C4R

Capacity for Rail

Assessment of Scenarios

FFE (Madrid, Spain) – 21 September 2017

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TÉCNICO LISBOA

SEVENTH FRAMEWORK PROGRAMME

C4R Innovation Assessment Methodologies

Capacity for Rail

Multi-Criteria Analysis

Impacts towards Vision for 2030/2050

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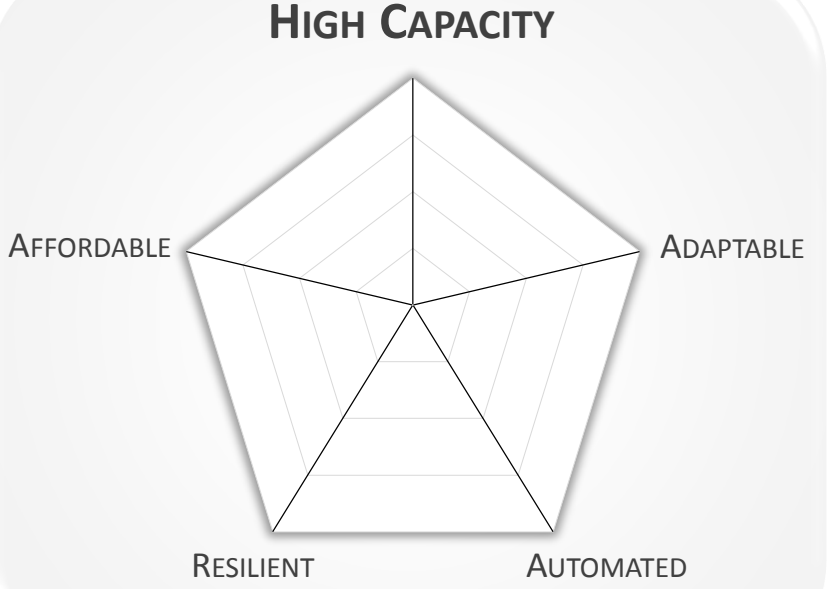
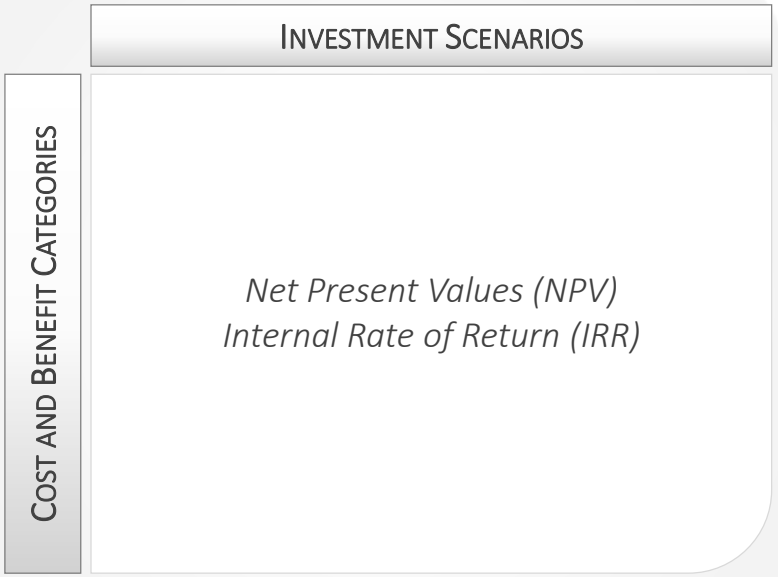
Cost-Benefit Analysis

Socio-economic appraisal

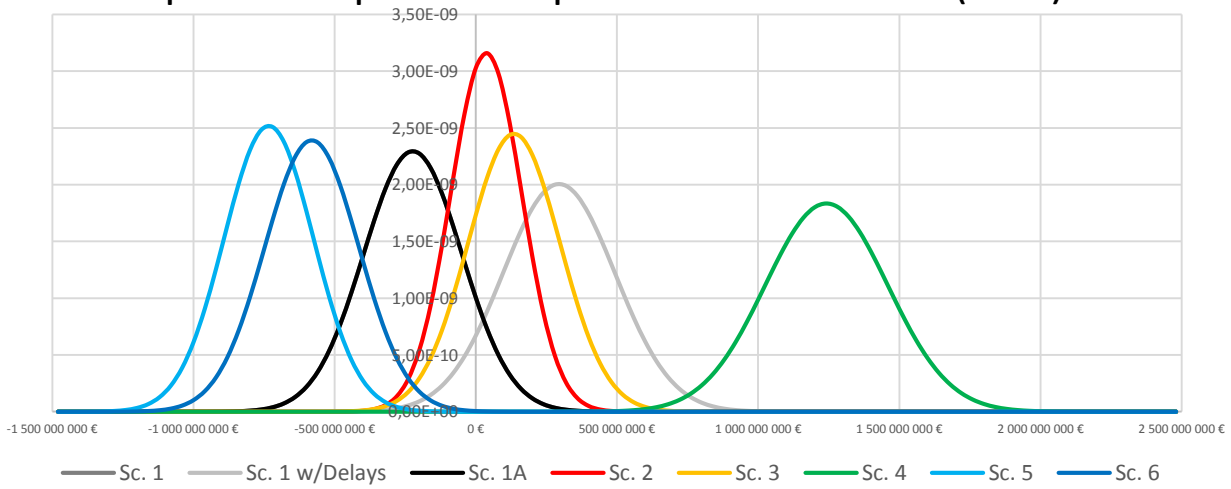




CBA Tool

Tool developed for CBA computation

Example of outputs: Comparison of scenarios (NPV)



			Users	Operators	Infrastructure Manager	Non Users	Government	Economic Value
			Freight	Freight	Rail			
Effects	User Service							
	Travel Time		-122 824 385 €					-122 824 385 €
	Reliability		0 €					0 €
	Operation							
	Direct	Fees		-115 858 559 €	115 858 559 €			0 €
		Vehicle Operating Costs		466 099 539 €				466 099 539 €
	Indirect	Taxes		89 456 304 €			-89 456 304 €	0 €
	Assets							
	Investment	Infrastructure			-765 367 260 €			-765 367 260 €
	Maintenance	Infrastructure			136 828 801 €			136 828 801 €
	External Effects							
	Environmental	GHG Emissions				50 858 469 €		50 858 469 €
Economic Profitability			-122 824 385 €	439 697 284 €	-512 679 901 €	50 858 469 €	-89 456 304 €	**-234 404 836 €**

CBA Structure Breakdown

- Investment Costs
- Maintenance Costs
- Producer Surplus
- Consumer Surplus
- Externalities

NPV, IRR, B/C, Probabilistic Analysis

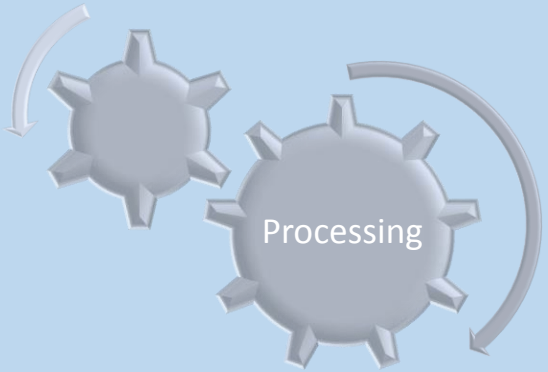
Stakeholder Effects Matrix

CBA Tool

Capacity for Rail

Inputs (for each Scenario)

- Reference Trains
- Reference Road Vehicles
- Rail Infrastructure Data
- Investment Scenario
- Demand Forecast
- Other CBA Parameters & Boundary Conditions



CBA Structure Breakdown

- Investment Costs
- Maintenance Costs
- Producer Surplus
- Consumer Surplus
- Externalities

