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Group of Experts on Benchmarking Transport Infrastructure Construction Costs

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Item 4 of the provisional agenda
Collection and analysis of benchmarking data

Benchmarking analysis of rail infrastructure construction costs in the ECE region

Submitted by the Group of Experts on Benchmarking Transport Infrastructure Construction Costs

I. Introduction

1. An important part of the mandate of the Group of Experts on Benchmarking Transport Infrastructure Construction Costs (GE.4) was to collect and analyse data to prepare a benchmarking analysis of transport infrastructure construction costs in the United Nations Economic Commission for Europe (ECE) region for each inland transport mode – road, rail, inland waterways – including intermodal terminals, freight/logistics centres and ports. The current report provides an overview of the analysis of rail infrastructure construction costs received from a group of twelve ECE member States. Polish railways has taken the lead on the railway sector data analysis.

II. Rail infrastructure costs

2. This section contains information on the responses of individual countries.

3. Values have been calculated as mean values from all relevant projects started in the period 2007–2016 Values have been provided in $US 2016 prices; value added cost and design costs should be excluded.

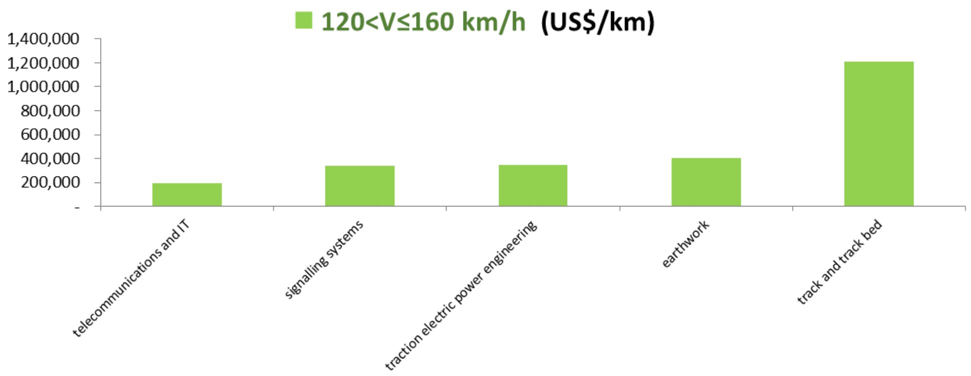
A. Bulgaria

4. Bulgaria has responded to part A of the questionnaire providing with the information on the cost of infrastructure elements for upgrade (for speeds between 120 and 160 km/h) and renewal (for speeds less than 120 km/h).

Table 1
Cost of infrastructure elements for upgrade in Bulgaria

	120<V≤160 km/h	type of line (electrified, non-electrified, number of tracks, gauge)	organisation responsible for construction
earthwork (US$/km)	401 472,71	double, electrified, gauge 1435 mm	SE NRIC
track and track bed (US$/km)	1 207 548,78	double, electrified, gauge 1435 mm	SE NRIC
one-sided turnouts (US$/unit)	39 769,62		SE NRIC
traction electric power engineering (US$/km)	347 610,33	double, electrified, gauge 1435 mm	SE NRIC
reinforced concrete bridges (US$/m)	13 431,79	double, electrified, gauge 1435 mm	SE NRIC
single tube tunnels (US$/m)	17 230,11	double, electrified, gauge 1435 mm	SE NRIC
twin tube tunnels (US$/m)	20 691,60	double, electrified, gauge 1435 mm	SE NRIC
elevators (US$/unit)	65 463,61		SE NRIC
escalators (US$/unit)	94 132,93		SE NRIC
signalling and telecommunication systems (US$/km)	340 876,53	double, electrified, gauge 1435 mm	SE NRIC
signal boxes (US$/unit)			
telecommunications and IT (ERTMS) (US$/km)	192 250,58	double, electrified, gauge 1435 mm	SE NRIC
railway infrastructure in ports and terminals (US$/m)	477,54	singal, electrified, gauge 1435 mm	SE NRIC
railway stations (excluding facilities for train operations) (US$/m^2)	523,37	double, electrified, gauge 1435 mm	SE NRIC
other (please specify) overpasses (US$/unit)	1 630 081,13	double, electrified, gauge 1435 mm	SE NRIC

Figure 1
Cost of upgrades of infrastructure elements expressed in US $/km in Bulgaria

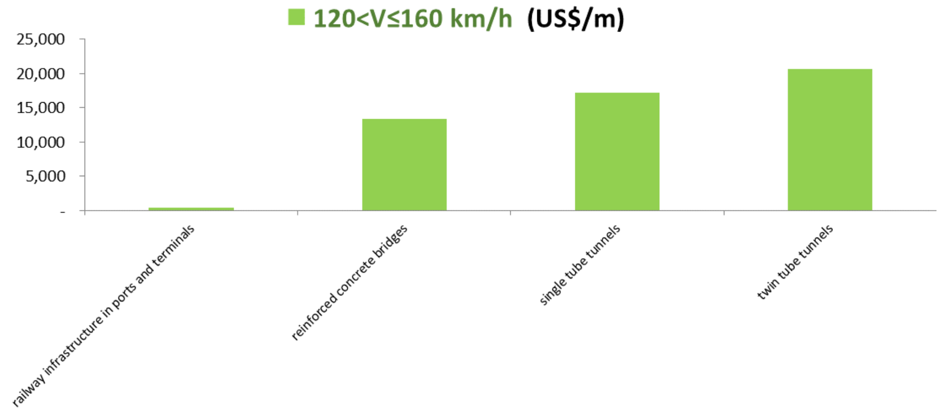


5. Figure 1 demonstrates infrastructure elements expressed in US $/km:

- telecommunications and IT
- signalling systems
- traction electric power engineering
- earthwork
- track and track bed.

6. The lowest cost in this category is telecommunications and IT whilst the most expensive is track and track bed. The other three elements are almost equal in cost.

Figure 2
Cost of upgrades of infrastructure elements expressed in US $/m in Bulgaria



7. The figure demonstrates eleven categories expressed in US $/m:

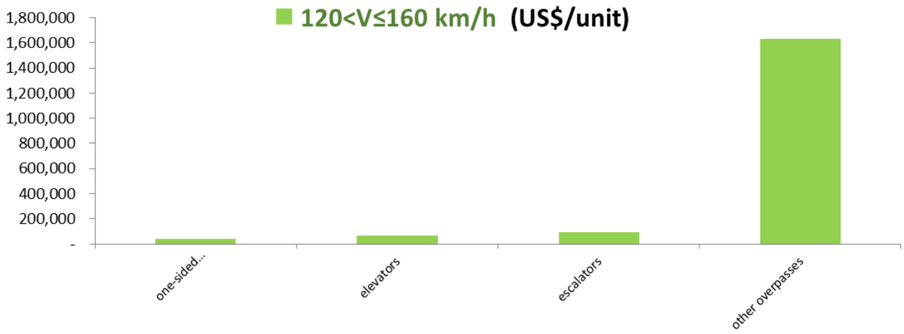
- railway infrastructure in ports and terminals
- reinforced concrete bridges
- single tube tunnels
- twin tube tunnels.

8. The most notable difference is between railway infrastructure in ports and terminals and the other three categories.

Figure 3
Cost of upgrades of the infrastructure elements expressed in US $/m2 in Bulgaria

9. One element is presented in US $/m2 - railway stations (excluding facilities for train operations).

Figure 4
Cost of upgrades of infrastructure elements expressed in US $/unit in Bulgaria



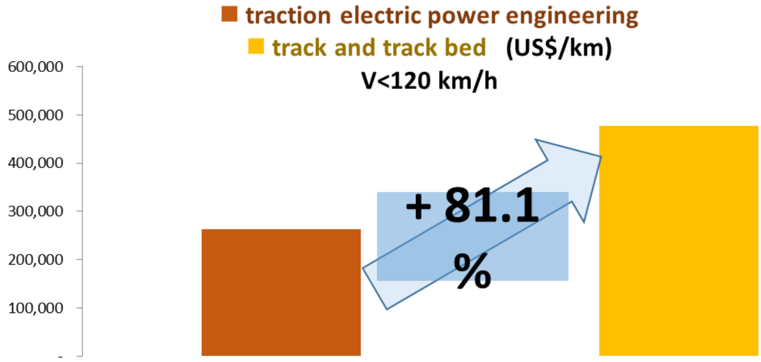
10. Figure 4 demonstrates infrastructure elements expressed in US $/unit:

- one-sided turnouts
- elevators
- escalators
- other overpasses.

11. The cost of overpasses is significantly higher than that of the first three categories.

Figure 5

Cost of renewal of the infrastructure elements expressed in US $/km in Bulgaria



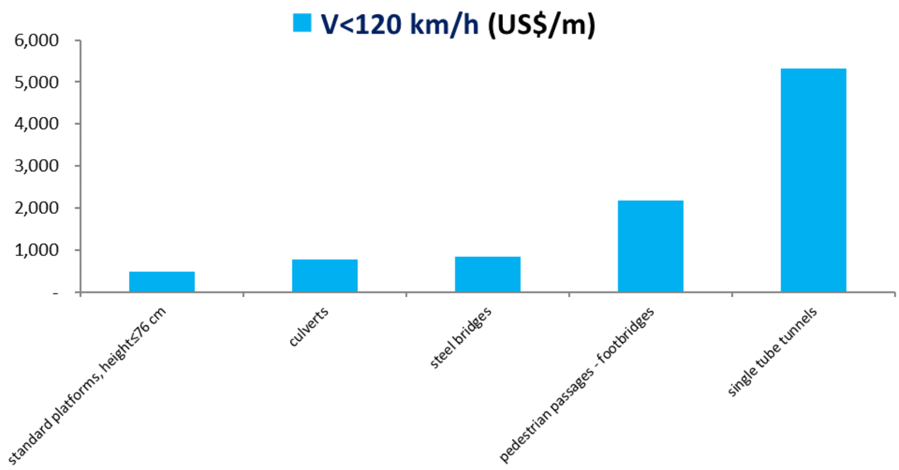
12. Two of the elements expressed in $US $/km can be compared – track and track bed are almost twice as costly as traction electric power engineering.

Table 2

Cost of infrastructure elements for renewal in Bulgaria

	V<120	type of line (electrified, non-electrified, number of tracks, gauge)	organisation responsible for construction
preparatory work (removal of trees and bushes, demolition etc.) (US$/m²)	0,87	electrified, gauge 1435 mm	SE NRIC
track and track bed (US$/km)	477 235,42	electrified, gauge 1435 mm	SE NRIC
one-sided turnouts (US$/unit)	92 265,51	electrified, gauge 1435 mm	SE NRIC
diamond crossing turnouts (US$/unit)	117 187,81	electrified, gauge 1435 mm	SE NRIC
timber turnout sleepers (US$/unit)	3 225,56	electrified, gauge 1435 mm	SE NRIC
traction electric power engineering (US$/km)	263 569,63	electrified, gauge 1435 mm	SE NRIC
steel bridges (US$/m)	837,81	electrified, gauge 1435 mm	SE NRIC
single tube tunnels (US$/m)	5 313,22	electrified, gauge 1435 mm	SE NRIC
culverts (US$/m)	766,91	electrified, gauge 1435 mm	SE NRIC
active level crossings – automatic with user-side warning (US$/unit)	238 617,71	singal, electrified, gauge 1435 mm	SE NRIC
pedestrian passages - footbridges (US$/m)	2 179,38	electrified, gauge 1435 mm	SE NRIC
standard platforms, height≤76 cm (US$/m)	477,24	electrified, gauge 1435 mm	SE NRIC

Figure 6
Cost of renewal of infrastructure elements expressed in US $/m in Bulgaria

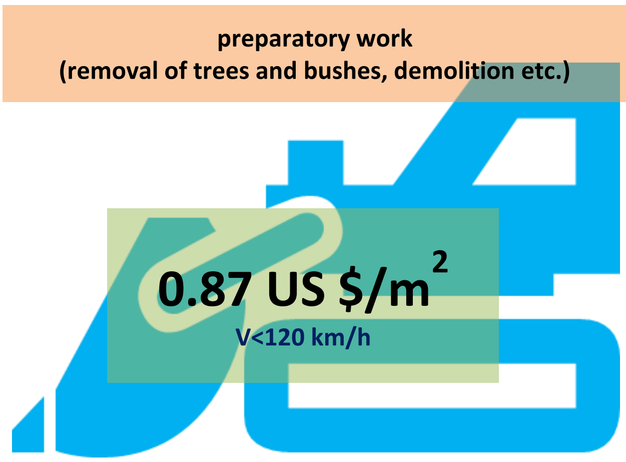


13. Five infrastructure elements expressed in US $/m are shown in this graph:

- standard platforms
- culverts
- steel bridges
- pedestrian passages – footbridges
- single tube tunnels.

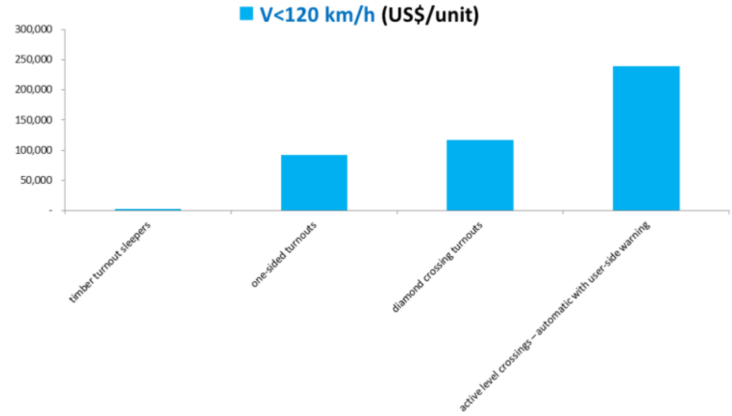
14. The cost of the first three elements are nearly the same level. Amongst all elements expressed in metres the tunnels are the most expensive.

Figure 7
Cost of renewal of infrastructure elements expressed in US $/m2 in Bulgaria



15. One element is presented in US $/m2 - preparatory work (removal of trees and bushes demolition etc.).

Figure 8
Cost of renewal of infrastructure elements expressed in US $/unit in Bulgaria



16. Figure 8 demonstrates infrastructure elements expressed in US $/unit:

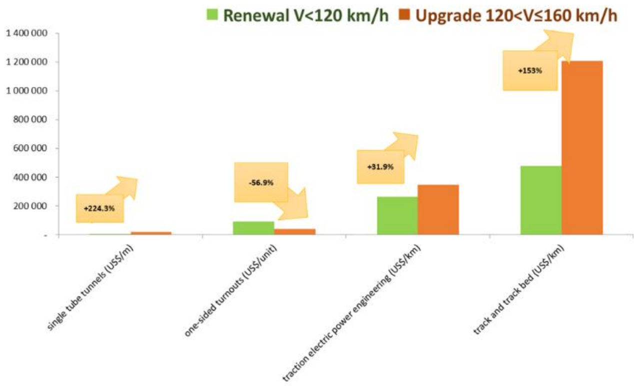
- timber turnout sleepers
- one-sided turnouts
- diamond crossing turnouts
- active level crossings – automatic with user-side warning.

17. The cost of level crossings is the highest – twice as much as that of turnouts.

Table 3
Cost of infrastructure elements for renewal and upgrade in Bulgaria

		V<120 km/h	120<V≤160 km/h
single tube tunnels (US$/m)	US$/m	5 313,22	17 230,11
one-sided turnouts (US$/unit)	US$/unit	92 265,51	39 769,62
traction electric power engineering (US$/km)	US$/km	263 569,63	347 610,33
track and track bed (US$/km)	US$/km	477 235,42	1 207 548,78

Figure 9
Comparison of cost of infrastructure elements for renewal and upgrade in Bulgaria



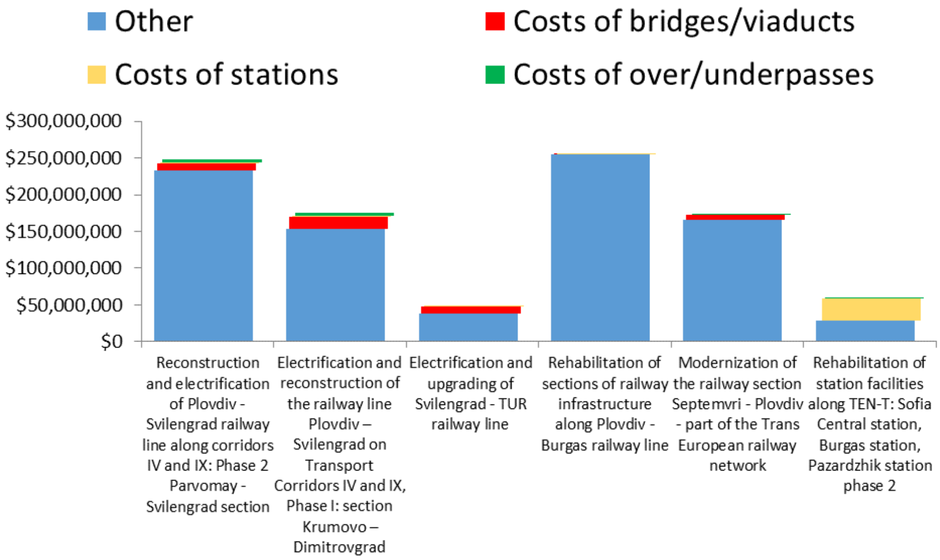
18. There are four elements to be compared for upgrade and renewal – single tube tunnels one-sided turnouts traction electric power engineering and track and track bed. Notably the cost of one-sided turnouts for upgrade is less than in the case of renewal. One-sided turnouts are cheaper for upgrade in comparison to traction electric power engineering which is 31.9 per cent more expensive for upgrade. Track and track bed are also significantly more expensive for upgrade – 153 per cent.

