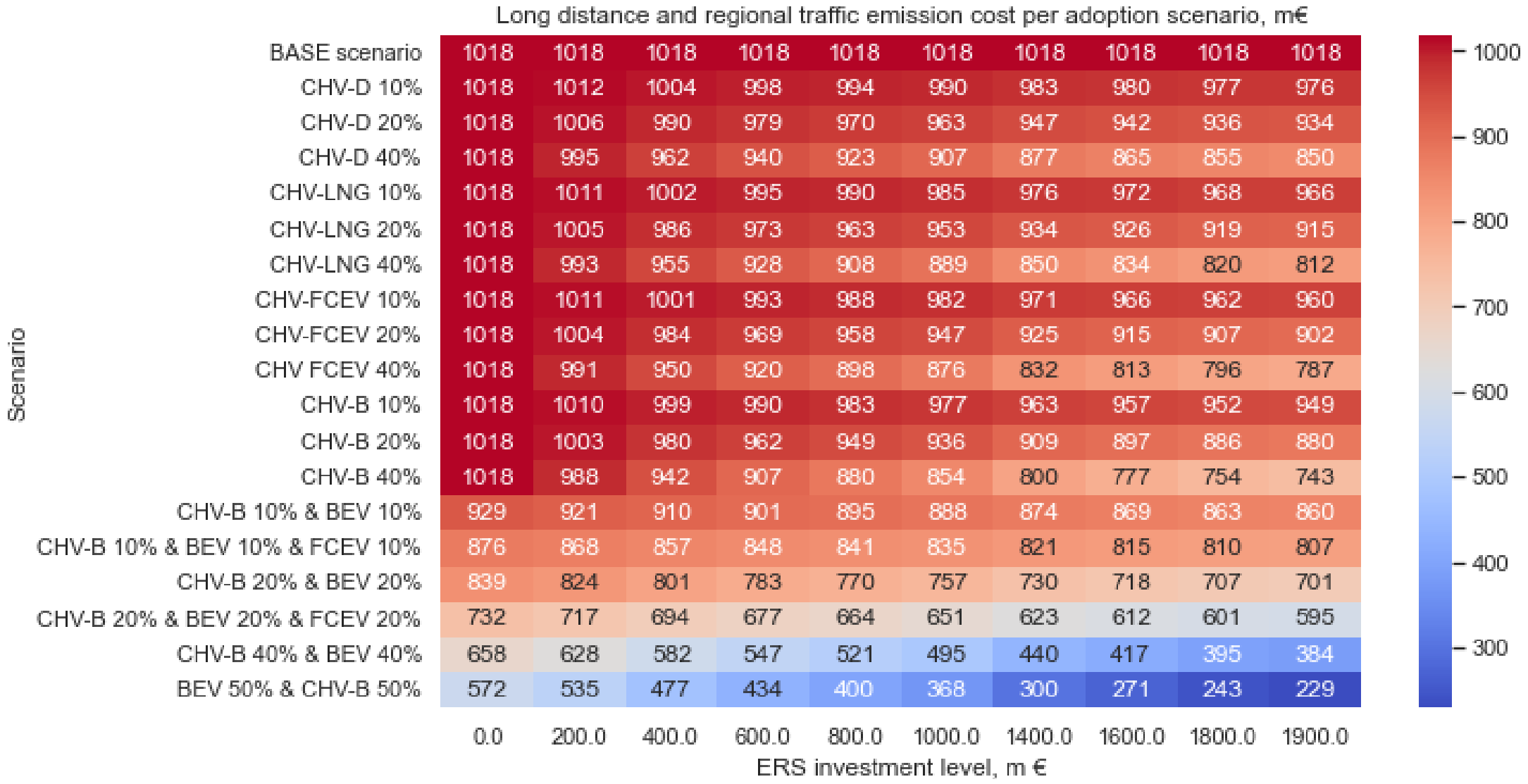
Impacts for network operator



Takeaway:

- Profitable operation of both, the trucking fleet and infrastructure operator is possible.

Societal impacts: Emission cost



Takeaways:

- Emission-related costs to the society can be radically reduced. E.g. at investment of 1.9B€ savings can reach 77% (69% CO_2 and complete local pollutant reduction, remaining CO_2 is from electricity generation).
- Catenary ERS is a very cheap way to reduce emissions.

Overall conclusion

- **Decarbonisation is the major challenge! It is possible, but a serious and coherent package of measures is needed.**
- **The same goes for modal shift**
- **For passenger transport: punctuality, direct connections and accessibility!**
- **For freight transport: flexibility and customer service!**

University of Antwerp
TPR | Research Group Transport and Regional Economics

Full time programmes:

Advanced Master in Maritime or Air Transport Management

Master Maritiem en Logistiek Management

Masterclasses and Summer Schools

Microcredentials

Maritime and Port | Air Transport | Urban Logistics | Regional Economics | Land transport

www.uantwerp.be/tpr www.c-mat.be www.transportnet.org