- NPV, IRR, B/C, Probabilistic Analysis
- Stakeholder Effects Matrix

CBA Tool

Capacity for Rail

Inputs
(for each Scenario)

- Reference Trains
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Reference Train	Train 1	2	3	4	5	6	
Consist							
Number of Locomotives	1	#	#	#	#	#	
Number of Wagons	20	#	#	#	#	#	
Length	425	#	#	#	#	#	m
Tare	490	#	#	#	#	#	T
Maximum Load	1000	#	#	#	#	#	T
Load Factor	50%	#	#	#	#	#	
Load	500	#	#	#	#	#	T
Gross Weight	990	#	#	#	#	#	T
Locomotives							
Power Source	Electric	#	#	#	#	#	
Weight	90	#	#	#	#	#	T
Length	25	#	#	#	#	#	m
Operating Cost	5	#	#	#	#	#	€/km
Tax	3	#	#	#	#	#	
Wagons							
Tare Weight	20	#	#	#	#	#	T
Maximum Load	50	#	#	#	#	#	T
Length	20	#	#	#	#	#	m
Operating Cost	0,15	#	#	#	#	#	€/km
Tax	0,03	#	#	#	#	#	
Operating Costs							
Operating Costs (excl. Tax)	0,016	#	#	#	#	#	€/(T·km)
GHG Emissions							
GHG Emissions	0,002	#	#	#	#	#	kg/(T·km)

CBA Tool

Capacity for Rail

Inputs
(for each Scenario)

- Reference Trains
- **Reference Road Vehicles**
- Rail Infrastructure Data
- Investment Scenario
- Demand Forecast
- Other CBA Parameters & Boundary Conditions

Reference Vehicle	Truck 1	2	3	4	5	6	
Maximum Load	26	##	##	##	##	##	T
Load Factor	60%	##	##	##	##	##	
Load	15,6	##	##	##	##	##	T
Operating Costs (excl. tax)	0,0712	##	##	##	##	##	€/(T·km)
Tax	0,0160	##	##	##	##	##	€/(T·km)
GHG Emissions	0,0420	##	##	##	##	##	kg/(T·km)

CBA Tool

Capacity for Rail

Inputs
(for each Scenario)

- Reference Trains
- Reference Road Vehicles
- **Rail Infrastructure Data**
- Investment Scenario
- Demand Forecast
- Other CBA Parameters & Boundary Conditions

			Section ########
Length		km	131,0
Passenger	Av. Speed	(km/h)	125
	Time	(h)	1,05
Freight	Av. Speed	(km/h)	80
	Time	(h)	1,64
	Terrain Type		Hilly
Number of Tracks			2
Switch Density		1/km	0,14
Max Train Length		m	630
Max Axle Load		T/axle	22,5
Capacity	Block Length	km	15
	Buffer Time		0,05
	Crossing Buffer		0
	Supplement for Maintenace	h/track	5,00
Passenger	Access Charges	€/train	42,5402
		€/(train·km)	0,6442
		€/(GT·km)	0,0000
Freight		€/train	42,5402
		€/(train·km)	0,6442
		€/(GT·km)	0,0007
Maintenance Costs	Track Fixed	€/(year·km)	15600
	Track Variable	€/(MGT·km)	309
	S&C Fixed	€/(year·switch)	34528
	S&C Variable	€/(MGT·switch)	3612
Delays	Punctuality (%)	Passenger	0,0%
		Freight	0,0%
	P. Delays (%)	Passenger	0,0%
		Freight	0,0%
	P. Cancellations (%)	Passenger	0,0%
		Freight	0,0%
	Delays (h)	Passenger	0,00
		Freight	0,00

CBA Tool

Capacity for Rail

Inputs (for each Scenario)

- Reference Trains
- Reference Road Vehicles
- Rail Infrastructure Data
- **Investment Scenario**
- Demand Forecast
- Other CBA Parameters & Boundary Conditions

Investment Projects		Included in		
		Baseline	TEN-T	C4R
SE36	Ängelholm-Maria: Upgrade to double track in existing alignment and grade-seperated crossings. Reconstruction of Maria station	No	Yes	Yes
SE37	Flackarp-Arlöv: The action involves two new tracks on the route Flackarp-Arlöv which constitute about 75 percent of the route	No	Yes	Yes
SE38	Flackarp-Lund (Högevall): Expansion from two to four tracks between Flackarp and Högevall	No	Yes	Yes
SE39	Pågatåg Nordost (Regional railway network improvement): Sixteen new stations are being built in the years 2011-2014 to improve commuting with regional trains in north eastern Skåne	No	Yes	Yes
SE40	Åstorp-Teckomatorp: Expansion of sidings, introduction of modern signalling systems and new stations for passenger	No	Yes	Yes

Investment Projects		Included in			Estimated Lifespan (years)	NPV	0	1	2
		Baseline	TEN-T	C4R			2015	2016	2017
BL1	Track renewal in Stockholm-Katrineholm	Yes	Yes	Yes	30	#####	0€	0€	0€
BL2	Track renewal in Katrineholm-Hallsberg	Yes	Yes	Yes	30	#####	0€	0€	0€
BL3	Track renewal in Katrineholm-Norrköping	Yes	Yes	No	30	#####	0€	0€	0€
BL4	Track renewal in Norrköping-Mjölby	Yes	Yes	Yes	30	#####	0€	0€	0€
BL34	S&C renewal in Öxnered-Göteborg	Yes	Yes	Yes	30	#####	0€	0€	0€
BL35	S&C renewal in Göteborg-Kungsbacka	Yes	Yes	No	30	#####	0€	0€	0€
BL36	S&C renewal in Kungsbacka-Ängelholm	Yes	Yes	Yes	30	#####	0€	0€	0€
BL37	S&C renewal in Ängelholm-Kävlinge via Helsingborg	Yes	Yes	Yes	30	#####	0€	0€	0€
BL38	S&C renewal in Ängelholm-Kävlinge via Åstorp	Yes	Yes	No	30	#####	0€	0€	0€
BL39	S&C renewal in Kävlinge-Lund	Yes	Yes	No	30	#####	0€	0€	0€
BL40	S&C renewal in Kävlinge-Malmö	Yes	Yes	No	30	#####	0€	0€	0€
BL41	S&C renewal in Malmö-Trelleborg	Yes	Yes	Yes	30	#####	0€	0€	0€
BL42	S&C renewal in Malmö-København	Yes	Yes	Yes	30	#####	0€	0€	0€
SE24	Implementation of ERTMS	No	Yes	Yes	30	#####	#####	######	####
SE46	Teckomatorp-Arlöv: Capacity enhancements and new stations for passenger service	No	Yes	Yes	30	#####	0€	0€	####
C4R'1	Slab track construction, Stockholm-Katrineholm	No	No	No	60	#####	0€	0€	0€
C4R'2	Slab track construction, Katrineholm-Hallsberg	No	No	No	60	#####	0€	0€	0€
C4R'3	Slab track construction, Katrineholm-Norrköping	No	No	Yes	60	#####	0€	0€	0€
C4R'14	Slab track construction, Göteborg-Kungsbacka	No	No	Yes	60	#####	0€	0€	0€
C4R'15	Slab track construction, Kungsbacka-Ängelholm	No	No	No	60	#####	0€	0€	0€
C4R'16	Slab track construction, Ängelholm-Kävlinge via Helsingborg	No	No	No	60	#####	0€	0€	0€
C4R'17	Slab track construction, Ängelholm-Kävlinge via Åstorp	No	No	Yes	60	#####	0€	0€	0€
C4R'18	Slab track construction, Kävlinge-Lund	No	No	Yes	60	#####	0€	0€	0€
C4R'19	Slab track construction, Kävlinge-Malmö	No	No	Yes	60	#####	0€	0€	0€
C4R'20	Slab track construction, Malmö-Trelleborg	No	No	No	60	#####	0€	0€	0€
C4R'21	Slab track construction, Malmö-København	No	No	No	60	#####	0€	0€	0€
C4R'22	New switches, Stockholm-Katrineholm	No	No	No	40	#####	0€	0€	0€
C4R'23	New switches, Katrineholm-Hallsberg	No	No	No	40	#####	0€	0€	0€
C4R'24	New switches, Katrineholm-Norrköping	No	No	Yes	40	#####	0€	0€	0€