19. Projects implemented in Bulgaria

Table 4
Cost of projects implemented in Bulgaria

	Start date	*End date*	*Construction costs of the project*	*Currency*	*Other*	*Costs of bridges/viaducts*	*Costs of stations*	*Costs of over/underpasses*	*Costs of 1km bridges/viaducts*	*Costs of one stations*	*Costs of one over/underpasses*
Reconstruction and electrification of Plovdiv - Svilengrad railway line along corridors IV and IX: Phase 2 Parvomay - Svilengrad section	2012	2016	248 306 228.23	USD	232 618 826.25	9 914 872.32	1 656 067.99	4 116 461.66	9 329 449.38	331 213.60	411 646.17
Electrification and reconstruction of the railway line Plovdiv – Svilengrad on Transport Corridors IV and IX Phase I: section Krumovo – Dimitrovgrad	2007	2012	175 242 368.00	USD	153 808 055.15	16 411 447.59	881 940.37	4 140 924.89	32 200 776.18	97 993.37	295 780.35
Electrification and upgrading of Svilengrad - TUR railway line	2009	2015	48 061 210.85	USD	38 569 144.17	9 462 646.75	29 419.92	0.00	10 924 573.13	29 419.92	n/a
Rehabilitation of sections of railway infrastructure along Plovdiv - Burgas railway line	2011	2016	255 653 174.58	USD	255 002 161.92	231 504.60	419 508.06	0.00	18 520 368.38	83 901.61	n/a
Modernization of the railway section Septemvri - Plovdiv - part of the Trans European railway network	2011	2016	174 548 152.31	USD	165 940 047.76	7 145 002.06	0.00	1 463 102.49	10 683 316.48	n/a	209 014.64
Rehabilitation of station facilities along TEN-T: Sofia Central station Burgas station Pazardzhik station phase 2	2013	2016	59 391 461.82	USD	28 956 899.74	0.00	29 570 193.93	864 368.15	n/a	n/a	432 184.08

Figure 10
Allocation of costs for projects in Bulgaria



20. Figure 10 demonstrates the allocation of costs for the projects implemented in Bulgaria:

- Reconstruction and electrification of Plovdiv - Svilengrad railway line along corridors IV and IX: Phase 2 Parvomay - Svilengrad section;
- Electrification and reconstruction of the railway line Plovdiv – Svilengrad on Transport Corridors IV and IX Phase I: section Krumovo – Dimitrovgrad;
- Electrification and upgrading of Svilengrad - TUR railway line;
- Rehabilitation of sections of railway infrastructure along Plovdiv - Burgas railway line;
- Modernization of the railway section Septemvri - Plovdiv - part of the Trans European railway network;
- Rehabilitation of station facilities along TEN-T: Sofia Central station Burgas station Pazardzhik station phase 2.

21. They were divided into costs of the construction of bridges viaducts stations overpasses and underpasses for selected projects. The remainder of the costs were classified as ‘others’ which constitute the most significant of all costs.

B. Croatia

22. Croatia has shared information on new construction upgrades and renewal. The costs are divided into those of stations level crossings tunnels bridges viaducts and others. The ‘others’ category dominates and stations also constitute a significant portion.

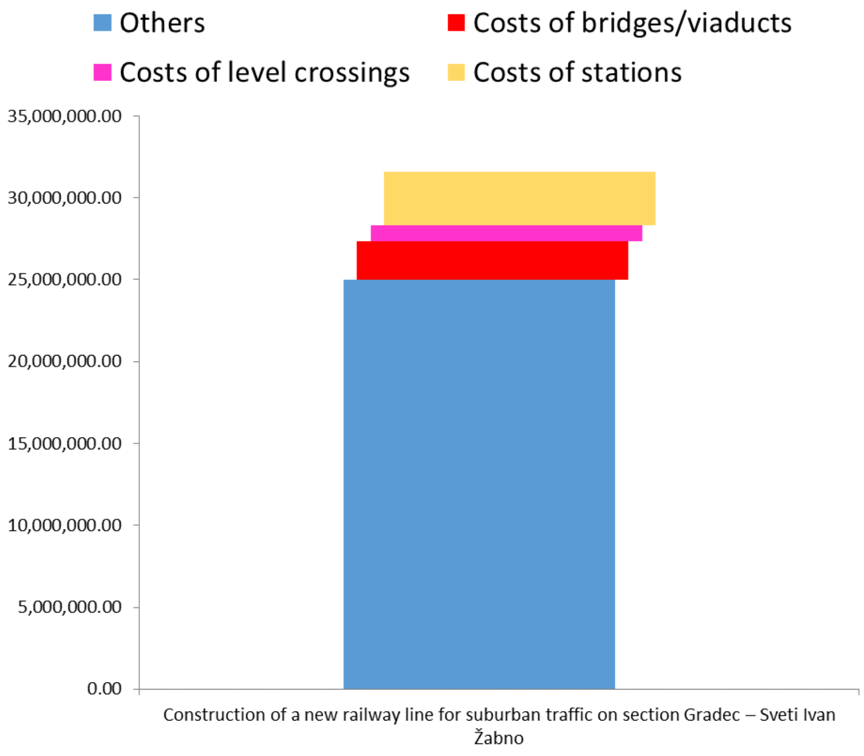
Table 5
Cost of projects implemented in Croatia

Project	*Start date*	*End date*	*Construction costs of the project*	*Currency*	*Line speed design*	*Rail work type*	*Type of line*	*Number of tracks*	*Others*	*Costs of tunnels*	*Costs of bridges/viaducts*	*Costs of level crossings*	*Costs of stations*	*Costs of over/underpasses*
Construction of a new railway line for suburban traffic on section Gradec – Sveti Ivan Žabno	26.08.2015.	18.07.2018.	31 562 961.99	USD	V<120	new construction	non-electrified	1	24 970 051.27		2 360 789.69	971 731.50	3 260 389.53	
Vinkovci to Tovarnik to State Border Railway Rehabilitation	18.08.2008.	12.12.2011.	70 860 721.17	USD	120<V ≤160 km/h	renewal	electrified	2	60 540 546.26			585 174.91	9 735 000.00	
Section renewal Moravice - (Skrad) Zagreb Main Station - Rijeka line	17.06.2013.	31.05.2107.	31 500 000.00	USD	V<120	renewal	electrified	1	31 500 000.00					
Section renewal Ogulin - (Moravice) Zagreb Main Station - Rijeka line	28.07.2014.	31.12.2020.	49 500 000.00	USD	V<120	renewal	electrified	1	49 500 000.00					
Section renewal Lokve-(Drivenik) Zagreb Main Station - Rijeka line	08.11.2010.	28.02.2014.	18 351 191.10	USD	V<120	renewal	electrified	1	14 218 886.70	2 138 959.95		127 899.45	1 865 445.00	
Section renewal Koprivnica -	25.07.2014.	30.11.2015.	16 991 465.44	USD	120<V ≤160 km/h	renewal	electrified	1	13 945 936.71			334 974.05	2 710 554.68	

Project	*Start date*	*End date*	*Construction costs of the project*	*Currency*	*Line speed design*	*Rail work type*	*Type of line*	*Number of tracks*	*Others*	*Costs of tunnels*	*Costs of bridges/viaducts*	*Costs of level crossings*	*Costs of stations*	*Costs of over/underpasses*
Botovo - State Border State Border - Botovo - Dugo Selo line														
Section renewal (Križevci)-(Koprivnica) State Border - Botovo - Dugo Selo line	24.05.2011.	11.06.2013.	27 888 850.30	USD	120<V ≤160 km/h	renewal	electrified	1	26 233 257.24			340 229.40	1 315 363.66	
Section renewal Zagreb Borongaj - (Dugo Selo) Zagreb Main Station - Dugo Selo line	01.09.2013.	01.07.2015.	34 824 880.24	USD	120<V ≤160 km/h	renewal	electrified	2	28 167 404.29			477 475.95	6 180 000.00	
Section renewal Velika Gorica - (Turopolje) Zagreb Main Station - Sisak - Novska line	03.07.2013.	29.05.2014.	9 675 000.00	USD	120<V ≤160 km/h	renewal	electrified	1	6 245 925.00			80 400.00	3 348 675.00	
Section renewal Klara - (Zagreb MS) Zagreb Main Station - Sisak - Novska line	13.03.2013.	30.05.2014.	6 045 000.00	USD	V<120	renewal	electrified	1	5 974 800.00			70 200.00		
Okučani to Novska Railway Rehabilitation and Upgrade	31.07.2012.	30.11.2016.	37 014 792.46	USD	120<V ≤160 km/h	upgrade	electrified	2	26 229 798.82			1 540 504.30	8 895 280.77	349 208.59

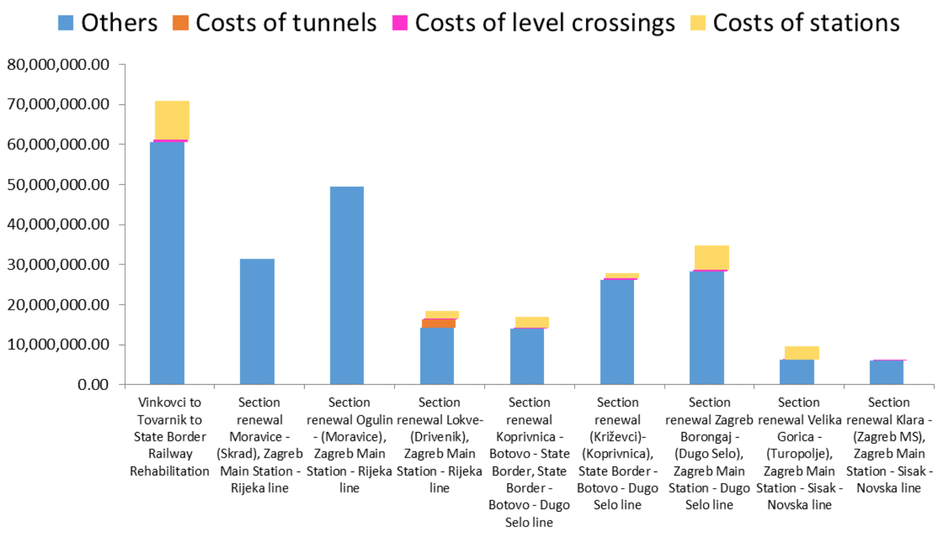
Project	*Start date*	*End date*	*Construction costs of the project*	*Currency*	*Line speed design*	*Rail work type*	*Type of line*	*Number of tracks*	*Others*	*Costs of tunnels*	*Costs of bridges/viaducts*	*Costs of level crossings*	*Costs of stations*	*Costs of over/underpasses*
Zagreb Main Railway Station - reconstruction (modernisation) of signalling and interlocking system in scope of IPA Fund	02.11.2010.	09.11.2017.	10 870 480.50	USD	120<V ≤160 km/h	upgrade	electrified	2	0.00				10 870 480.50	
Reconstruction of existing and construction of second track on section Dugo Selo - Križevci State Border - Botovo - Dugo Selo line	25.07.2016.	planned Q2/ 2022	181 500 000.00	USD	120<V ≤160 km/h	upgrade	electrified	2	132 110 000.00		3 850 000.00	550 000.00	42 900 000.00	2 090 000.00
Modernisation and section upgrade of Oštarije - Knin - Split line	2009.	2020.	261 600 000.00	USD	V<120	upgrade	non-electrified	1	253 800 000.00		6 000 000.00			1 800 000.00

Figure 11
Allocation of costs for new construction projects in Croatia



23. Figure 11 demonstrates the allocation of costs for the construction of a new railway line for suburban traffic on the section Gradec – Sveti Ivan Žabno. The most significant are costs classified as 'others'. However the cost of construction of stations is also meaningful.

Figure 12
Allocation of costs for the renewal projects in Croatia



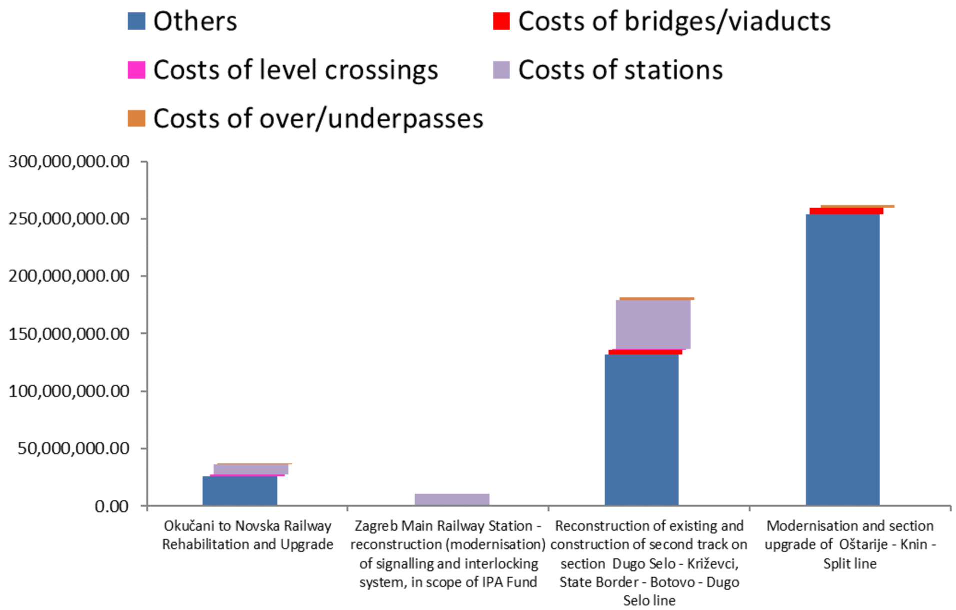
24. This figure refers to the renewal projects:

- Vinkovci to Tovarnik to State Border Railway Rehabilitation;
- Section renewal Moravice - (Skrad) Zagreb Main Station - Rijeka line;
- Section renewal Ogulin - (Moravice) Zagreb Main Station - Rijeka line;

- Section renewal Lokve- (Drivenik) Zagreb Main Station - Rijeka line;
- Section renewal Koprivnica - Botovo - State Border State Border - Botovo - Dugo Selo line;
- Section renewal (Križevci)- (Koprivnica) State Border - Botovo - Dugo Selo line;
- Section renewal Zagreb Borongaj - (Dugo Selo) Zagreb Main Station - Dugo Selo line;
- Section renewal Velika Gorica - (Turopolje) Zagreb Main Station - Sisak - Novska line;
- Section renewal Klara - (Zagreb MS) Zagreb Main Station - Sisak - Novska line.

25. Here the same situation as with new construction can be observed – 'others' are the most expensive elements whilst amongst the named costs stations are the most significant.

Figure 13
Allocation of costs for upgrade projects in Croatia



26. Figure 13 demonstrates the allocation of costs of the upgrade of the following projects:

- Okučani to Novska Railway Rehabilitation and Upgrade;
- Zagreb Main Railway Station - reconstruction (modernisation) of signalling and interlocking system in scope of IPA Fund;
- Reconstruction of existing and construction of second track on section Dugo Selo - Križevci;
- State Border - Botovo - Dugo Selo line;
- Modernisation and section upgrade of Oštarije - Knin - Split line.

27. One project is the reconstruction of the Zagreb Main Railway Station so there is only one category shown here. The size of costs of the remaining three projects is insignificant between new construction and renewal.

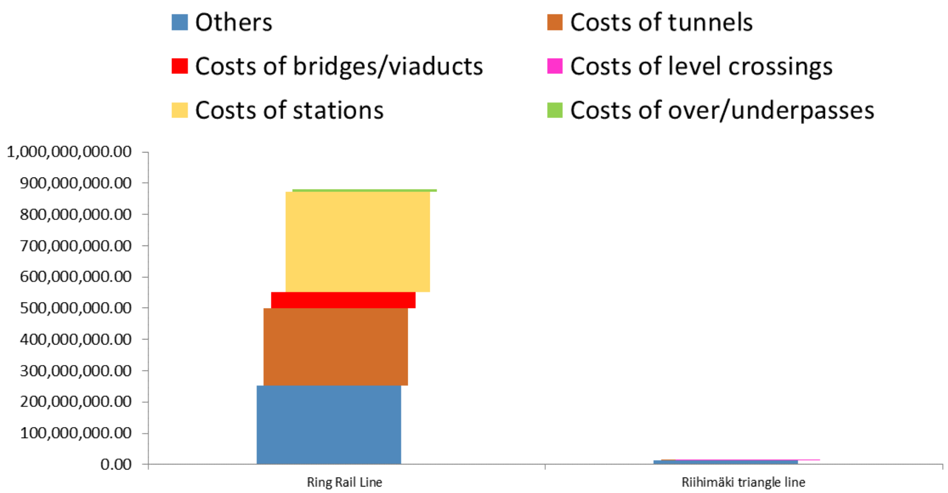
C. Finland

28. Finland has provided information about new construction and upgrades.

Table 6
Cost of projects implemented in Finland

Project	*Start date**	*End date***	*Construction costs of the project*	*Currency*	*Line speed design*	*Rail work type*	*Type of line*	*Number of tracks*	*Others*	*Costs of tunnels*	*Costs of bridges/viaducts*	*Costs of level crossings*	*Costs of stations*	*Costs of over/underpasses*
Ring Rail Line	2009-03-06	2015-07-01	881 100 000,00	USD	V<120	new construction	electrified	2	252 241 000,00	248 710 000,00	51 700 000,00	0,00	319 000 000,00	9 449 000,00
Riihimäki triangle line	2016-03-10	2016-12-31	13 200 000,00	USD	V<120	new construction	electrified	1	12 078 000,00	770 000,00	0,00	352 000,00	0,00	0,00
Railway project Seinäjoki–Oulu	2007-02-27	2016-12-31	968 000 000,00	USD	160<V≤200 km/h	upgrade	electrified	1	902 396 000,00	0,00	33 000 000,00	20 790 000,00	55 000,00	11 759 000,00
way project Huopalahti-Vantaank	2010-03-01	2014-05-01	17 600 000,00	USD	V<120	upgrade	electrified	1	17 105 000,00	0,00	0,00	0,00	495 000,00	0,00
Railwayproject Lahti-Luumaki	2008-02-01	2010-08-01	231 000 000,00	USD	160<V≤200 km/h	upgrade	electrified	2	136 323 000,00	0,00	1 100 000,00	5 940 000,00	86 900 000,00	737 000,00

Figure 14
Allocation of costs for new construction projects in Finland



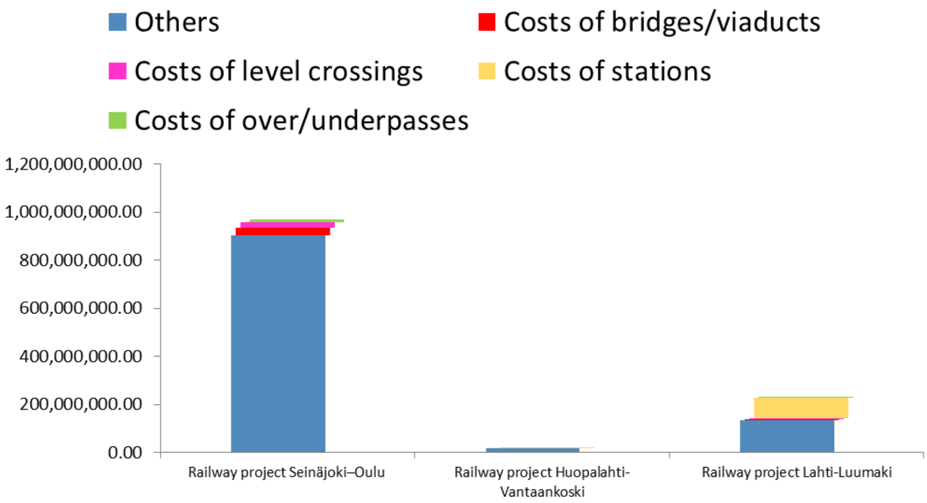
29. This figure represents the new construction of two lines:

- the Ring Rail Line;
- the Riihimäki triangle line.