CBA Tool

Capacity for Rail

Inputs
(for each Scenario)

- Reference Trains
- Reference Road Vehicles
- Rail Infrastructure Data
- Investment Scenario
- **Demand Forecast**
- Other CBA Parameters & Boundary Conditions

Rail Passenger Demand Elasticities		
Demand elasticity with GDP		######
Demand elasticity with Price		######
Price elasticity with Operating Costs		######
Demand elasticity with Operating Costs		######

Rail Freight Demand Elasticities		
Demand elasticity with GDP		######
Demand elasticity with Price		######
Price elasticity with Operating Costs		######
Demand elasticity with Operating Costs		######

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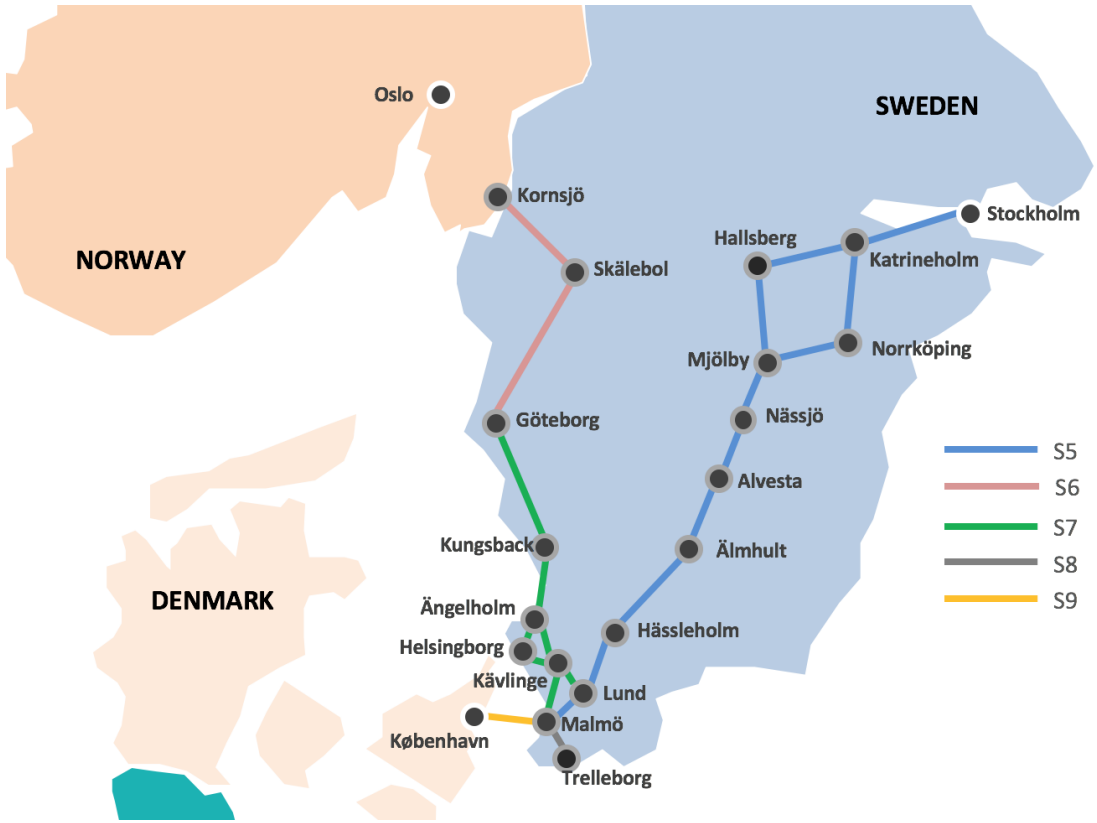
CBA Boundaries		
Time horizon	40	years
Year 1	2016	
Economic Boundary Conditions		
Discount rate	4,00%	
Shadow price conversion factor	0,95	
Energy Costs		

Time Valuation		
Passengers		
Business passengers VOT	30	€/h
Business passengers	50%	
Leisure VOT	10	€/h
Leisure passengers	10%	
Commuter VOT	15	€/h
Commuter passengers	40%	
Average	22	€/h
Freight		
Rail	1,66	€/h
Road	4,05	€/h
Diverted from Road to Rail	1,66	€/h

Externalities		
GHG Emissions Cost Initial Value	0,031	€/kg
GHG Emissions Cost Annual Growth	0,001	€/kg



CASE STUDY 1: SWEDISH SECTIONS OF THE SCANDINAVIAN-MEDITERRANEAN CORRIDOR

C4R Scenarios

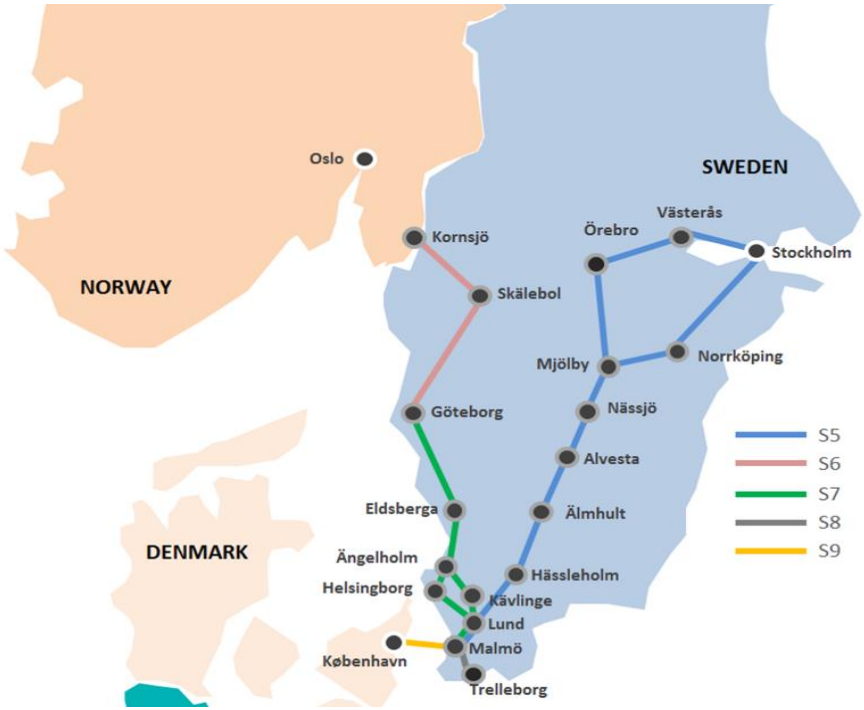
‘Baseline & TEN-T’ Scenario

Maintenance or replacement of End Of Life items and Investment already planned in TEN-T corridors (timeline and costs defined in TEN-T reports)

C4R Scenarios

- C4R Scenario 1
- C4R Scenario 1 with Delays
- C4R Scenario 2
- C4R Scenario 3
- C4R Scenario 4
- C4R Scenario 5
- C4R Scenario 6

C4R Scenarios



C4R Scenarios

C4R Scenario 1

- Innovative Slab Track
- Advanced Monitoring
- Innovative Switches
- Innovative Freight Concepts

Introduced in the whole corridor

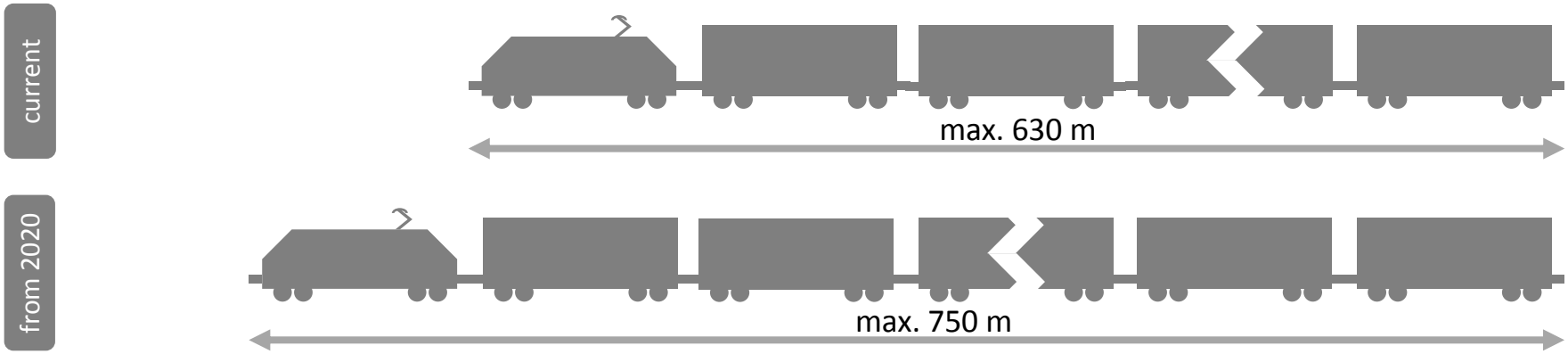
Key Assumptions

- Case study focused on **freight** transportation
- Time horizon: 40 years (2016-2056); Discount Rate: 4%
- Combined **C4R Infrastructure Innovations** reduce **Infrastructure Downtime** for Maintenance by 60%
  - Also reduce Maintenance Costs (German benchmark)
- Innovative Slab Track Target Cost limited to 1000 €/m of single track
- **No Increase** in Track Access Charges

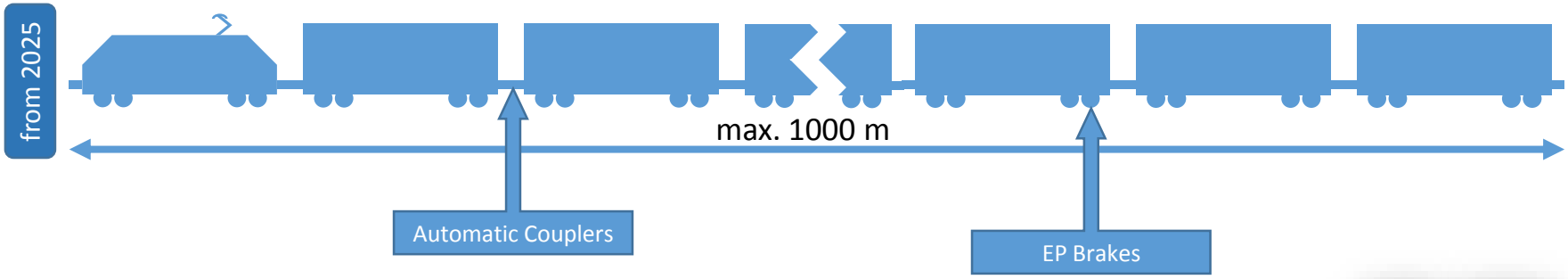
Key Assumptions

Capacity for Rail

‘Baseline & TEN-T’ Scenario



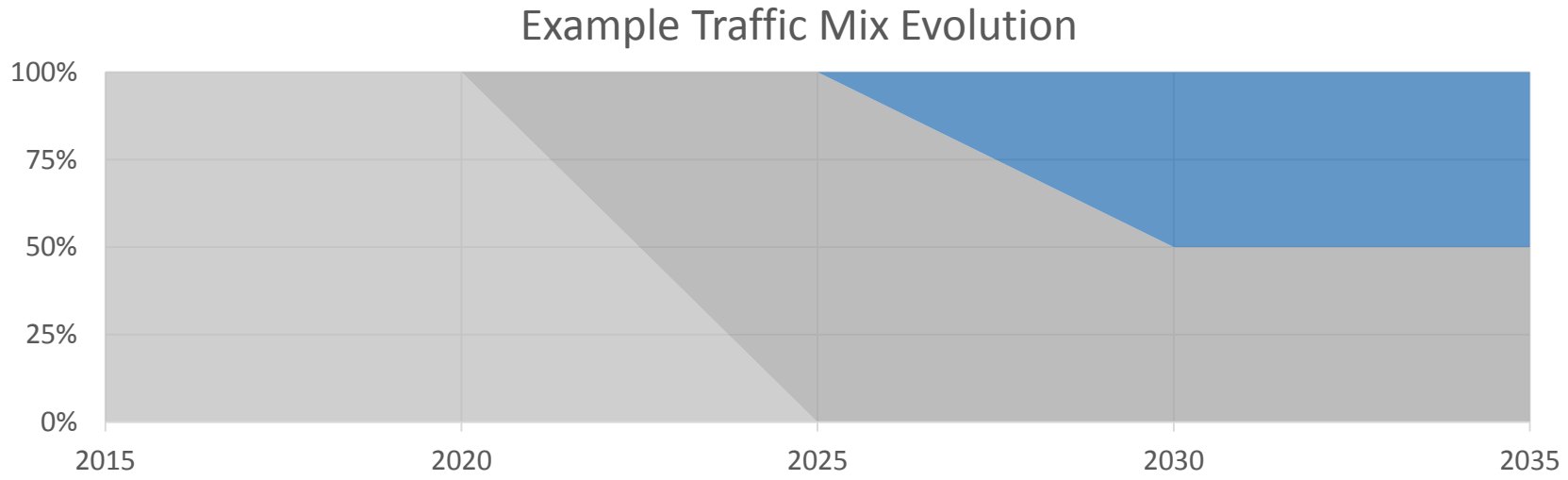
C4R Scenario 1

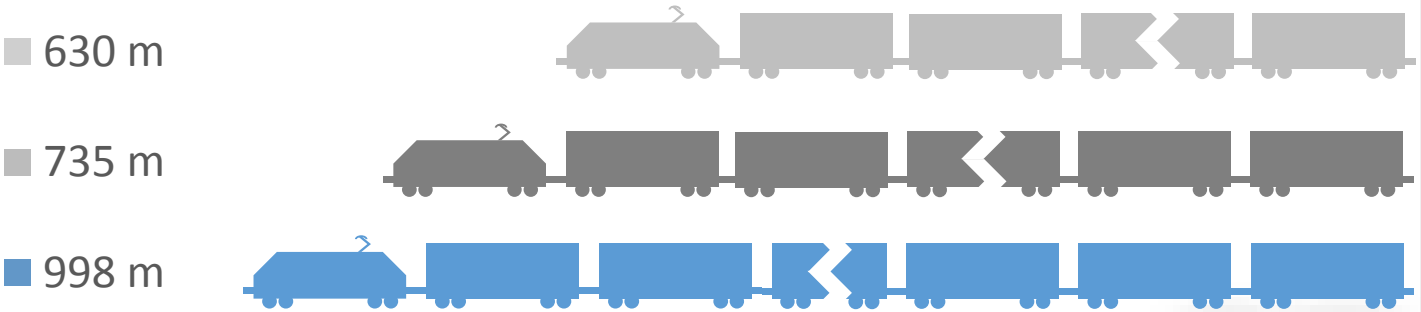


Key Assumptions

- 5 Market Segments:

Wagon Load	Train Load	Intermodal Container	Intermodal Trailer	Wagon Load Feeder

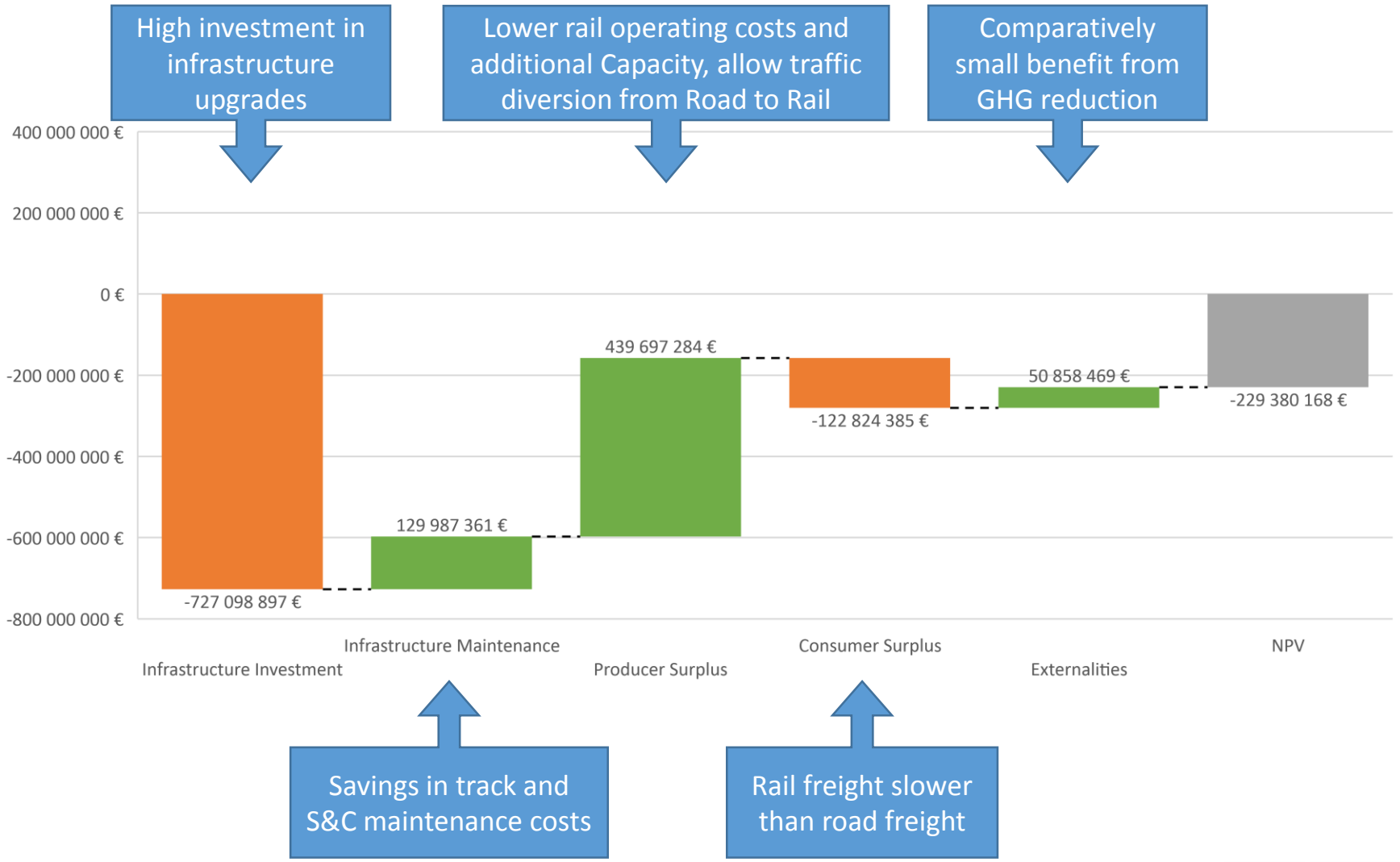




Results

C4R Scenario 1

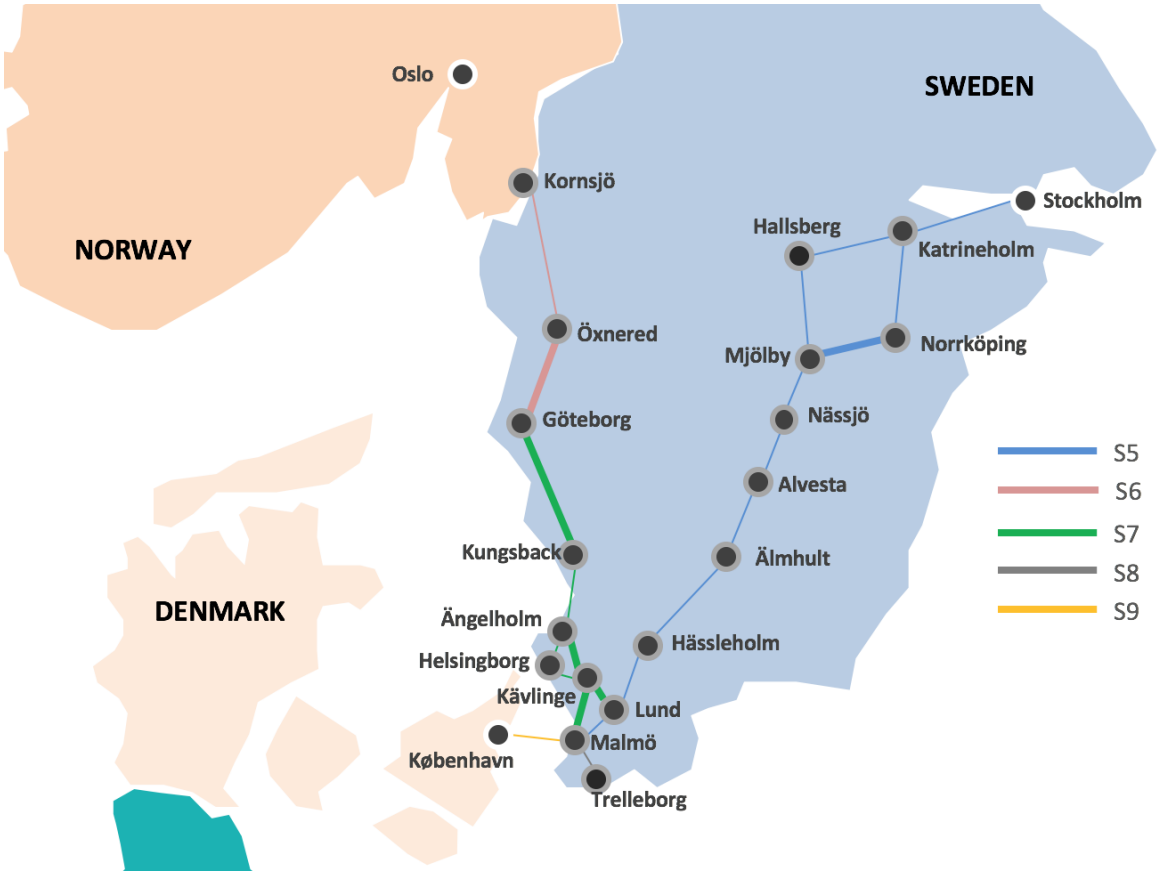
Capacity for Rail



C4R Scenario 2

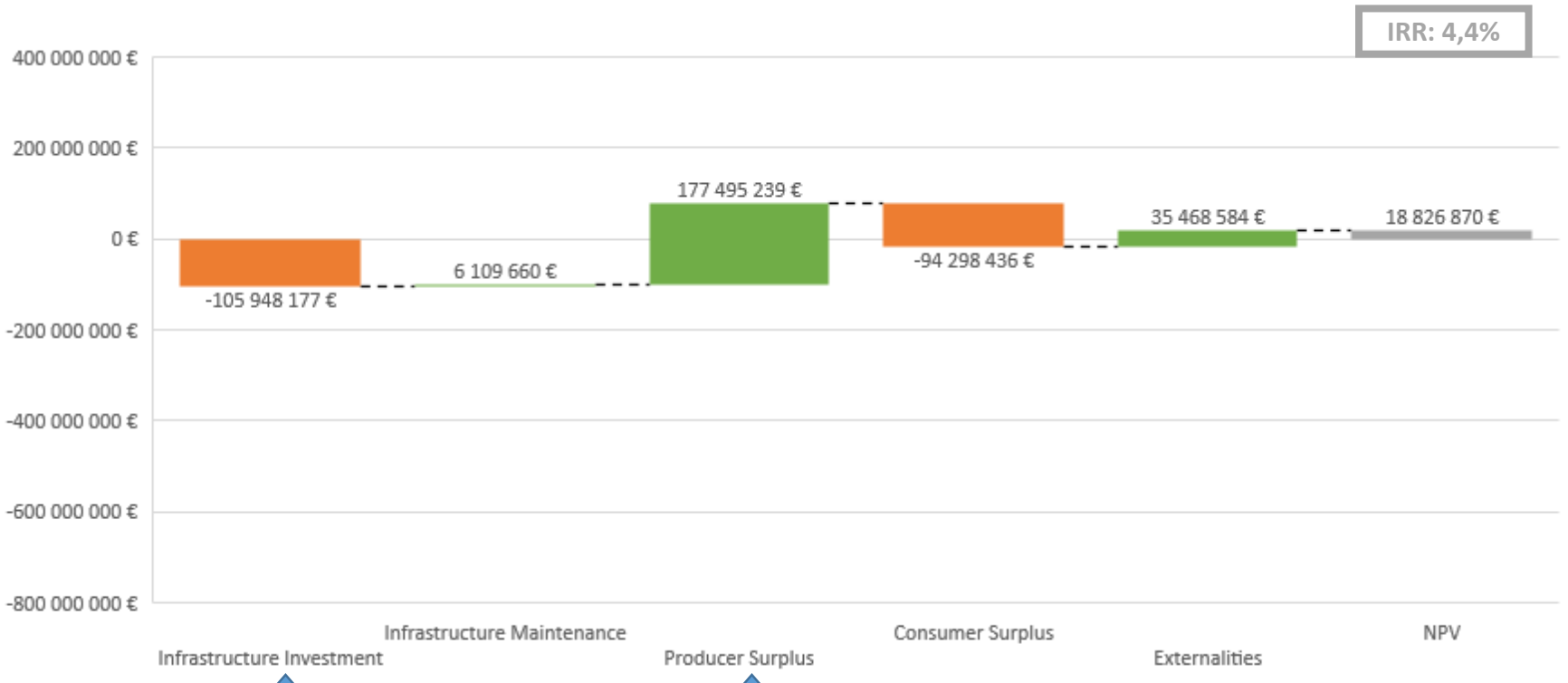
Capacity for Rail

- C4R infrastructure innovations implemented only in most congested sections



C4R Scenario 2

Capacity for Rail



Much smaller investment compared with Scenario 1

Smaller benefit from modal transfer in absolute terms, but sufficient to offset investment