30. In the Ring Rail Line the most expensive cost was the construction of stations. Also tunnels represent a significant amount of expenditure. The third category is other costs the fourth is the cost of bridges or viaducts and finally the least expensive is over or underpasses. It is noteworthy that no costs for level crossings occur.

31. The second line was much less expensive to construct where most expenditure was not classified and the remainder was spent on level crossings.

Figure 15
Allocation of costs for upgrade projects in Finland



32. Figure 21 demonstrates the upgrade projects:

- Railway project Seinäjoki–Oulu;
- Railway project Huopalahti-Vantaankoski;
- Railway project Lahti-Luumaki.

33. The most expensive is the first project and most of its costs are not classified. Construction of stations is the costliest element of the Lahti-Luumaki project. Minor funds were spent on bridges or viaducts level crossings and over or underpasses. The second project is significantly less costly and except for the cost of stations the costs are unclassified. In the third project there are stations level crossings and over or underpasses. Other costs are unclassified.

D. Poland

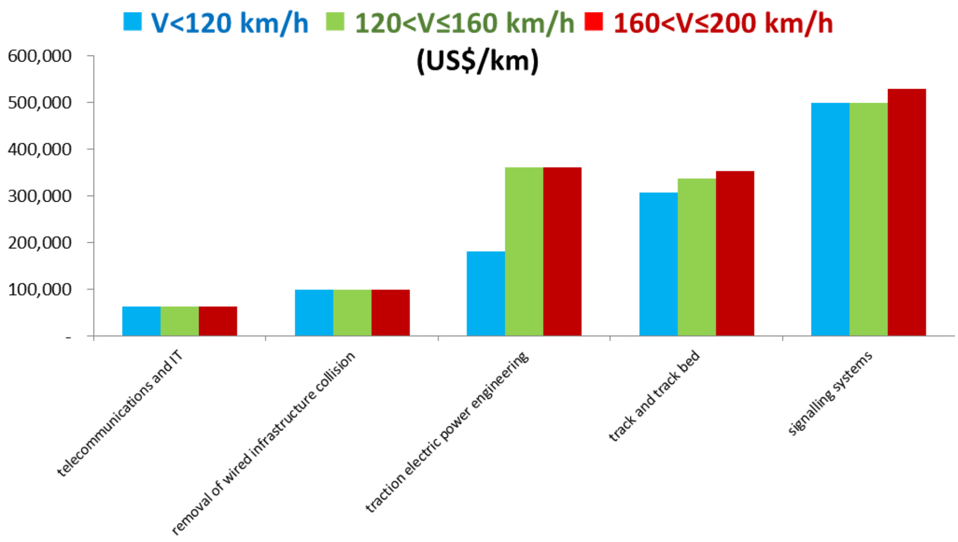
34. Poland has responded to version A of the questionnaire providing the costs of different categories of infrastructure elements. Version B of the questionnaire is covered in the TER section.

35. The Polish rail infrastructure manager PKP Polskie Linie Kolejowe S.A. has been implementing the largest programme of railway upgrades in recent years. Therefore the upgrade component has been achieved.

Table 7
Cost of infrastructure elements for upgrade in Poland

	V<120	120<V≤160 km/h	160<V≤200 km/h
preparatory work (removal of trees and bushes, demolition etc.) (US$/unit)	26,61	26,61	26,61
earthwork (US$/m^3)	14,49	14,49	14,49
track and track bed (US$/km)	306 804,28	336 262,65	353 159,80
one-sided turnouts (US$/unit)	63 862,84	86 755,14	93 333,33
diamond crossing turnouts (US$/unit)	61 594,20	61 594,20	n/a
prestressed concrete turnout sleepers (US$/m)	45,86	45,86	45,86
timber turnout sleepers (US$/m^3)	579,71	n/a	n/a
traction electric power engineering (US$/km)	181 723,77	360 827,30	360 827,30
removal of wired infrastructure collision (US$/km)	99 577,86	99 577,86	99 577,86
steel bridges (US$/m)	33 497,50	33 497,50	33 497,50
composite bridges (US$/m)	33 869,27	33 869,27	33 869,27
reinforced concrete bridges (US$/m)	22 345,58	22 345,58	22 345,58
single tube tunnels (US$/m)	25 217,39	n/a	n/a
twin tube tunnels (US$/m)	n/a	n/a	n/a
underwater tunnels (US$/m)	n/a	n/a	n/a
viaducts (US$/m)	48 772,56	48 772,56	48 772,56
culverts (US$/m)	7 404,16	7 404,16	7 404,16
retaining structures (US$/m^3)	266,23	266,23	266,23
passive level crossings (US$/unit)	n/a	n/a	n/a
active level crossings – manual (US$/unit)	279 590,83	279 590,83	n/a
active level crossings – automatic with user-side warning (US$/unit)	367 980,29	367 980,29	n/a
active level crossings – automatic with user-side protection (US$/unit)	337 037,32	337 037,32	n/a
active level crossings – rail-side protected (US$/unit)	231 336,66	231 336,66	n/a
pedestrian passages - footbridges (US$/m)	9 181,56	9 181,56	9 181,56
pedestrian passages - tunnels (US$/m)	27 698,61	27 698,61	n/a
ecopassages (US$/m)	5 779,63	5 779,63	5 779,63
standard platforms, height≤76 cm (US$/m)	931,68	931,68	931,68
other platforms (US$/m)	n/a	n/a	n/a
elevators (US$/unit)	59 202,36	59 202,36	59 202,36
escalators (US$/unit)	220 025,51	220 025,51	220 025,51
signalling systems (US$/km)	499 797,28	499 797,28	528 782,79
signal boxes (US$/unit)	727 147,88	727 147,88	727 147,88
telecommunications and IT (US$/km)	63 526,23	63 526,23	63 526,23
passenger information systems (US$/unit)	n/a	n/a	n/a
lighting installations (US$/unit)	831,09	831,09	831,09

Figure 16
Cost of upgrades of infrastructure elements expressed in US $/km in Poland



36. The figure demonstrates five types of infrastructure element expressed in $US $/km:

- telecommunications and IT
- removal of wired infrastructure collision
- traction electric power engineering
- track and track bed
- signalling systems.

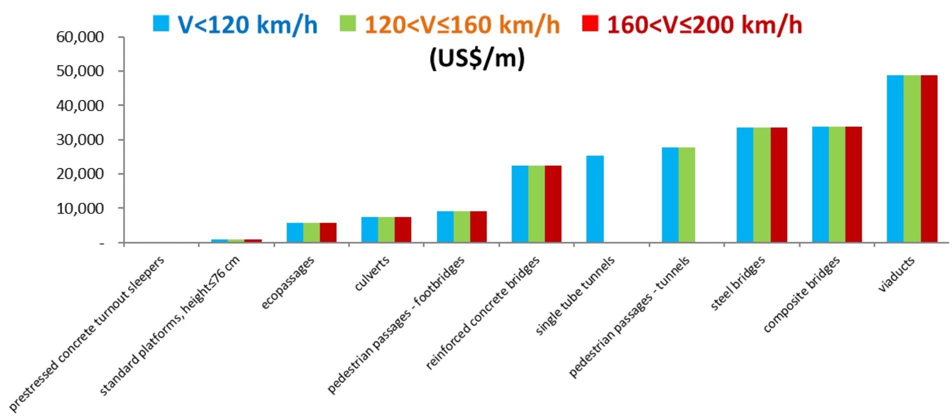
37. The most expensive category is the signalling system and the cost is irrelevant to the speed. The cost of the signalling system increases by 5.8 per cent (approx. 30 000 US $) only for the highest speed.

38. The cost of track and track bed increases by 9.6 per cent and 5 per cent respectively for higher speeds.

39. The case of traction electric power engineering is noteworthy as the cost of this work is half as much for speeds lower than 120 km/h.

40. The figure reveals that the cost of Information Technology as well as that related to the removal of wired infrastructure collision is at the same level for all speed categories.

Figure 17
Cost of upgrades of infrastructure elements expressed in US $/m in Poland

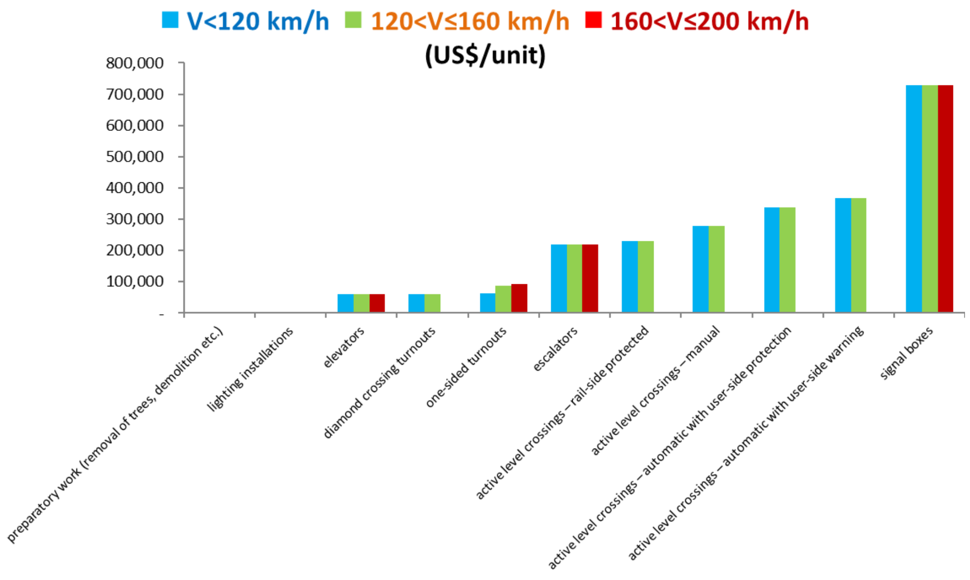


41. The figure demonstrates eleven categories expressed in US $/m:

- prestressed concrete turnout sleepers
- standard platforms height≤76 cm
- eco-passages
- culverts
- pedestrian passages – footbridges
- reinforced concrete bridges
- single tube tunnels
- pedestrian passages – tunnels
- steel bridges
- composite bridges
- viaducts.

42. The cheapest categories are prestressed concrete turnout sleepers and standard platforms. The most expensive are viaducts bridges and tunnels. The cost is irrelevant to the speed.

Figure 18
Cost of upgrades of infrastructure elements expressed in US $/unit in Poland



43. Figure 18 demonstrates infrastructure elements expressed in US $/unit:

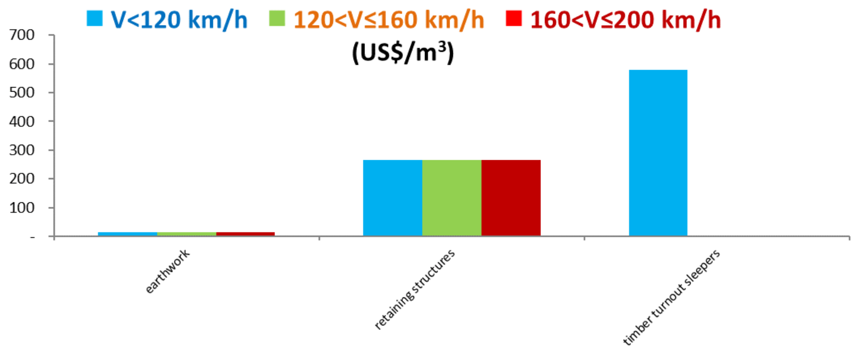
- preparatory work (removal of trees demolition etc.)
- lighting installations
- elevators
- diamond crossing turnouts
- one-sided turnouts
- escalators
- active level crossings – rail-side protected
- active level crossings – manual
- active level crossings – automatic with user-side protection

- active level crossings – automatic with user-side warning
- signal boxes.

44. Except for one-sided turnouts there is no relationship between cost and speed.

45. The lowest share of cost is for preparatory work and lighting installation whilst the greatest share is for signal boxes.

Figure 19
Cost of upgrades of infrastructure elements expressed in US $/m³ in Poland



46. Three elements are expressed in US $/m³:

- earthwork
- retaining structures
- timber turnout sleepers.

47. None of the costs are dependent on the speed. The graphs demonstrate that the cost of most of the elements does not depend on the speed designed for a specific line.

E. Serbia

48. Serbia has provided information about new construction and upgrades.

Table 8
Projects implemented in Serbia

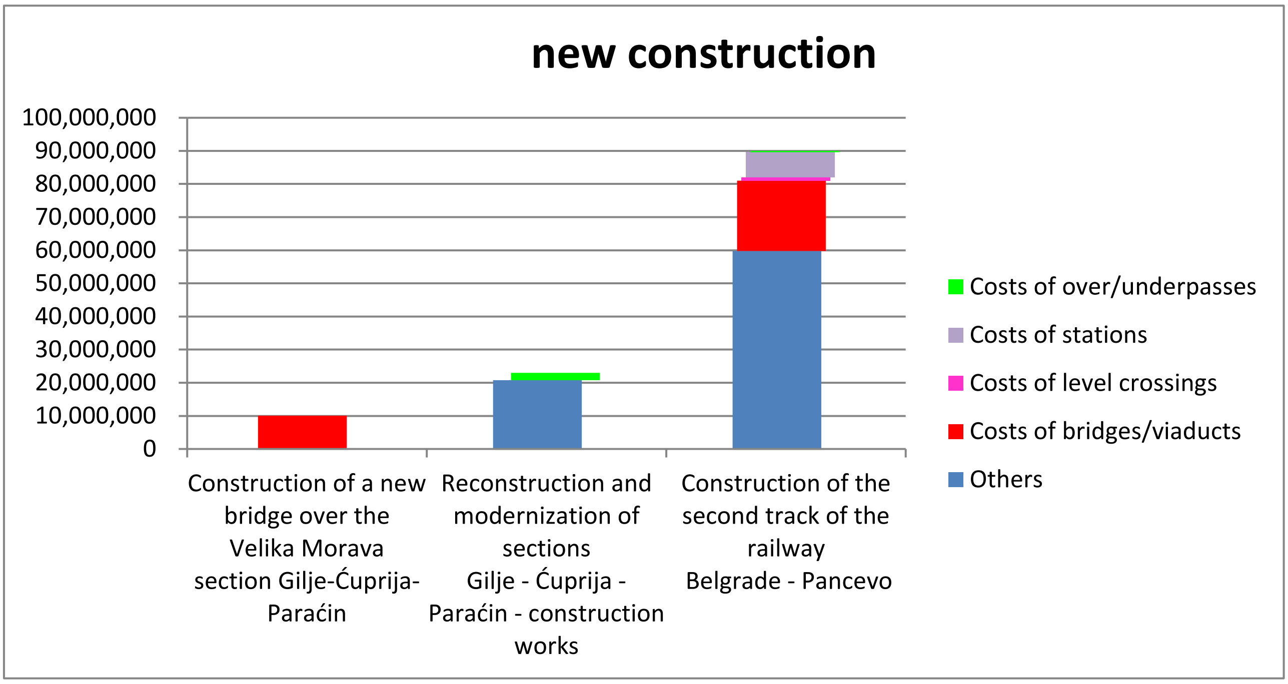
Project	*Start date**	*End date***	*Construction costs of the project*	*Currency*	*Prices of (year)*	*Line speed design*	*Rail work type*	*Type of line*	*Number of tracks*	*Others*	*Costs of tunnels*	*Costs of bridges/viaducts*	*Costs of level crossings*	*Costs of stations*	*Costs of over/underpasses*
Construction of a new bridge over the Velika Morava section Gilje-Ćuprija-Paraćin	23/04/2014	07/05/2015	10 002 161.29	USD		120<V≤160 km/h	new construction	electrified	2	0	0	10 002 161	0	0	0
Reconstruction and modernization of sections Gilje - Ćuprija - Paraćin - construction works	11/02/2013	10/08/2016	23 015 173.41	USD		120<V≤160 km/h	new construction	electrified	2	20 779 452	0	0	0	0	2 235 721
Construction of the second track of the railway Belgrade - Pancevo	12/03/2014	24/02/2017	89 946 473.58	USD		120<V≤160 km/h	new construction	electrified	2	59 737 898	0	21 314 347	929 716	7 622 942	341 572
Reconstruction and modernization sections Batajnica - Golubinci	08/12/2008	01/11/2009	18 850 110.05	USD		V<120	upgrade	electrified	2	18 850 110	0	0	0	0	0
Reconstruction of the northern section of Corridor X -	19/02/2015	30/10/2015	10 771 716.71	USD		V<120	upgrade	electrified	2	10 749 929	0	0	21 788	0	0

Project	*Start date**	*End date***	*Construction costs of the project*	*Currency*	*Prices of (year)*	*Line speed design*	*Rail work type*	*Type of line*	*Number of tracks*	*Others*	*Costs of tunnels*	*Costs of bridges/viaducts*	*Costs of level crossings*	*Costs of stations*	*Costs of over/underpasses*
Golubinci-Ruma															
Reconstruction of the northern section of Corridor X - Mala Krsna-Velika Plana	14/10/2015	01/06/2016	17 275 473.77	USD		V<120	upgrade	electrified	1	17 190 756	0	0	84 718	0	0
Reconstruction of the northern section of Corridor X - Sopot Kosmajski-Kovačevac	06/04/2015	02/09/2015	10 106 360.79	USD		V<120	upgrade	electrified	1	9 853 154	0	0	253 207	0	0
Reconstruction of the southern section of Corridor X - Vinarce-Leskovac-Đorđevo	20/10/2016	23/04/2017	9 220 175.19	USD		V<120	upgrade	electrified	1	8 755 886	0	0	464 289	0	0
Reconstruction of the southern section of Corridor X - Vranjska Banja-Ristovac	20/04/2016	23/03/2017	11 770 951.52	USD		V<120	upgrade	electrified	1	11 488 900	0	0	282 052	0	0
Reconstruction of the southern section of Corridor X -	20/04/2016	14/03/2017	8 356 499.41	USD		V<120	upgrade	electrified	1	8 275 721	0	0	80 779	0	0

Project	*Start date**	*End date***	*Construction costs of the project*	*Currency*	*Prices of (year)*	*Line speed design*	*Rail work type*	*Type of line*	*Number of tracks*	*Others*	*Costs of tunnels*	*Costs of bridges/viaducts*	*Costs of level crossings*	*Costs of stations*	*Costs of over/underpasses*
Bujanovac-Bukarevac															