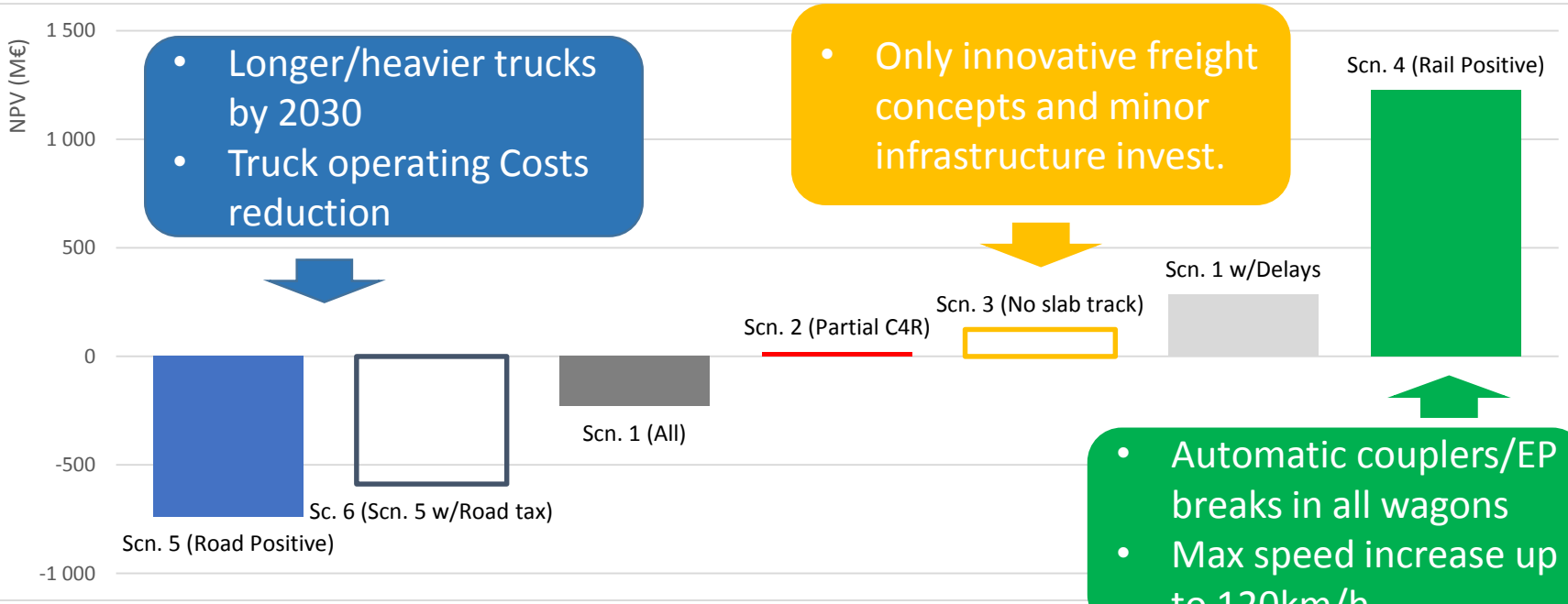
C4R Scenario Ranking

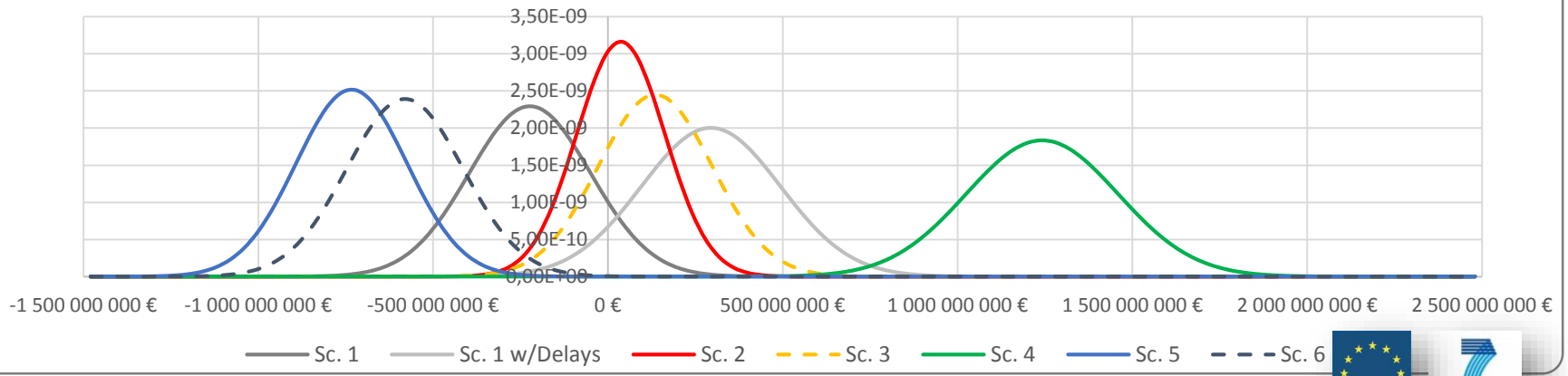
Capacity for Rail

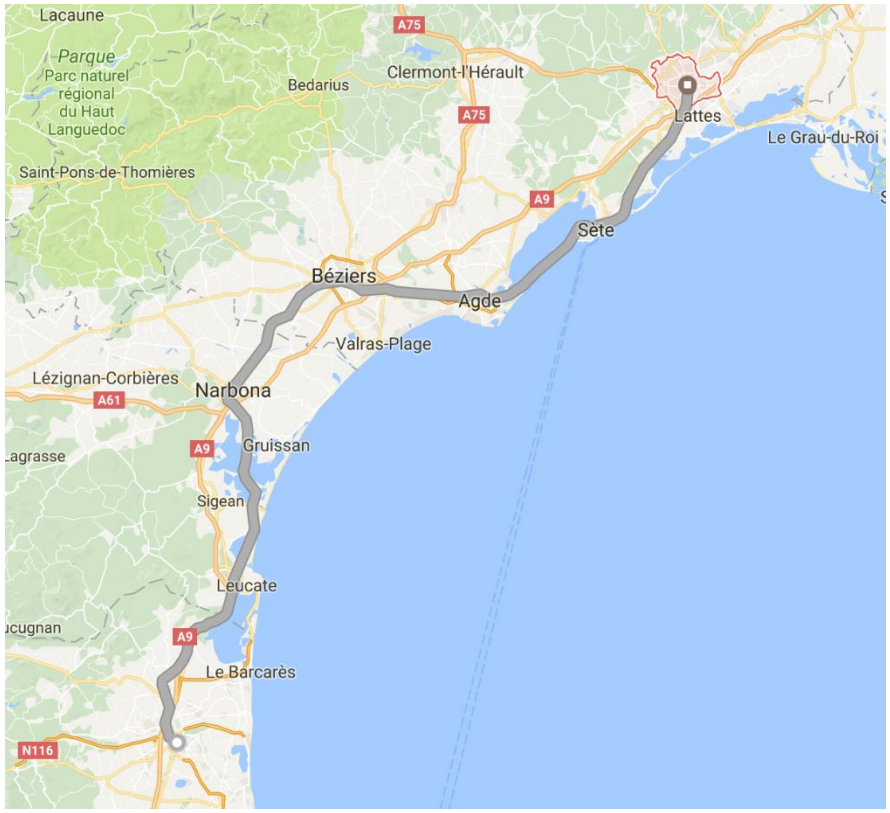
- Longer/heavier trucks by 2030
- Truck operating Costs reduction

- Only innovative freight concepts and minor infrastructure invest.

- Automatic couplers/EP breaks in all wagons
- Max speed increase up to 120km/h