Figure 20

Allocation of costs for new construction projects in Serbia

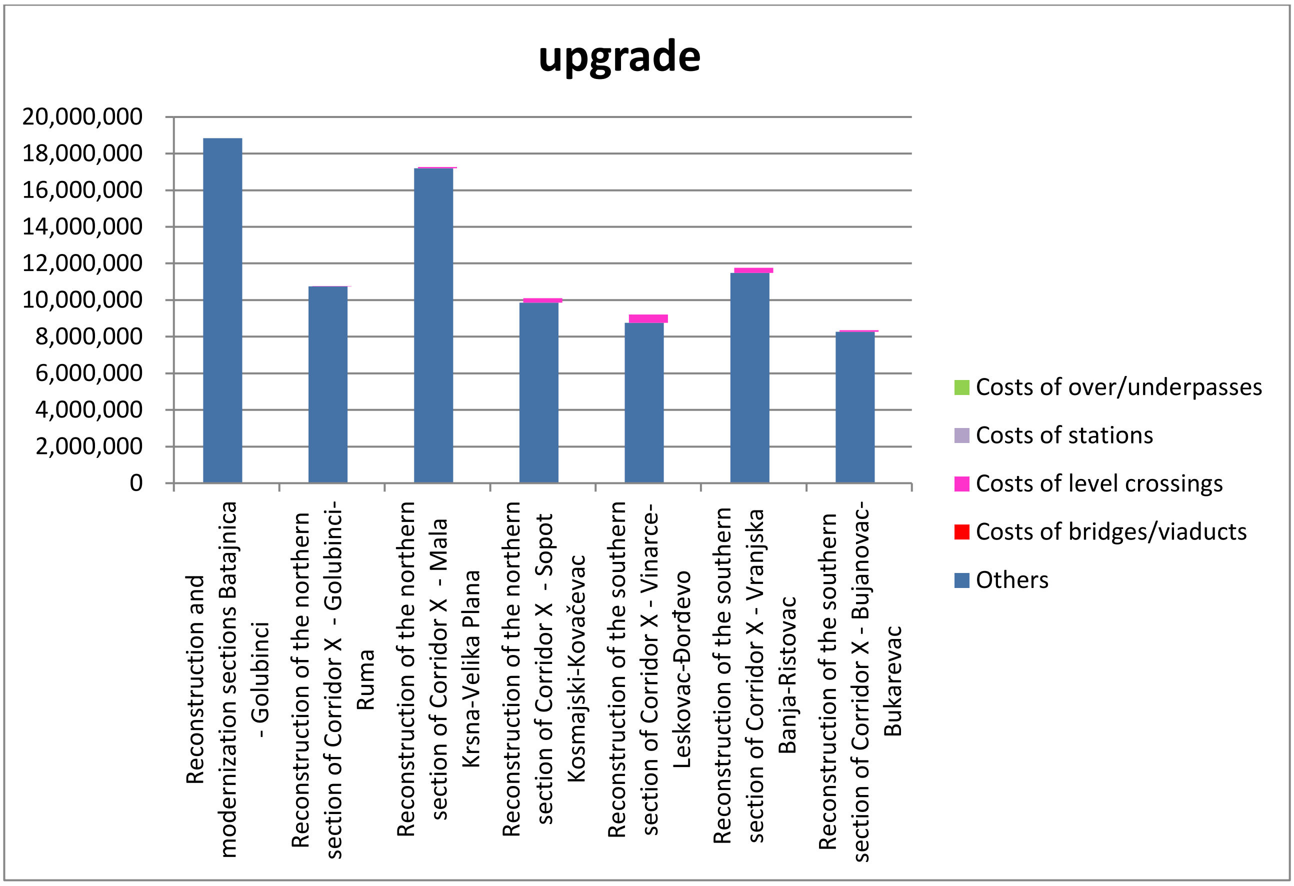


49. This figure refers to the new construction projects:

- Construction of a new bridge over the Velika Morava section Gilje-Ćuprija-Paraćin;
- Reconstruction and modernization of sections Gilje - Ćuprija - Paraćin - construction works;
- Construction of the second track of the railway Belgrade – Pancevo.

50. For the last two projects 'others' are the most expensive elements whilst amongst the named costs over/underpasses are the most significant.

Figure 21
Allocation of costs for upgrade projects in Serbia



51. Figure 21 demonstrates the allocation of costs for the upgrade projects implemented in Serbia:

- Reconstruction and modernization sections Batajnica - Golubinci;
- Reconstruction of the northern section of Corridor X - Golubinci-Ruma;
- Reconstruction of the northern section of Corridor X - Mala Krsna-Velika Plana;
- Reconstruction of the northern section of Corridor X - Sopot Kosmajski-Kovačevac;
- Reconstruction of the southern section of Corridor X - Vinarce-Leskovac-Đorđevo;
- Reconstruction of the southern section of Corridor X - Vranjska Banja-Ristovac;
- Reconstruction of the southern section of Corridor X - Bujanovac-Bukarevac;
- Reconstruction of the Belgrade-Vrbnica railway section Resnik - Valjevo (Phase I);
- Rehabilitation of the railway track in the length of 1.3 km from Ćuprija to Paraćin and construction of a new track in the length of 1.8 km from Zmič to Paraćin.

52. They were divided into costs of the upgrade of over/underpasses stations level crossings bridges and viaducts. The remainder of the costs were classified as ‘others’ which for three projects constitute the most significant of all costs. For four other projects the level crossings are the most expensive elements. For the first two – costs of bridges and viaducts.

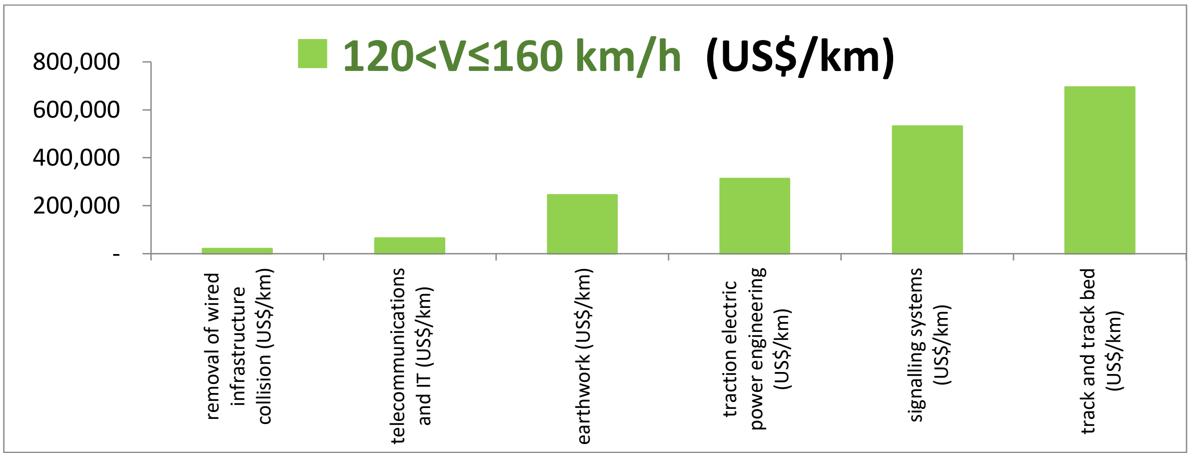
F. Slovenia

53. Slovenia has completed both parts of the questionnaire providing the costs of particular elements of infrastructure and of a project of reconstruction and modernisation.

Table 9
Cost of infrastructure elements for upgrade in Slovenia

		120<V≤160 km/h
removal of wired infrastructure collision (US$/km)	(US$/km)	$20 121 30
telecommunications and IT (US$/km)	(US$/km)	$63 840 00
earthwork (US$/km)	(US$/km)	$243 985 84
traction electric power engineering (US$/km)	(US$/km)	$311 982 89
signalling systems (US$/km)	(US$/km)	$532 000 00
track and track bed (US$/km)	(US$/km)	$693 685 44
other platforms (US$/m)	(US$/m)	$260 68
standard platforms height≤76 cm (US$/m)	(US$/m)	$955 47
culverts (US$/m)	(US$/m)	$3 439 91
retaining structures (US$/m)	(US$/m)	$5 234 88
pedestrian passages - footbridges (US$/m)	(US$/m)	$5 640 26
viaducts (US$/m)	(US$/m)	$14 342 72
reinforced concrete bridges (US$/m)	(US$/m)	$14 672 56
pedestrian passages - tunnels (US$/m)	(US$/m)	$15 100 29
preparatory work (removal of trees and bushes demolition etc.) (US$/$m^2$)	(US$/m2)	$17 02
railway stations (excluding facilities for train operations) (US$/$m^2$)	(US$/m2)	$159 60
prestressed concrete turnout sleepers (US$/unit)	(US$/unit)	$43 62
timber turnout sleepers (US$/unit)	(US$/unit)	$56 39
elevators (US$/unit)	(US$/unit)	$28 196 00
passenger information systems (US$/unit)	(US$/unit)	$31 920 00
escalators (US$/unit)	(US$/unit)	$59 392 48
one-sided turnouts (US$/unit)	(US$/unit)	$112 072 18
active level crossings – automatic with user-side protection (US$/unit)	(US$/unit)	$532 000 00

Figure 22
Cost of upgrade of infrastructure elements expressed in US$/km in Slovenia



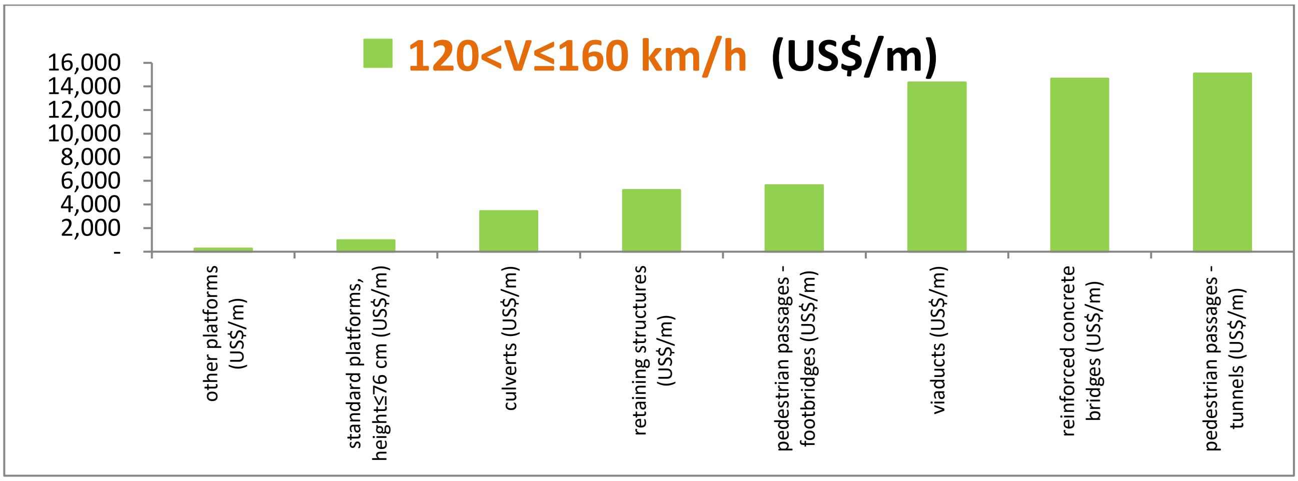
54. Figure 22 demonstrates infrastructure elements expressed in US$/km:

- removal of wired infrastructure collision
- telecommunications and IT
- earthwork

- traction electric power engineering
- signalling systems
- track and track bed.

55. The lowest cost in this category is removal of wired infrastructure collision and telecommunications and IT whilst the most expensive is track and track bed.

Figure 23
Cost of upgrade of infrastructure elements expressed in US$/m in Slovenia



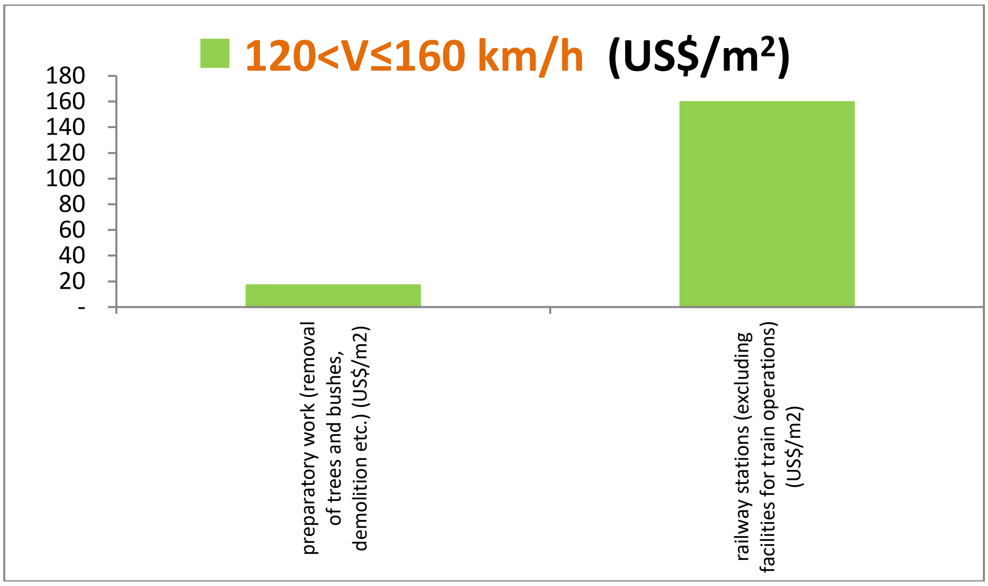
56. Eight infrastructure elements expressed in US$/m are shown in this graph:

- platforms including the standard ones
- culverts
- retaining structures
- pedestrian passages – footbridges
- viaducts
- reinforced concrete bridges
- pedestrian passages - tunnels.

57. The cost of the last three elements is at almost the same level. Amongst all elements expressed in metres the viaducts bridges and tunnels are the most expensive.

Figure 24

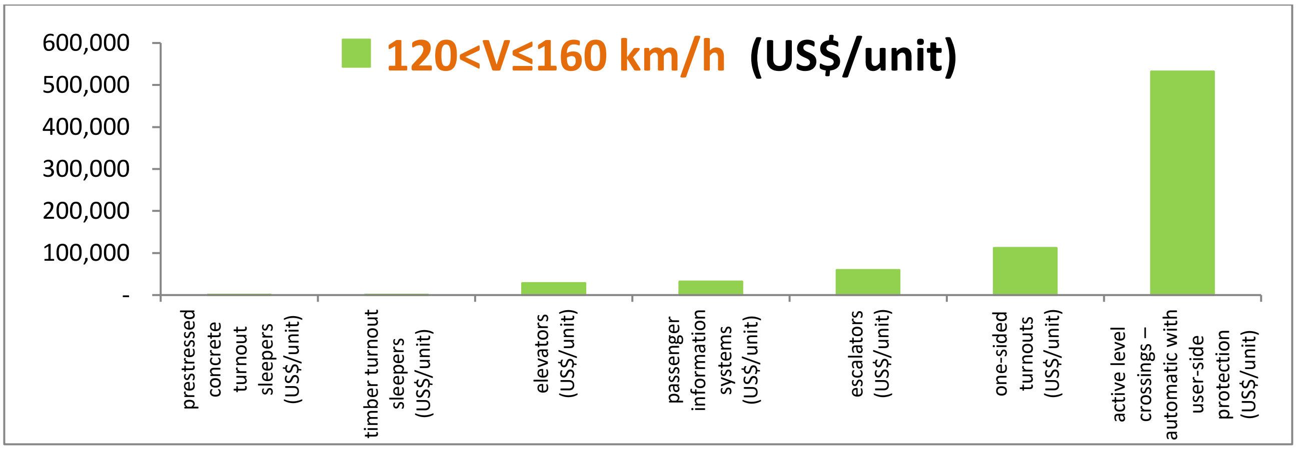
Cost of upgrade of the infrastructure elements expressed in US$/m2 in Slovenia



58. The figure represents two elements of which the cost is expressed in US$/m². These are preparatory work and railway stations.

Figure 25

Cost of upgrade of infrastructure elements expressed in US$/unit in Slovenia



59. The figure demonstrates the following infrastructure elements expressed in US$/unit:

- prestressed concrete turnout sleepers
- timber turnout sleepers
- elevators
- passenger information systems
- escalators
- one-sided turnouts
- active level crossings – automatic with user-side protection.

60. The most expensive are level crossings. What is worth emphasising is that escalators are double expensive than elevators.

61. Project implemented in Slovenia

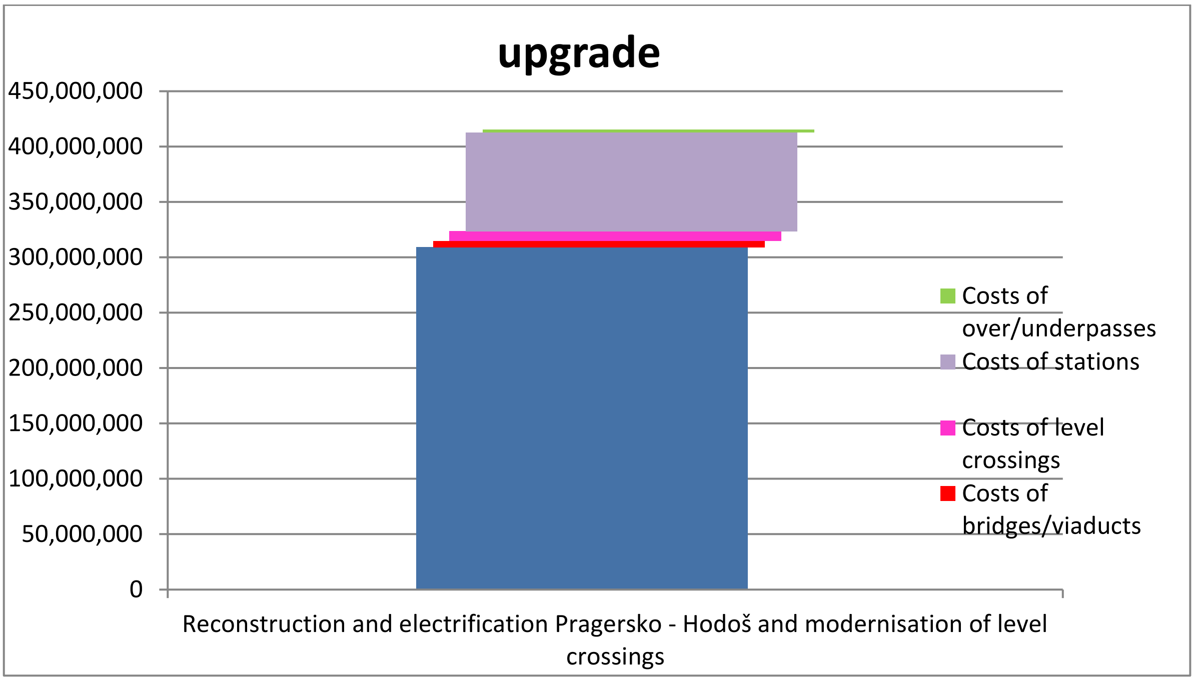
62. Slovenia shared the information about the reconstruction and electrification Pragersko - Hodoš and modernisation of level crossings

Table 10
Cost of project implemented in Slovenia

Project	*Start date**	*End date***	*Construction costs of the project*	*Currency*	*Prices of (year)*	*Line speed design*	*Rail work type*	*Type of line*	*Number of tracks*	*Others*	*Costs of bridges/viaducts*	*Costs of level crossings*	*Costs of stations*	*Costs of over/under passes*
Reconstruction and electrification Pragersko - Hodoš and modernisation of level crossings	17/04/2009	05/06/2016	414 930 712	USD	2016	120<V ≤160 km/h	upgrade	electrified	1	309 408 042	5 420 029	8 801 713	89 170 610	2 130 318

Figure 26

Allocation of costs for a project in Slovenia



63. In the project Pragersko - Hodoš apart from the other cost the most expensive one was the construction of stations. Also cost of level crossings bridges and viaducts occurs. The least expensive are over or underpasses.

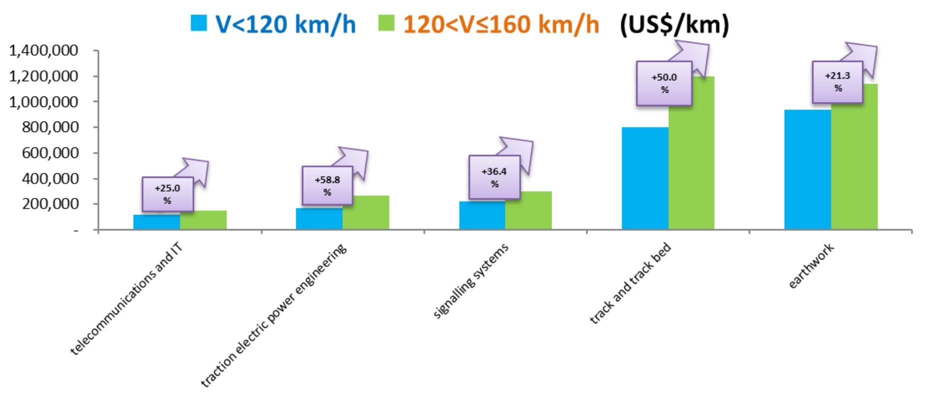
G. Turkey

64. Turkey has completed both parts of the questionnaire providing the costs of elements of infrastructure.

Table 11
Cost of infrastructure elements for new construction in Turkey

		V<120	120<V≤160 km/h
telecommunications and IT	US$/km	120000,00	150000,00
traction electric power engineering	US$/km	170000,00	270000,00
signalling systems	US$/km	220000,00	300000,00
track and track bed	US$/km	800000,00	1200000,00
earthwork	US$/km	940000,00	1140000,00
pedestrian passages - footbridges	US$/m	100,00	100,00
ramps	US$/m	2000,00	3000,00
retaining structures	US$/m	3000,00	3500,00
sidings	US$/m	3000,00	4000,00
railway infrastructure in ports and terminals	US$/m	4000,00	4000,00
culverts	US$/m	4500,00	5000,00
reinforced concrete bridges	US$/m	12000,00	16000,00
single tube tunnels	US$/m	12500,00	14000,00
twin tube tunnels	US$/m	14500,00	16500,00
viaducts	US$/m	15000,00	19000,00
preparatory work (removal of trees and bushes, demolition etc.) (US$/m^2)	US$/m2	0,30	0,30
prestressed concrete turnout sleepers	US$/unit	65,00	70,00
passive level crossings	US$/unit	1200,00	1200,00
lighting installations	US$/unit	2500,00	2500,00
active level crossings – manual	US$/unit	3000,00	3000,00
active level crossings – automatic with user-side warning	US$/unit	10000,00	10000,00
active level crossings – automatic with user-side protection	US$/unit	12000,00	12000,00
one-sided turnouts	US$/unit	28000,00	33000,00
diamond crossing turnouts	US$/unit	38000,00	44000,00

Figure 27
Cost of new construction of infrastructure elements expressed in US $/km in Turkey



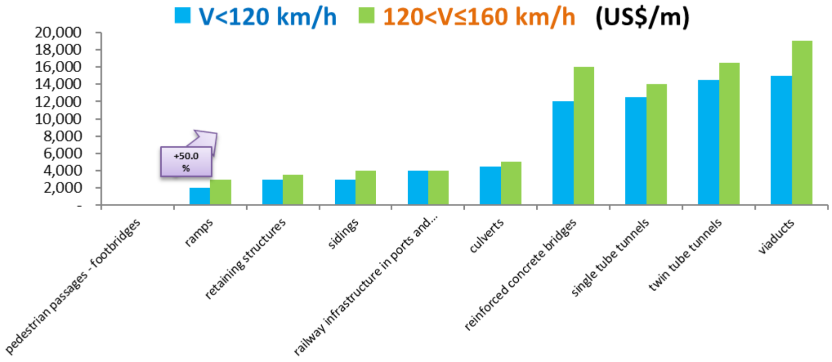
65. Figure 27 demonstrates costs expressed in US $/km:

- telecommunications and IT
- traction electric power engineering
- signalling systems

- track and track bed
- earthwork.

66. All of these costs increase with higher speeds. The most visible difference is for traction electric power engineering and track and track bed.

Figure 28
Cost of new construction of infrastructure elements expressed in US $/m in Turkey

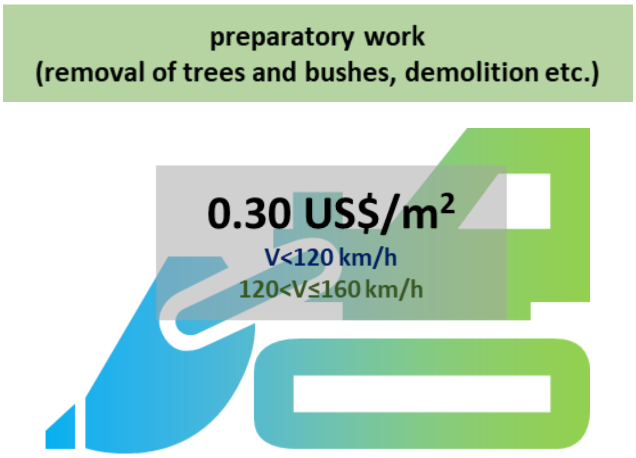


67. The figure represents the following infrastructure elements of which the cost is expressed in US $/m:

- pedestrian passages – footbridges
- ramps
- retaining structures
- sidings
- railway infrastructure in ports and terminals
- culverts
- reinforced concrete bridges
- single tube tunnels
- twin tube tunnels
- viaducts.

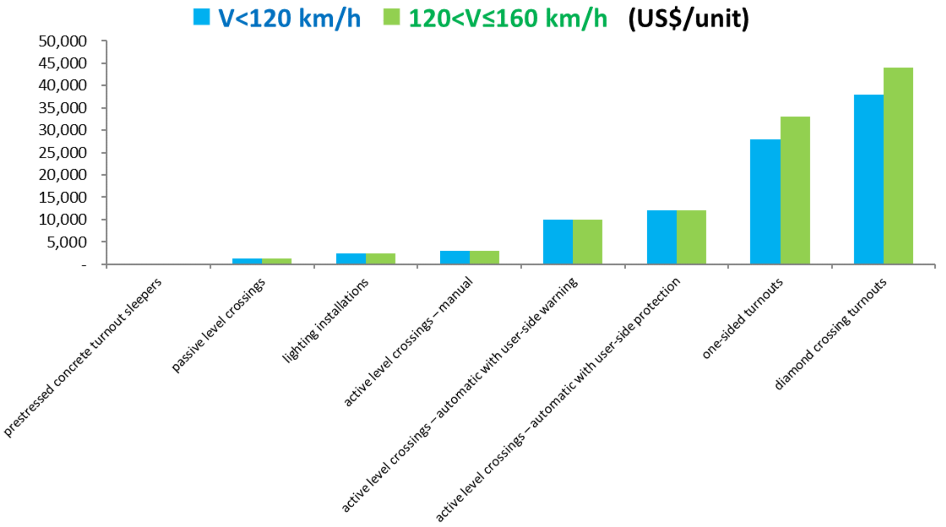
68. This is another example of higher costs for higher speed projects. The only exception is railway infrastructure in ports and terminals in which the cost for both speed ranges is equal.

Figure 29
Cost of new construction of infrastructure elements expressed in US $/m^2 in Turkey



69. One infrastructure element is measured in US $/m2 and price and speed do not correlate.

Figure 30
Cost of new construction of infrastructure elements expressed in US $/unit



70. This figure demonstrates elements expressed in US $/unit:

- prestressed concrete turnout sleepers
- passive level crossings
- lighting installations
- active level crossings – manual
- active level crossings – automatic with user-side warning
- active level crossings – automatic with user-side protection
- one-sided turnouts
- diamond crossing turnouts.

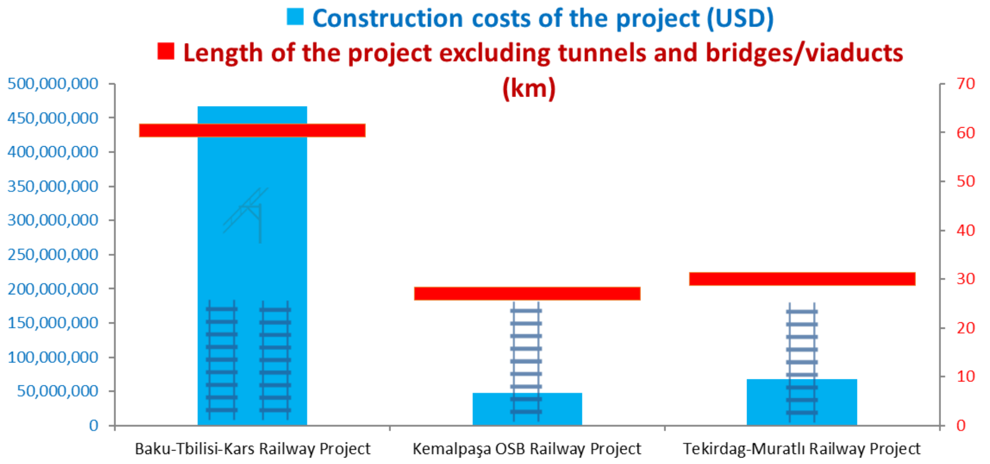
71. The costs of many elements are equal for the construction of new infrastructure for speeds between 120 and 160 km/h in comparison with speeds less than 120 km/h. However three categories represent higher costs for higher speed. This is the case for sleepers and turnouts.

72. Projects implemented in Turkey:

Table 12
Cost of projects implemented in Turkey

Project	*Start date**	*End date***	*Construction costs of the project*	*Currency*	*Prices of (year)*	*Line speed design*	*Rail work type*	*Type of line*	*Number of tracks*	*Length of the project excluding tunnels and bridges/viaducts in km*
Baku-Tbilisi-Kars Railway Project	2007	2022	467 274 000	USD	2016	V<120	new construction	electrified	2	60,345
Kemalpaşa OSB Railway Project	2007	2016	48 000 000	USD	2016	120<V≤160 km/h	new construction	non-electrified	1	27
Tekirdag-Muratlı Railway Project	2007	2012	68 000 000	USD	2016	120<V≤160 km/h	new construction	non-electrified	1	30

Figure 31
Cost (US $) of new construction projects in Turkey vs. length



73. Since 2007 Turkey has implemented two new construction projects and one remains in progress:

- Baku-Tbilisi-Kars Railway Project;
- Kemalpaşa OSB Railway Project;
- Tekirdag-Muratlı Railway Project.

74. The difference between the project in progress and the two completed is that the former is electrified and double-tracked whereas the latter are not. The cost of the project in progress is much higher when its length is accounted for.

H. Bulgaria, Poland, Slovenia

75. Taking into account that all these countries have provided information on the cost of upgrades for speeds between 120 and 160 km/h this data was able to be compared.

Table 13
Cost of infrastructure elements for upgrade in Bulgaria, Poland and Slovenia

		120<V≤160 km/h	*120<V≤160 km/h*	*120<V≤160 km/h*
telecommunications and IT	US$/km	192 250 58	63 526 23	63 840 00
signalling systems	US$/km	340 876 53	499 797 28	532 000 00
traction electric power engineering	US$/km	347 610 33	360 827 30	311 982 89
track and track bed	US$/km	1 207 548 78	336 262 65	693 685 44
removal of wired infrastructure collision	US$/km		99 577 86	20 121 30
railway infrastructure in ports and terminals	US$/m	477 54		-
reinforced concrete bridges	US$/m	13 431 79	22 345 58	14 672 56
single tube tunnels	US$/m	17 230 11		-
twin tube tunnels	US$/m	20 691 60		-
railway stations (excluding facilities for train operations)	US$/m2	523 37		159 60
one-sided turnouts	US$/unit	39 769 62	86 755 14	112 072 18
elevators	US$/unit	65 463 61	59 202 36	28 196 00
escalators	US$/unit	94 132 93	220 025 51	59 392 48

		120<V≤160 km/h	*120<V≤160 km/h*	*120<V≤160 km/h*
other overpasses	US$/unit	1 630 081 13		

Figure 32

Comparison of upgrade of infrastructure elements expressed in US$/km in Bulgaria, Poland and Slovenia

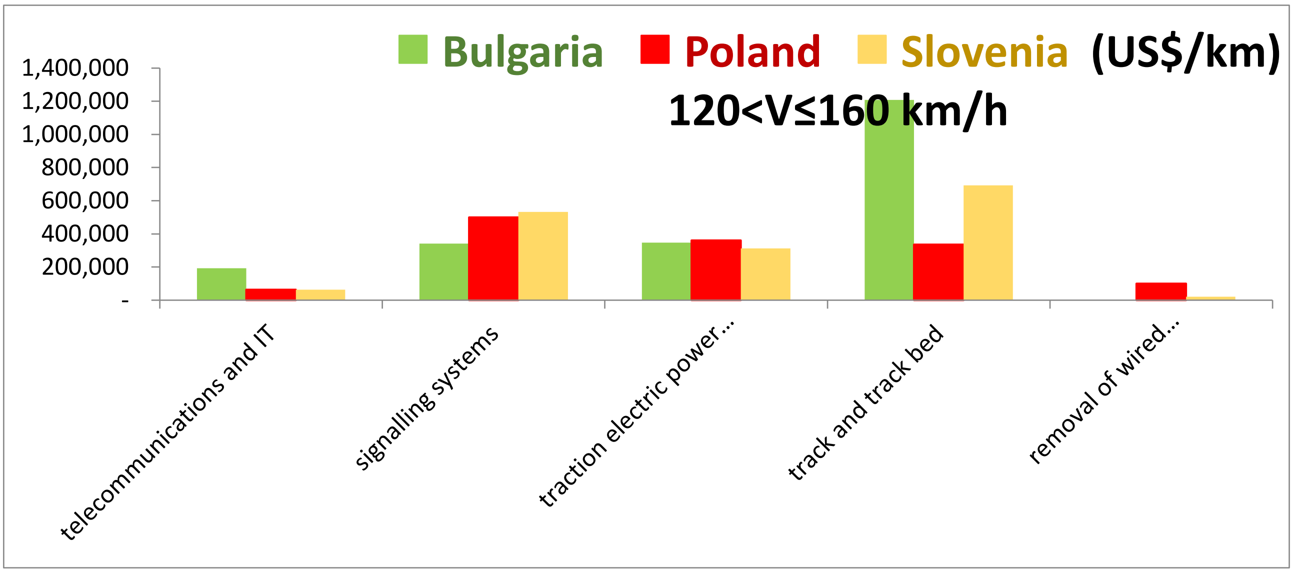


Figure 33

Comparison of upgrade of infrastructure elements expressed in US$/m in Bulgaria Poland and Slovenia