CASE STUDY 2: MONTPELLIER – PERPIGNAN SECTION OF THE MEDITERRANEAN CORRIDOR

C4R Scenarios

C4R
Capacity for Rail

Baseline

- No investment besides maintenance or replacement of End Of Life items

C4R Investment Level 1

- Operational improvements and investments to allow trains up to 1000 m

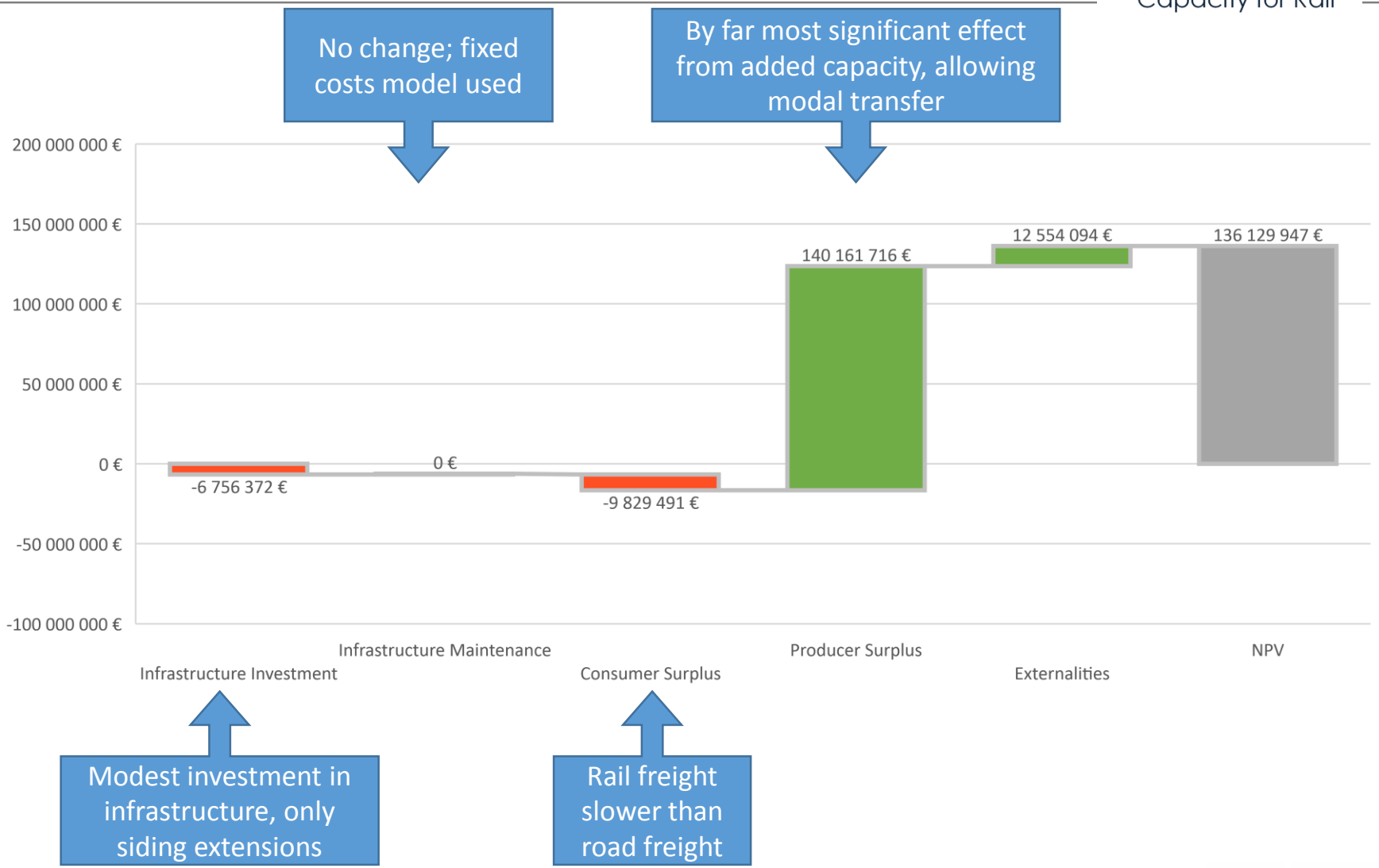
C4R Investment Level 2

- Upgrade to slab track and new S&C
- Innovative freight concepts with trains up to 1500 m