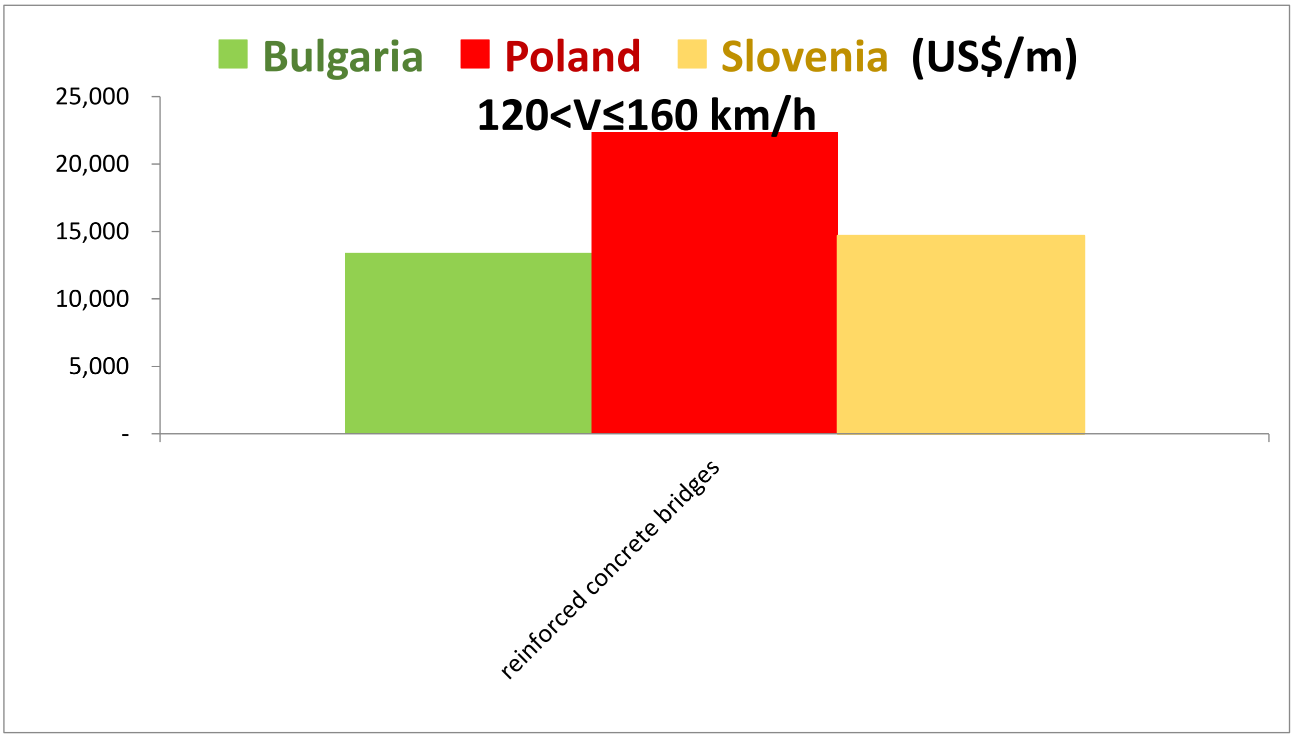
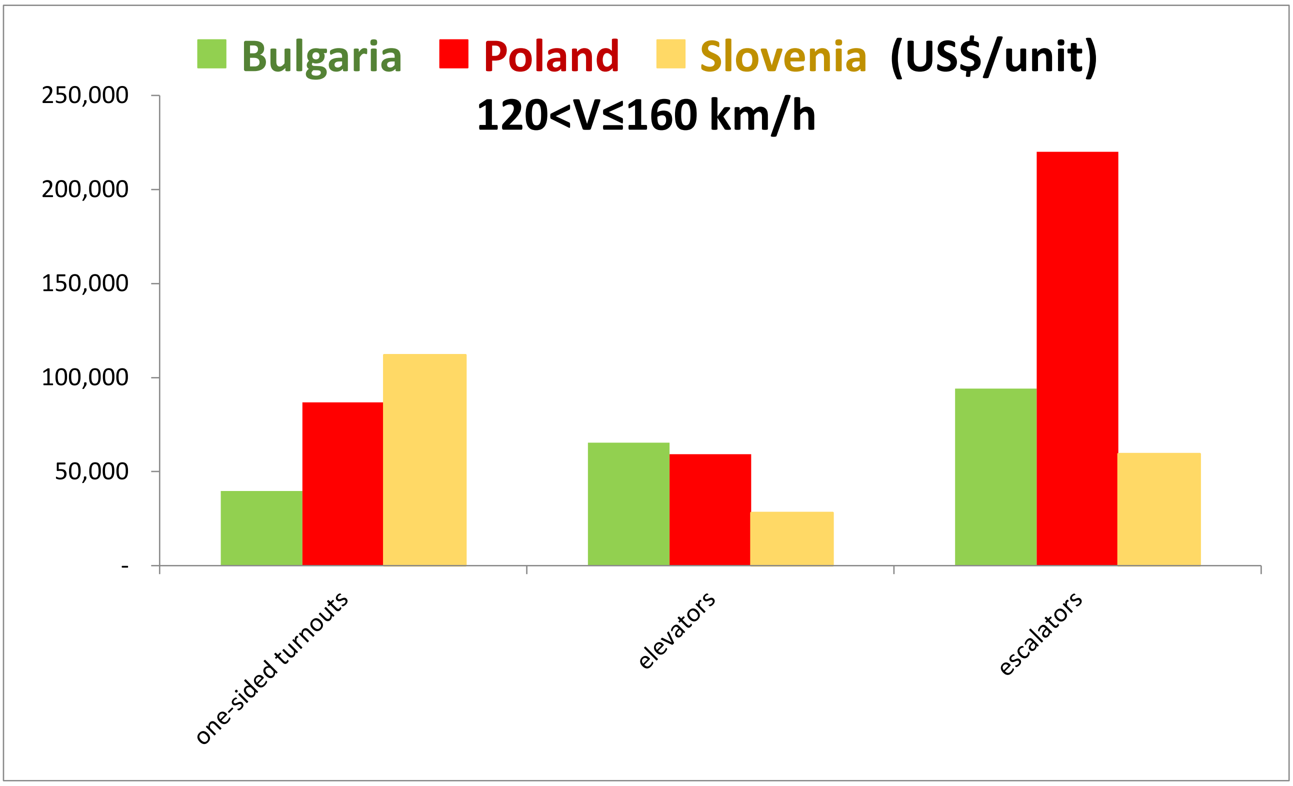


Figure 34

Comparison of upgrade of infrastructure elements expressed in US$/unit in Bulgaria Poland and Slovenia



76. Telecommunications and IT (almost the same values in Poland and Slovenia) as well as track and track bed are significantly more expensive in Bulgaria whereas reinforced concrete bridges (comparable values in Bulgaria and Slovenia) and especially escalators are much more expensive in Poland. Slovenia has only one element which is significantly more expensive – one-sided turnouts this element is the cheapest in Bulgaria. Signalling systems are also the cheapest elements in Bulgaria. In Poland and Slovenia this value is comparable. The cost of traction electric power engineering is comparable in all countries. The cost of elevators is comparable in Bulgaria and Poland whilst double cheaper in Slovenia. Removal of wired infrastructure collision can be compared only in Poland and Slovenia – it is more expensive in Poland.

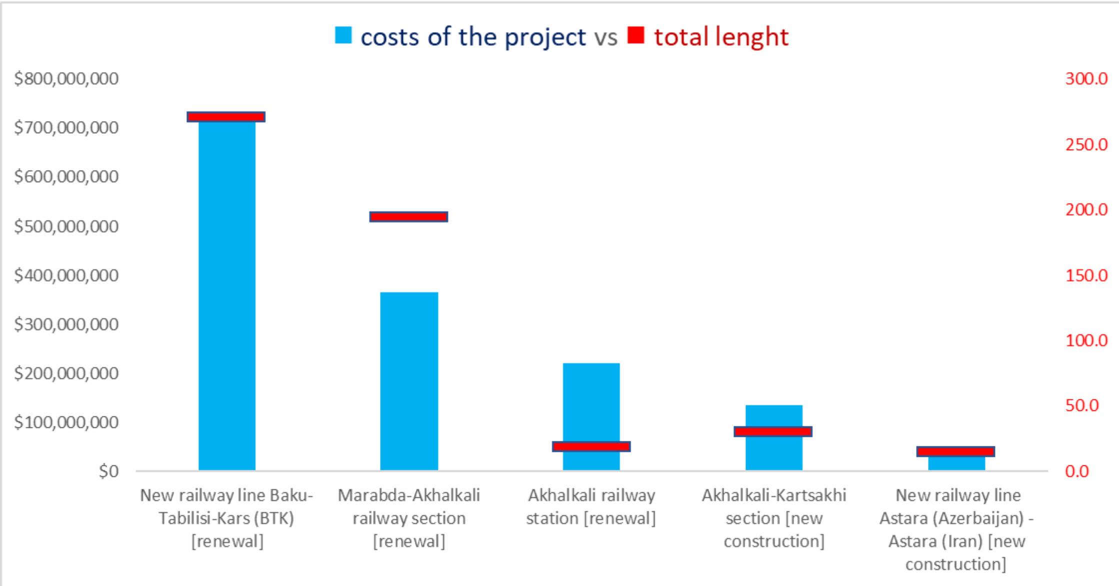
77. This section has been developed according to the data collected amongst countries participating in the ECO-ECE-ISdB GIS project.

I. Azerbaijan

Table 14
Cost of projects in Azerbaijan and their length

Project	Construction costs of the project	Currency	Prices of (year)	Line speed design	Rail work type	Type of line	Number of tracks	Total lenght of the projects	Length of the project excluding tunnels and bridges/viaducts in km	Cost of the project excluding tunnels and bridges/viaducts	Number of tunnels	Length of tunnels in km	Costs of tunnels	Number of bridges/viaducts	Length of bridges/viaducts in km	Costs of bridges/viaducts	Total length of the project in km	Number of active level crossings	Costs of level crossings	Number of stations	Costs of stations	Number of over/underpasses for pedestrians	
New railway line Baku-Tabilisi-Kars (BTK) [renewal]	$720 800 000	USD		V<120km/h	renewal	non-electrified	1	271,2	237	$382 207 400	1	2,05	$42 000000	21	1,56	$13 300 000	271,2	6	$883 000	13	$282 000 000	2	$409 600
Marabda-Akhalkali railway section [renewal]	$365 200 000	USD		V<120km/h	renewal	non-electrified	1	195,1	194	$319 417 000	0	0	$0	17	1,1	$800 000	195,1	6	$883 000	11	$44 100 000	0	$0
Akhalkali railway station [renewal]	$220 000 000	USD		V<120km/h	renewal	non-electrified	1	19,0	19,07	$509 600	0	0	$0	0	0	$0	19	0	$0	1	$220 100 000	2	$409 600
Akhalkali-Kartsakhi section [new construction]	$135 600 000	USD		V<120km/h	new construction	non-electrified	1	31,1	27	$63 300000	1	2,05	$42 000000	4	0,45	$12 500 000	31,1	0	$0	1	$17 800 000	0	$0
New railway line Astara (Azerbaijan) - Astara (Iran) [new construction]	$30 000 000	USD		V<120km/h	new construction	non-electrified	1	15,1	14,8	$30 000000	1			8	0,316					1			

Figure 35
Cost of the projects in Azerbaijan vs. length

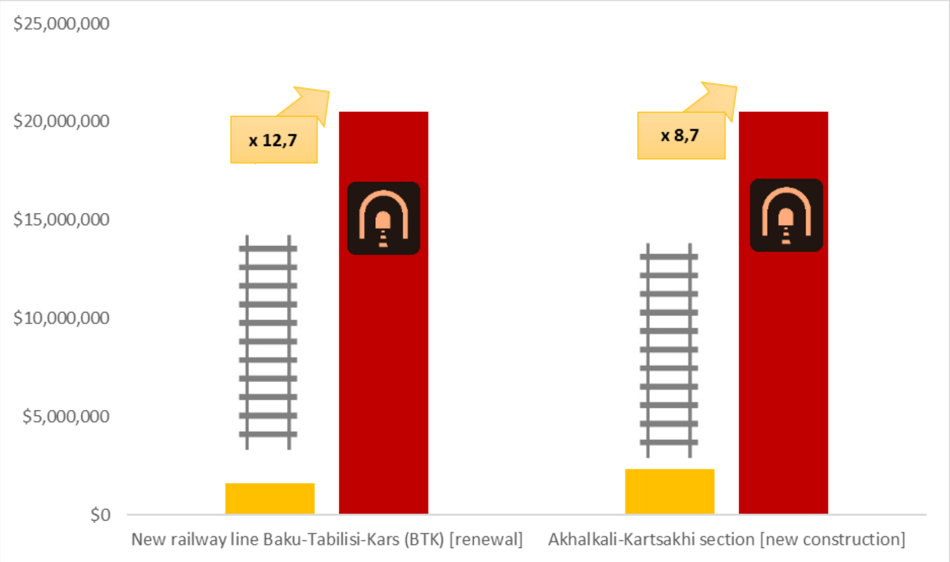


78. Azerbaijan has shared information on five projects including the construction of two new railway lines:

- New railway line Baku-Tabilisi-Kars (BTK) (renewal);
- Marabda-Akhalkali railway section (renewal);
- Akhalkali railway station (renewal);
- Akhalkali-Kartsakhi section (new construction);
- New railway line Astara (Azerbaijan) - Astara (Iran) (new construction).

79. The cost of particular projects is not proportional to their lengths however. The most efficient in this regard is the renewal of Marabda-Akhalkali railway section.

Figure 36
Cost of 1 km of rail tracks in Azerbaijan vs. cost of tunnels



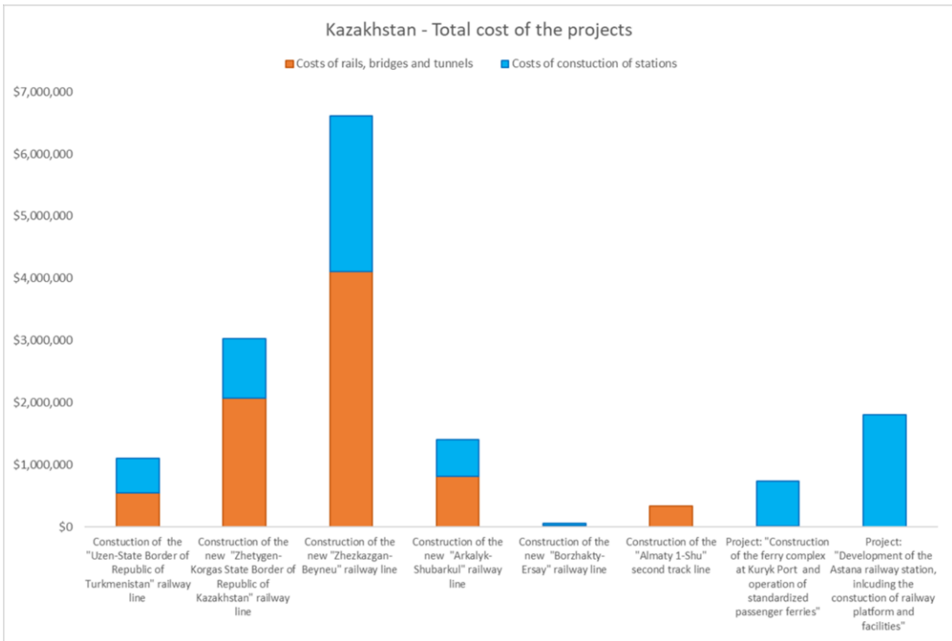
80. As an example the cost of one km of track and tunnel were compared. The cost of the tunnel is about ten times higher than cost of track.

J. Kazakhstan

Table 15
Cost of projects implemented in Kazakhstan

Project	*Currency (Kazakhstan Tenge)*	*Costs of rails, bridges and tunnels*	*Costs of constuction of stations*
Constuction of the "Uzen-State Border of Republic of Turkmenistan" railway line	1 105 081	543 735	561 347
Construction of the new "Zhetygen-Korgas State Border of Republic of Kazakhstan" railway line	3 034 022	2 066 005	968 018
Construction of the new "Zhezkazgan-Beyneu" railway line	6 614 699	4 105 042	2 509 657
Construction of the new "Arkalyk-Shubarkul" railway line	1 409 163	815 791	593 372
Construction of the new "Borzhakty-Ersay" railway line	61 811	25 773	36 038
Construction of the "Almaty 1-Shu" second track line	329 793	329 793	0
Project: "Construction of the ferry complex at Kuryk Port and operation of standardized passenger ferries"	732 931	15 718	717 213
Project: "Development of the Astana railway station, inlcuding the constuction of railway platform and facilities"	1 800 897	0	1 800 897

Figure 37
Cost of the projects in Kazakhstan



81. Kazakhstan has sent information about several large-scale projects – mostly pertaining to the construction of infrastructure:

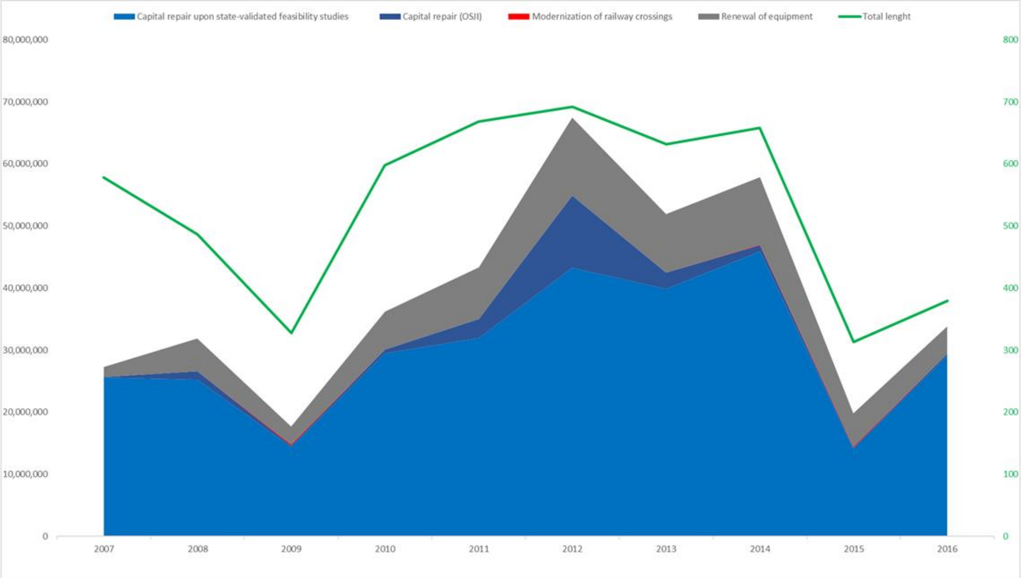
- Constuction of the "Uzen-State Border of Republic of Turkmenistan" railway line;
- Construction of the new "Zhetygen-Korgas State Border of Republic of Kazakhstan" railway line;
- Construction of the new "Zhezkazgan-Beyneu" railway line;
- Construction of the new "Arkalyk-Shubarkul" railway line;
- Construction of the new "Borzhakty-Ersay" railway line;
- Construction of the "Almaty 1-Shu" second track line;
- Construction of the ferry complex at Kuryk Port and operation of standardized passenger ferries;
- Development of the Astana railway station including the construction of railway platform and facilities.

82. The most expensive is the construction of the new "Zhezkazgan-Beyneu" railway line. A large part of this cost is allocated to the construction of stations.