Results

C4R Investment Level 1

Capacity for Rail

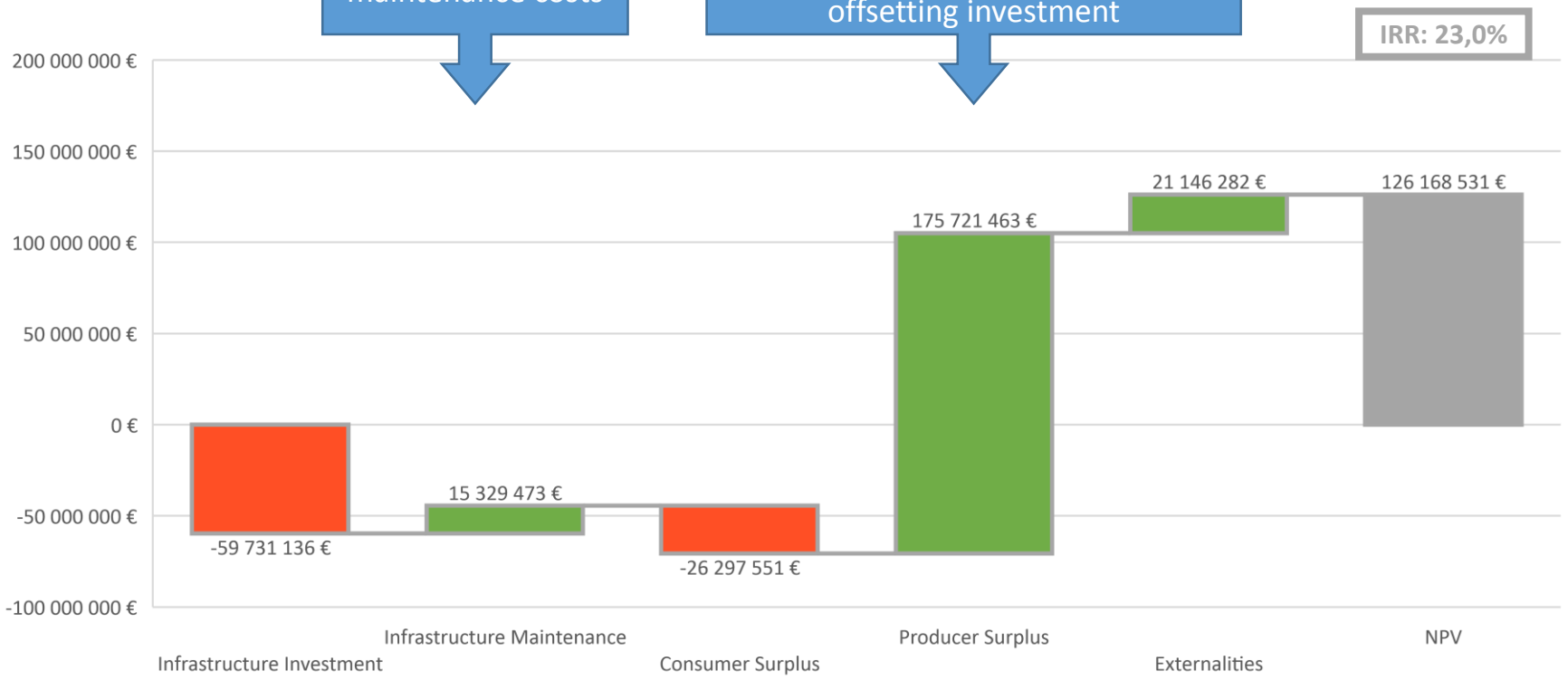


C4R Investment Level 2

Capacity for Rail

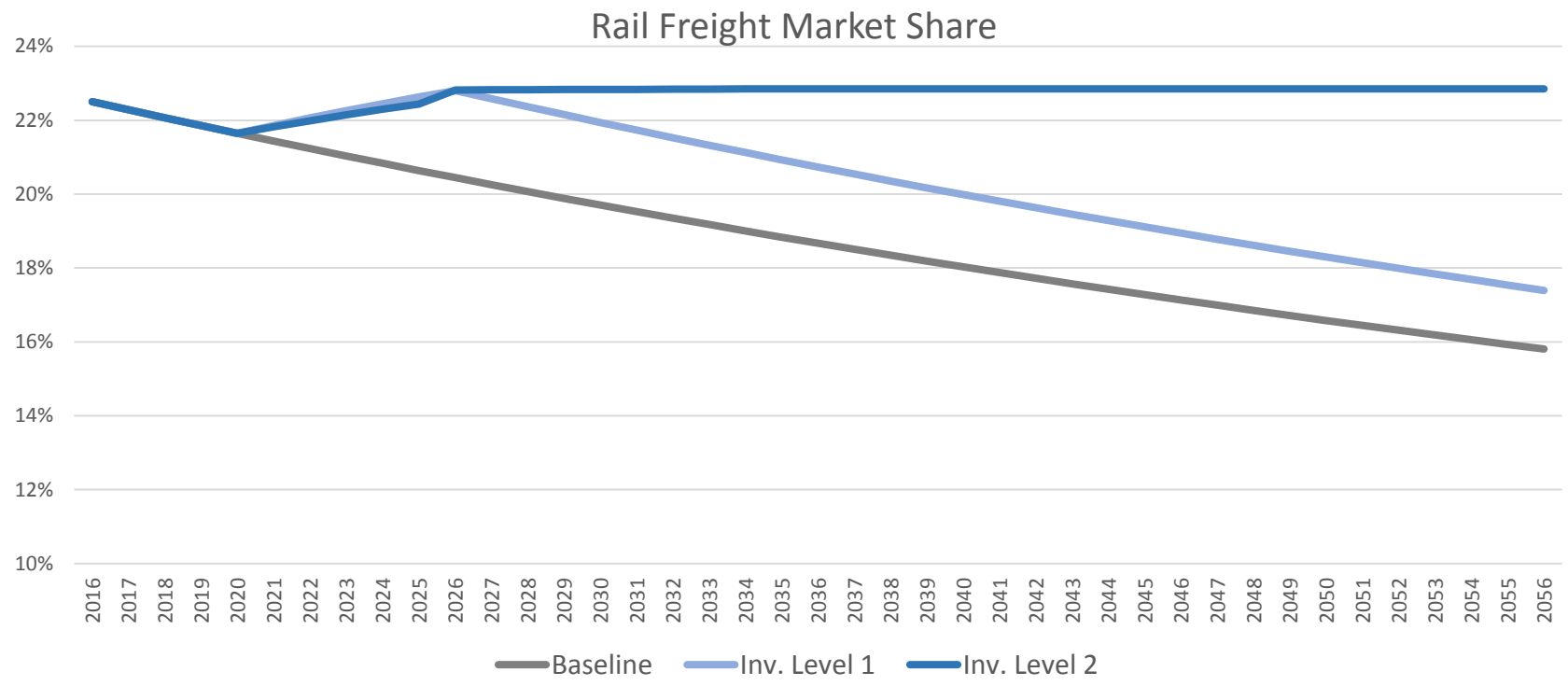
Reduction in maintenance costs

Additional capacity allows further traffic to be diverted from road, offsetting investment



Investment in slab track and S&C

Market Share Evolution



Gains in capacity from longer trains and reduction in unavailability allow rail to maintain its current market share in the 40 year horizon of the analysis, against a baseline of expected loss

Conclusions

- Deep Infrastructure Innovations **in existing lines** may be profitable in capacity constrained sections
- Investments in **Operational concepts** (longer trains, EP breaks, automatic couplers, etc.) combined with minor infrastructure improvements (sidings, improved track for higher axle loads) in most cases **can have very positive effects** (with no increase in access charges)
- Market share targets unattainable solely through C4R innovations

Thank you for your kind attention

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