Table 16
Cost of modernisation of infrastructure in Kazakhstan in 2007-2016 and total length of the projects

Title	2007 Amount	2008 Amount	2009 Amount	2010 Amount	2011 Amount	2012 Amount	2013 Amount	2014 Amount	2015 Amount	2016 Amount
Total	27 248 184	31 846 217	17 696 283	36 162 689	43 309 265	67 487 938	51 959 159	57 883 206	19 822 347	33 823 507
Capital repair upon state-validated feasibility studies	25 595 751	25 266 379	14 393 821	29 497 722	31 990 301	43 228 376	39 866 304	45 906 266	14 133 537	29 023 815
Capital repair (OSJI)	45 000	1 339 596	204 060	548 309	3 016 102	11 688 703	2 637 351	1 021 836	183 523	339 494
Modernization of railway crossings	24 780	16 317	227 459	0	0	0	13 622	98 908	101 985	0
Renewal of equipment	1 582 653	5 223 925	2 870 943	6 116 657	8 302 863	12 570 859	9 441 882	10 856 196	5 403 301	4 460 198
Title	2007 KM	2008 KM	2009 KM	2010 km	2011 km	2012 km	2013 km	2014 km	2015 km	2016 km
Total	578	487	328	598	668	692	632	659	313	380

Figure 38
Data on modernisation of infrastructure in Kazakhstan in 2007-2016 and total length of the projects



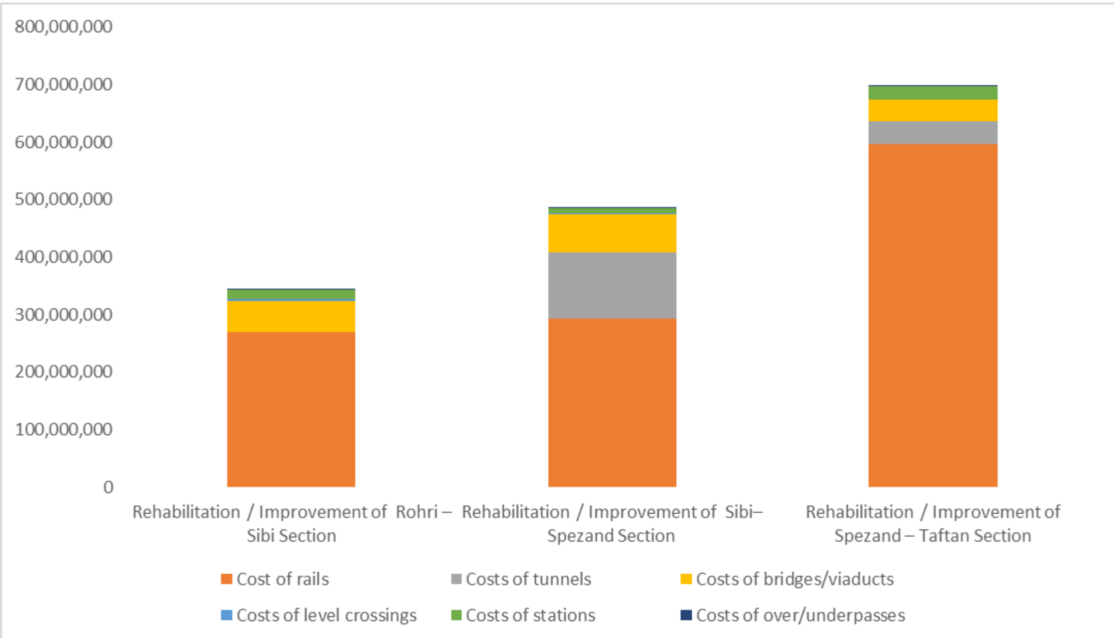
83. Figure 38 demonstrates that the cost of the projects is coherent with their lengths.

K. Tajikistan

Table 17
Cost of projects implemented in Tajikistan

Project	Construction costs of the project	Cost of rails	Costs of tunnels	Costs of bridges/viaducts	Costs of level crossings	Costs of stations	Costs of over/underpasses	Total length of the project in km	Length of the project excluding tunnels and bridges/viaducts in km	Length of tunnels in km	Length of bridges/viaducts in km
Rehabilitation / Improvement of Rohri – Sibi Section	345 000 000	269 000 000	0	54 000 000	5 000 000	15 000 000	2 000 000	239,190	231,730	0	7,460
Rehabilitation / Improvement of Sibi– Spezand Section	486 000 000	293 900 000	114 000 000	67 000 000	600000	9 000 000	1 500 000	116,340	83,149	22,652	10,539
Rehabilitation / Improvement of Spezand – Taftan Section	698 000 000	596 500 000	40 000 000	37 000 000	1 000 000	22 000 000	1 500 000	638,690	628,030	4,855	5,805

Figure 39
Cost of the projects in Tajikistan (US $)

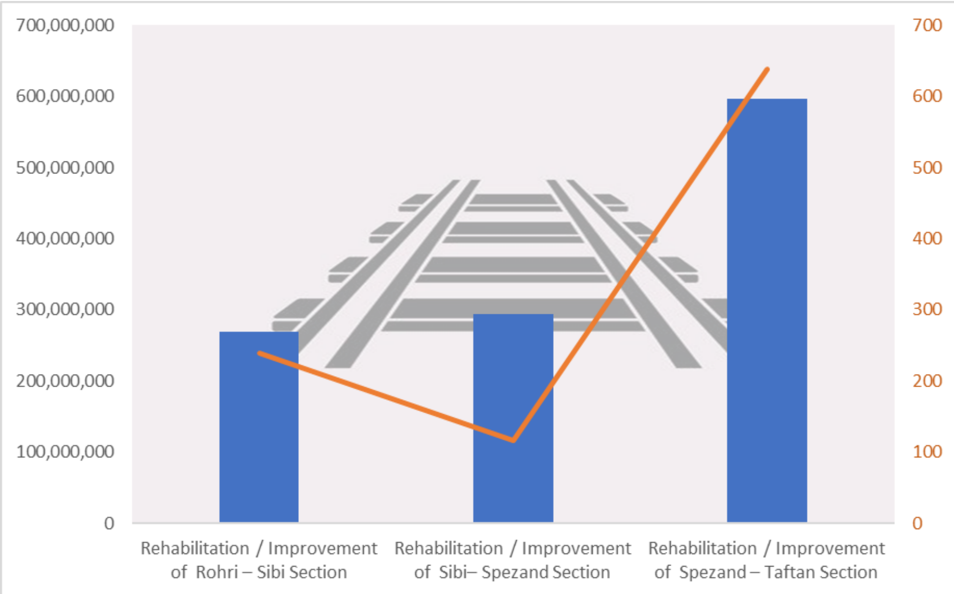


84. Tajikistan shared the information about three projects:

- Rehabilitation / Improvement of Rohri – Sibi Section;
- Rehabilitation / Improvement of Sibi– Spezand Section;
- Rehabilitation / Improvement of Spezand – Taftan Section.

85. Figure 39 demonstrates that the majority of expenditures were spent on work and material related to tracks. The cost of tunnels bridges and viaducts is also significant. One of the three projects mentioned—the rehabilitation/improvement of the Sibi-Spezand section—is more expensive per km than the two others.

Figure 40
Cost of rail tracks (US $) vs. length



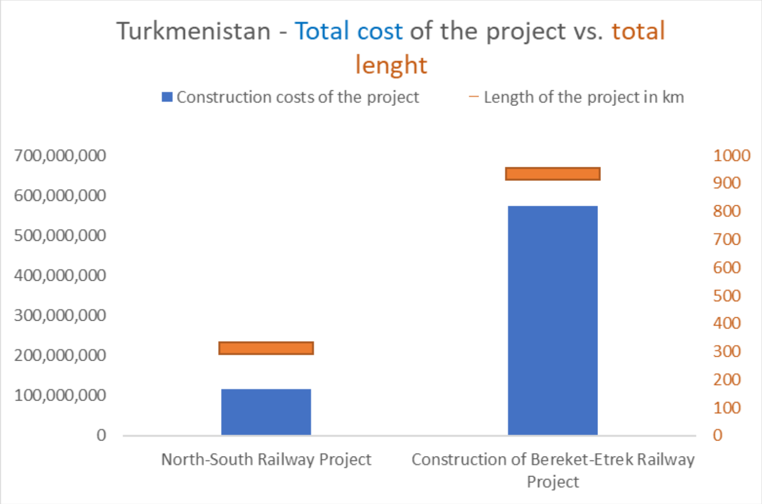
86. In the first and the third project the cost in regard to the length is proportional whilst the cost of the second project is higher when its length is accounted for.

L. Turkmenistan

Table 18
Cost of projects implemented in Turkmenistan and their length

Project	*Construction costs of the project*	*Length of the project in km*
North-South Railway Project	116 273 204	311
Construction of Bereket-Etrek Railway Project	575 000 000	936

Figure 41
Cost of projects (US $) vs. length



87. Turkmenistan has submitted information about two projects:

- North-South Railway Project
- Construction of the Bereket-Etrek Railway Project.

88. Figure 41 demonstrates that the cost of both projects is proportional to their lengths.

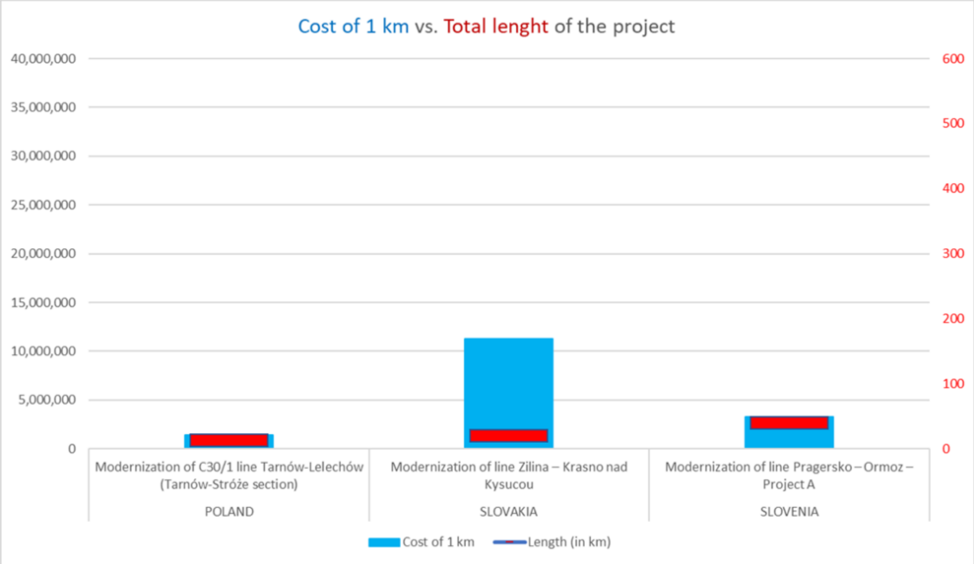
III. Trans-European Railway (TER) project

89. For the purpose of works conducted by the Group of Experts on Benchmarking Transport Infrastructure Construction Costs the data of the Trans-European Railway project—which is also run within ECE—has been used. The main objective of the project is to develop a coherent and efficient rail and intermodal transport system connecting Central and Eastern Europe with other European countries. Hence it has been of great importance to have up- to-date knowledge on the development of the TER network. The data presented has been collected since 2012 so that there is knowledge about projects that have been put into operation since 2011 for the purpose of the Annual TER Network Report. It contains basic information – such as the name length and cost of a project. TER classifies projects into two categories: ‘upgrading’ and ‘modernisation’. The use of either term however refers to the same thing – conducting major modification works which improve the overall performance of the infrastructure. For the purpose of this material ‘upgrading’ is used as the primary term. Only a handful of the projects concerned the construction of new infrastructure.

Table 19
Cost of projects put into operation by TER countries in 2011

Country	Project description	Length (in km)	Construction cost in USD	Cost of 1 km
POLAND	Modernization of C30/1 line Tarnów-Lelechów (Tarnów-Stróże section)	13,00	18 092 100,00	1 391 700,00
SLOVAKIA	Modernization of line Zilina – Krasno nad Kysucou	20,00	225 455 400,00	11 272 770,00
SLOVENIA	Modernization of line Pragersko – Ormoz – Project A	40,00	132 211 500,00	3 305 287,50

Figure 42
Cost of projects put into operation by TER countries in 2011 vs. length



90. Three projects were put into operation in 2011:

- Modernization of C30/1 line Tarnów-Lelechów (Tarnów-Stróże section) (Poland);
- Modernization of line Zilina – Krasno nad Kysucou (Slovakia);
- Modernization of line Pragersko – Ormoz – Project A (Slovenia).

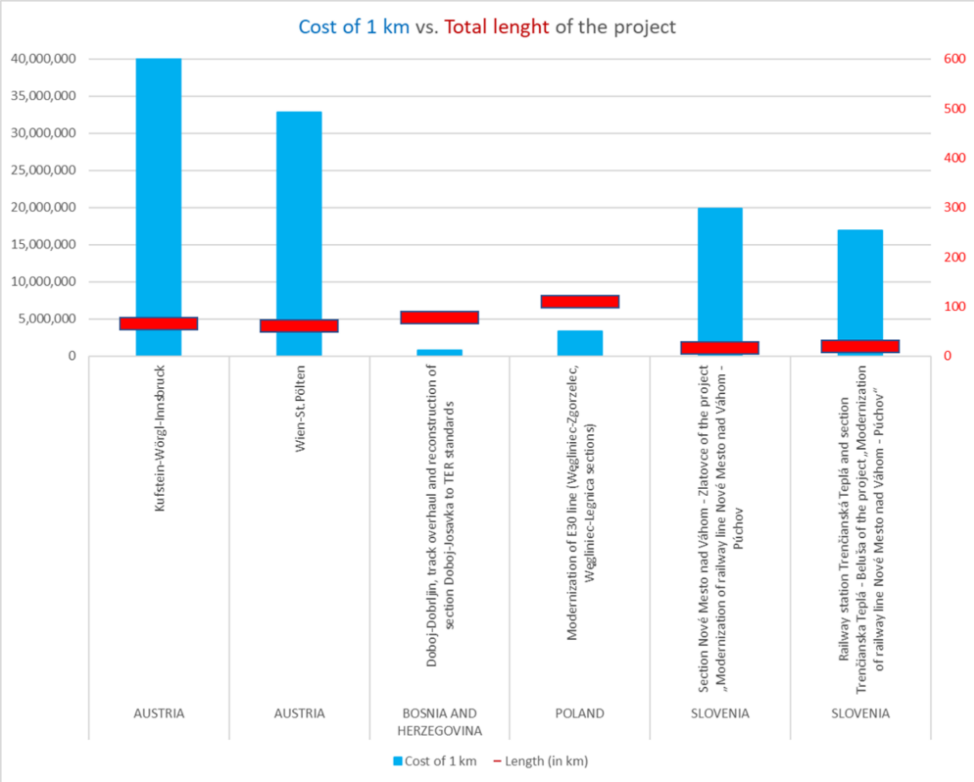
91. Slovakia implemented relatively expensive project taking into account its length whilst the projects of Poland and Slovenia are not as costly in regard to their length.

Table 20
Cost of projects put into operation by TER countries in 2012

Country	Project description	Length (in km)	Construction cost in USD	Cost of 1 km
AUSTRIA	Kufstein-Wörgl-Innsbruck	65,00	3 053 300 000,00	46 973 846,15
AUSTRIA	Wien-St.Pölten	61,00	2 000 393 600,00	32 793 337,70
AND HERZE	Doboj-Dobrljin, track overhaul and reconstruction of section Doboj-Josavka to TER standards	78,00	64 280 000,00	824 102,56
POLAND	Modernization of E30 line (Węgliniec-Zgorzelec, Węgliniec-Legnica sections)	110,00	366 396 000,00	3 330 872,73
SLOVENIA	Section Nové Mesto nad Váhom - Zlatovce of the project „Modernization of railway line Nové Mesto nad Váhom - Púchov	17,00	338 112 800,00	19 888 988,24
SLOVENIA	Railway station Trenčianská Teplá and section Trenčianska Teplá - Beluša of the project „Modernization of railway line Nové Mesto nad Váhom - Púchov“	20,00	338 112 800,00	16 905 640,00

Figure 43

Cost of projects put into operation by TER countries in 2012 vs. length



92. This figure demonstrates projects put into operation by four countries in 2012:

- Kufstein-Wörgl-Innsbruck (Austria);
- Wien-St.Pölten (Austria);
- Doboj-Dobrljin track overhaul and reconstruction of section Doboj-Josavka to TER standards (Bosnia and Herzegovina);
- Modernization of E30 line (Węgliniec-Zgorzelec Węgliniec-Legnica sections) (Poland);
- Section Nové Mesto nad Váhom - Zlatovce of the project "Modernization of railway line Nové Mesto nad Váhom – Púchov (Slovenia)";
- Railway station Trenčianská Teplá and section Trenčianska Teplá - Beluša of the project "Modernization of railway line Nové Mesto nad Váhom - Púchov (Slovenia)".

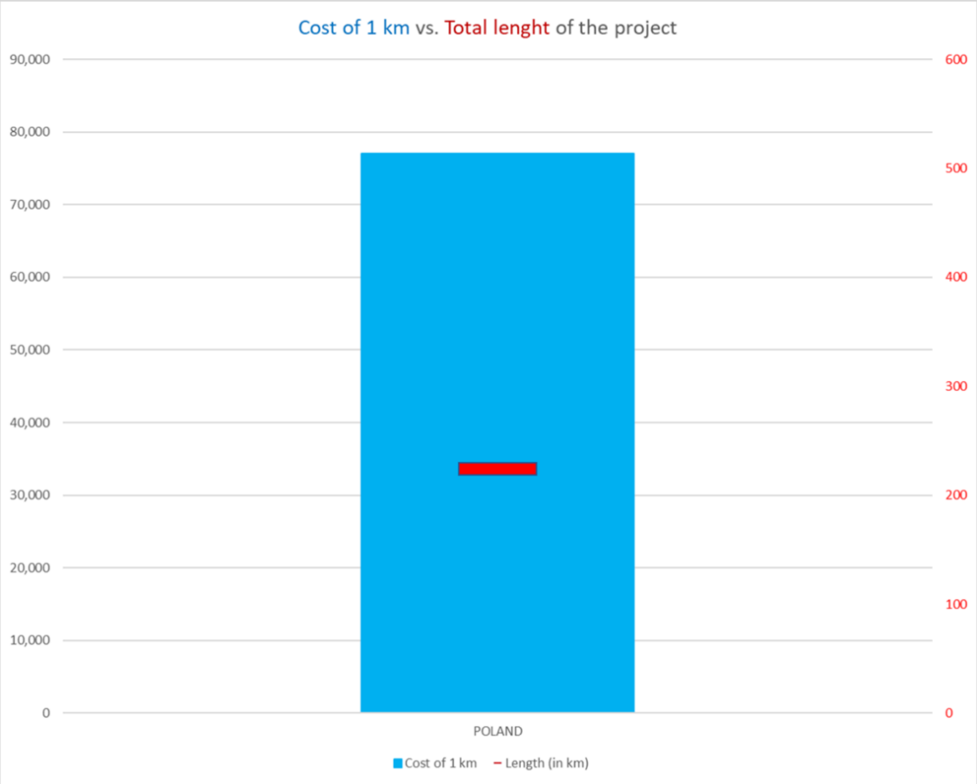
93. The projects of Bosnia and Herzegovina and Poland were implemented at relatively low level of expenditures regarding the length. The projects undertaken by Austria and Slovenia were more costly in this regard.

Table 21

Cost of projects put into operation by TER countries in 2013

Country	Project description	Length (in km)	Construction cost in USD	Cost of 1 km
POLAND	Project and development of ETCS 1 on E65 line (CMK) (Grodzisk Mazowiecki-Zawiercie section)	224,00	17 266 600,00	77 083,04

Figure 44
Cost of project put into operation by TER country - Poland - in 2013 vs. length



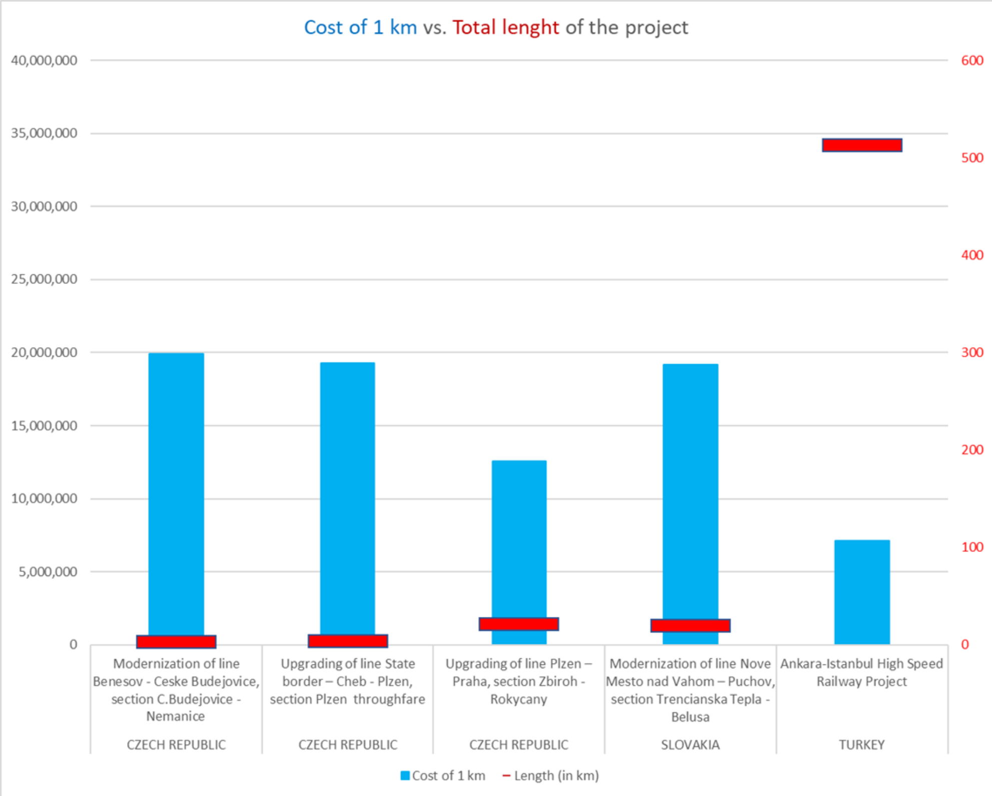
94. Only one project was put into operation in 2013 – the Polish one - Project and development of a European Train Control System (ETCS) 1 on the E65 line (CMK) (Grodzisk Mazowiecki-Zawiercie section). Its cost is relatively high considering its length.

Table 22
Cost of projects put into operation by TER countries in 2014

Country	Project description	Length (in km)	Construction cost in USD	Cost of 1 km
CZECH REPUBLIC	Modernization of line Benesov - Ceske Budejovice, section C.Budejovice - Nemanice	3,00	59 796 000,00	19 932 000,00
CZECH REPUBLIC	Upgrading of line State border – Cheb - Plzen, section Plzen throughfare	4,00	77 070 400,00	19 267 600,00
CZECH REPUBLIC	Upgrading of line Plzen – Praha, section Zbiroh - Rokycany	21,00	264 431 200,00	12 591 961,90
SLOVAKIA	Modernization of line Nove Mesto nad Vahom – Puchov, section Trencianska Tepla - Belusa	20,00	384 023 200,00	19 201 160,00
TURKEY	Ankara-Istanbul High Speed Railway Project	513,00	3 667 488 000,00	7 149 099,42

Figure 45

Cost of projects put into operation by TER countries in 2014 vs. length



95. Five projects were put into operation in 2014:

- Modernization of line Benesov - Ceske Budejovice section C.Budejovice – Nemanice (Czechia);
- Upgrading of line State border – Cheb - Plzen section Plzen throughfare (Czechia);
- Upgrading of line Plzen – Praha section Zbiroh – Rokycany (Czechia);
- Modernization of line Nove Mesto nad Vahom – Puchov section Trencianska Tepla – Belusa (Slovakia);
- Ankara-Istanbul High Speed Railway Project (Turkey).

96. There is a large difference between the project of Turkey and those of Czechia and Slovakia regarding the cost versus length. The latter ones were more costly concerning their length.

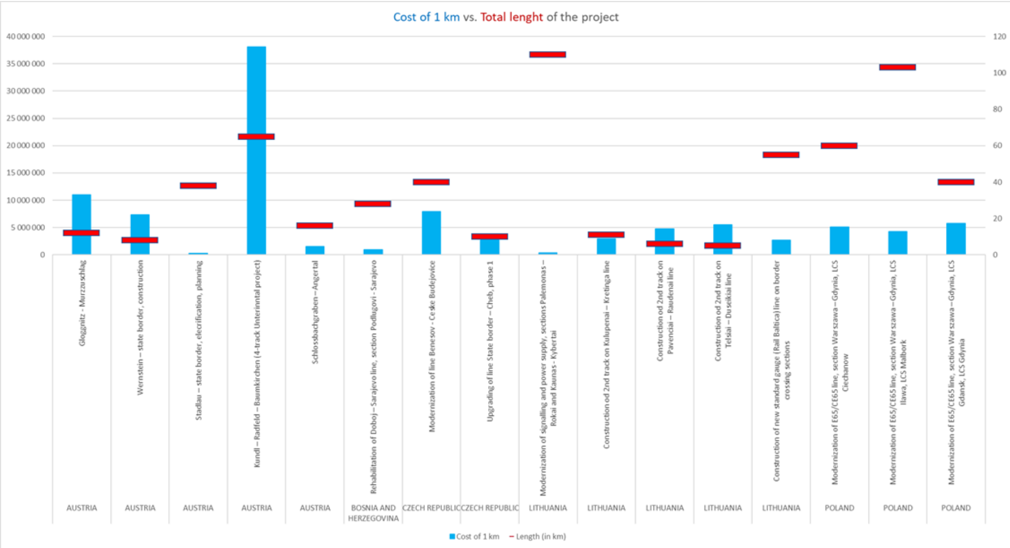
Table 23

Cost of projects put into operation by TER countries in 2015

Country	Project description	Length (in km)	Construction cost in USD	Cost of 1 km
AUSTRIA	Gloggnitz - Murzzuschlag	12,00	132 042 400,00	11 003 533,33
AUSTRIA	Wernstein – state border, construction	8,00	58 808 800,00	7 351 100,00
AUSTRIA	Stadlau – state border, elecrification, planning	38,00	12 205 600,00	321 200,00
AUSTRIA	Kundl – Radfeld – Baumkirchen (4-track Unterinntal project)	65,00	2 474 408 000,00	38 067 815,38
AUSTRIA	Schlossbachgraben – Angertal	16,00	24 411 200,00	1 525 700,00
BOSNIA AND HERZEGOVINA	Rehabilitation of Doboj – Sarajevo line, section Podlugovi - Sarajevo	28,00	25 520 800,00	911 457,14
CZECH REPUBLIC	Modernization of line Benesov - Ceske Budejovice	40,00	316 236 000,00	7 905 900,00
CZECH REPUBLIC	Upgrading of line State border – Cheb, phase 1	10,00	26 630 400,00	2 663 040,00
LITHUANIA	Modernization of signalling and power supply, sections Palemonas – Rokai and Kaunas - Kybertai	110,00	43 274 400,00	393 403,64
LITHUANIA	Construction od 2nd track on Kulupenai – Kretinga line	11,00	32 178 400,00	2 925 309,09
LITHUANIA	Construction od 2nd track on Pavenciai – Raudenai line	6,00	28 849 600,00	4 808 266,67
LITHUANIA	Construction od 2nd track on Telsiai – Duseikiai line	5,00	27 740 000,00	5 548 000,00
LITHUANIA	Construction of new standard gauge (Rail Baltica) line on border crossing sections	55,00	146 467 200,00	2 663 040,00
POLAND	Modernization of E65/CE65 line, section Warszawa – Gdynia, LCS Ciechanow	60,00	308 468 800,00	5 141 146,67
POLAND	Modernization of E65/CE65 line, section Warszawa – Gdynia, LCS Ilawa, LCS Malbork	103,00	437 182 400,00	4 244 489,32
POLAND	Modernization of E65/CE65 line, section Warszawa – Gdynia, LCS Gdansk, LCS Gdynia	40,00	231 906 400,00	5 797 660,00

Figure 46

Cost of projects put into operation by TER countries in 2015 vs. length



97. In 2015 the projects were much more numerous:

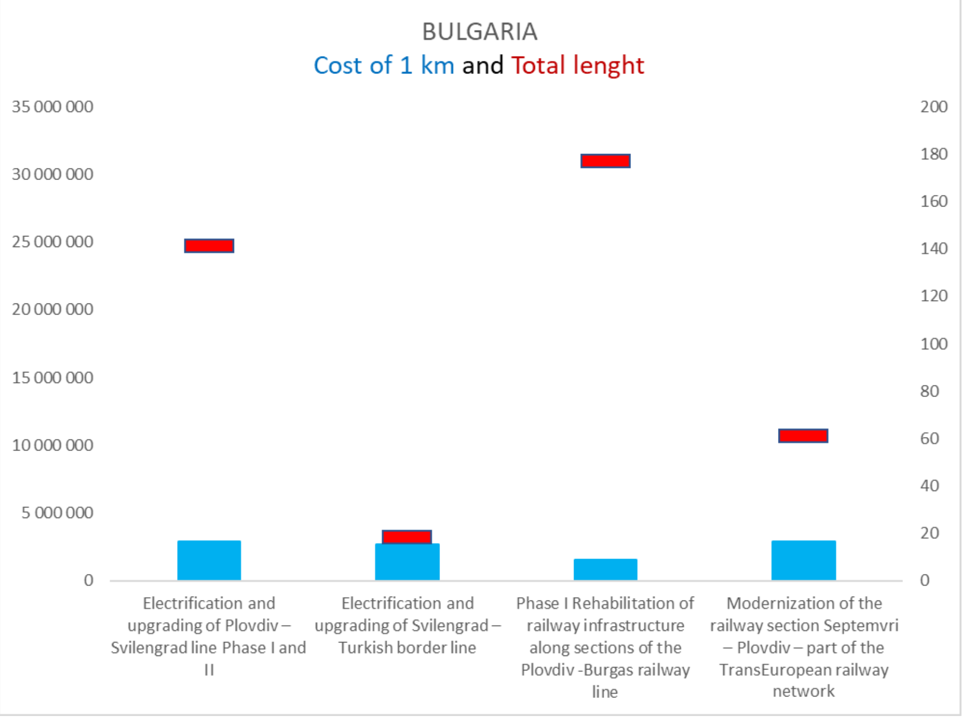
- Gloggnitz – Murzzuschlag (Austria);
- Wernstein – state border construction (Austria);
- Stadlau – state border elecrification planning (Austria);
- Kundl – Radfeld – Baumkirchen (4-track Unterinntal project) (Austria);
- Schlossbachgraben – Angertal (Austria);
- Rehabilitation of Doboj – Sarajevo line section Podlugovi – Sarajevo (Bosnia and Herzegovina);
- Modernization of line Benesov - Ceske Budejovice (Czechia);
- Upgrading of line State border – Cheb phase 1 (Czechia);
- Modernization of signalling and power supply sections Palemonas – Rokai and Kaunas – Kybertai (Lithuania);
- Construction od 2nd track on Kulupenai – Kretinga line (Lithuania);
- Construction od 2nd track on Pavenciai – Raudenai line (Lithuania);
- Construction od 2nd track on Telsiai – Duseikiai line (Lithuania);
- Construction of new standard gauge (Rail Baltica) line on border crossing sections (Lithuania);
- Modernization of E65/CE65 line section Warszawa – Gdynia LCS Ciechanow (Poland);
- Modernization of E65/CE65 line section Warszawa – Gdynia LCS Ilawa LCS Malbork (Poland);
- Modernization of E65/CE65 line section Warszawa – Gdynia LCS Gdansk LCS Gdynia (Poland).

98. Approximately two thirds of these projects are cost efficient when their length is accounted for. The most advantageous in this regard one the project of Lithuania on modernisation of signalling and power supply. A modernisation project of Poland is outstanding but also the Austrian one the scope of which is planning of work. The most expensive in regard to length is the other projects of Austria and Lithuania.

Table 24
Cost of projects put into operation by TER country - Bulgaria - in 2016

Country	Project description	Length (in km)	Construction cost in USD	Cost of 1 km
BULGARIA	Electrification and upgrading of Plovdiv – Svilengrad line Phase I and II	141	406 122 200	2 880 299
BULGARIA	Electrification and upgrading of Svilengrad – Turkish border line	18	47 583 800	2 643 544
BULGARIA	Phase I Rehabilitation of railway infrastructure along sections of the Plovdiv - Burgas railway line	177	270 010 400	1 525 482
BULGARIA	Modernization of the railway section Septemvri – Plovdiv – part of the TransEuropean railway network	61	175 949 400	2 884 416

Figure 47
Cost of projects put into operation by TER country - Bulgaria - in 2016 vs. length



99. Figure 47 demonstrates projects of Bulgaria put into operation in 2016:

- Electrification and upgrading of Plovdiv – Svilengrad line Phase I and II;
- Electrification and upgrading of Svilengrad – Turkish border line;
- Phase I Rehabilitation of railway infrastructure along sections of the Plovdiv -Burgas railway line;
- Modernization of the railway section Septemvri – Plovdiv – part of the TransEuropean railway network.

100. Only one project is relatively expensive regarding the length. The other three are more cost efficient in this regard.

Table 25
Cost of projects put into operation by TER country - Czechia - in 2016

Country	Project description	Length (in km)	Construction cost in USD	Cost of 1 km
CZECH REPUBLIC	Bystrice nad Olsi – Cesky Tesin, phase II, station Cesky Tesin	2	68 609 200	34 304 600
CZECH REPUBLIC	Beroun – Plzen –Cheb, introduction of GSM-R system	185	23 238 600	125 614
CZECH REPUBLIC	Modernization of line Praha – Plzen, section Rokycany - Plzen	282	79 675 200	282 536
CZECH REPUBLIC	Modernization of line Praha – Česka Trebova, junction Usti nad Orlici	2	58 649 800	29 324 900
CZECH REPUBLIC	Usti nad Orlici – Letohrad, modernization	13	26 558 400	2 042 954
CZECH REPUBLIC	Teplice nad Becvou – Hustopece nad Becvou, modernization	8	32 091 400	4 011 425
CZECH REPUBLIC	Valasske Mezirici – Vsetin – Horni Lidec, modernization	34	33 198 000	976 412
CZECH REPUBLIC	Brno Malomerice – Brno Zidenice, modernization	3	38 731 000	12 910 333
CZECH REPUBLIC	Praha Bubenec – Praha Holesovice, modernization	3	50 903 600	16 967 867

Figure 48
Cost of projects put into operation by TER country - Czechia - in 2016 vs. length

101. There are nine projects put into operation by Czechia in 2016:

- Bystrice nad Olsi – Cesky Tesin phase II station Cesky Tesin;
- Beroun – Plzen –Cheb introduction of GSM-R system;
- Modernization of line Praha – Plzen section;
- Modernization of line Praha – Česka Trebova;
- Usti nad Orlici – Letohrad;
- Teplice nad Becvou – Hustopece nad Becvou modernization;
- Valasske Mezirici – Vsetin – Horni Lidec modernization;

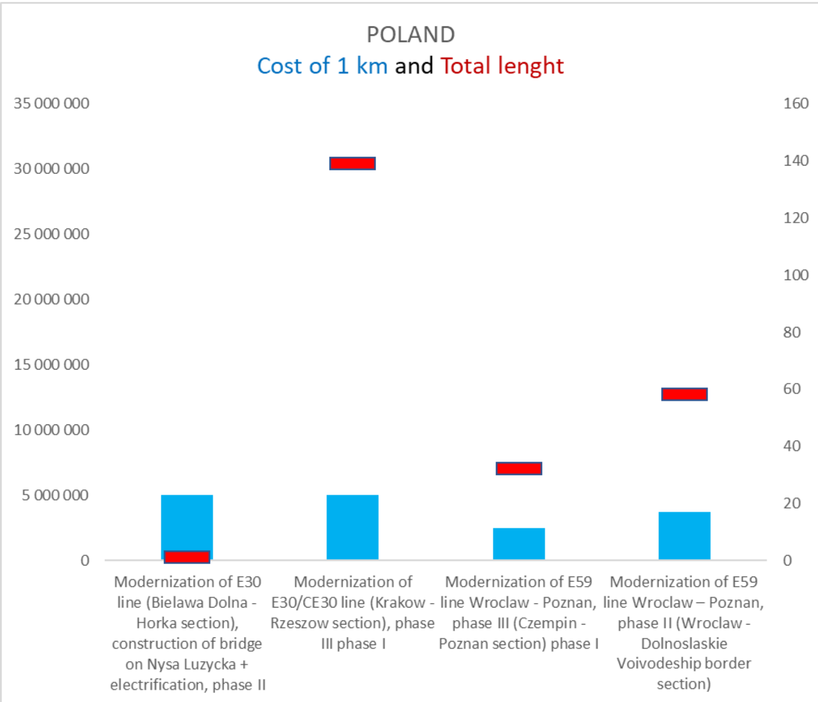
- Brno Malomerice – Brno Zidenice modernization;
- Praha Bubenec – Praha Holesovice modernization.

102. The cost of four of them is much higher in regard to the length in comparison to the other projects. The project concerning introduction of GSM-R is of relatively low cost in this regard.

Table 26
Cost of projects put into operation by TER country - Poland - in 2016

Country	Project description	Length (in km)	Construction cost in USD	Cost of 1 km
POLAND	Modernization of E30 line (Bielawa Dolna - Horka section), construction of bridge on Nysa Luzycka + electrification, phase II	1	5 533 000	5 000 000
POLAND	Modernization of E30/CE30 line (Krakow - Rzeszow section), phase III phase I	139	774 620 000	5 035 971
POLAND	Modernization of E59 line Wroclaw - Poznan, phase III (Czempin - Poznan section) phase I	32	88 528 000	2 500 000
POLAND	Modernization of E59 line Wroclaw – Poznan, phase II (Wroclaw - Dolnoslaskie Voivodeship border section)	58	240 132 200	3 741 379

Figure 49
Cost of projects put into operation by TER country - Poland - in 2016 vs. length



103. Poland put four projects into operation in 2016:

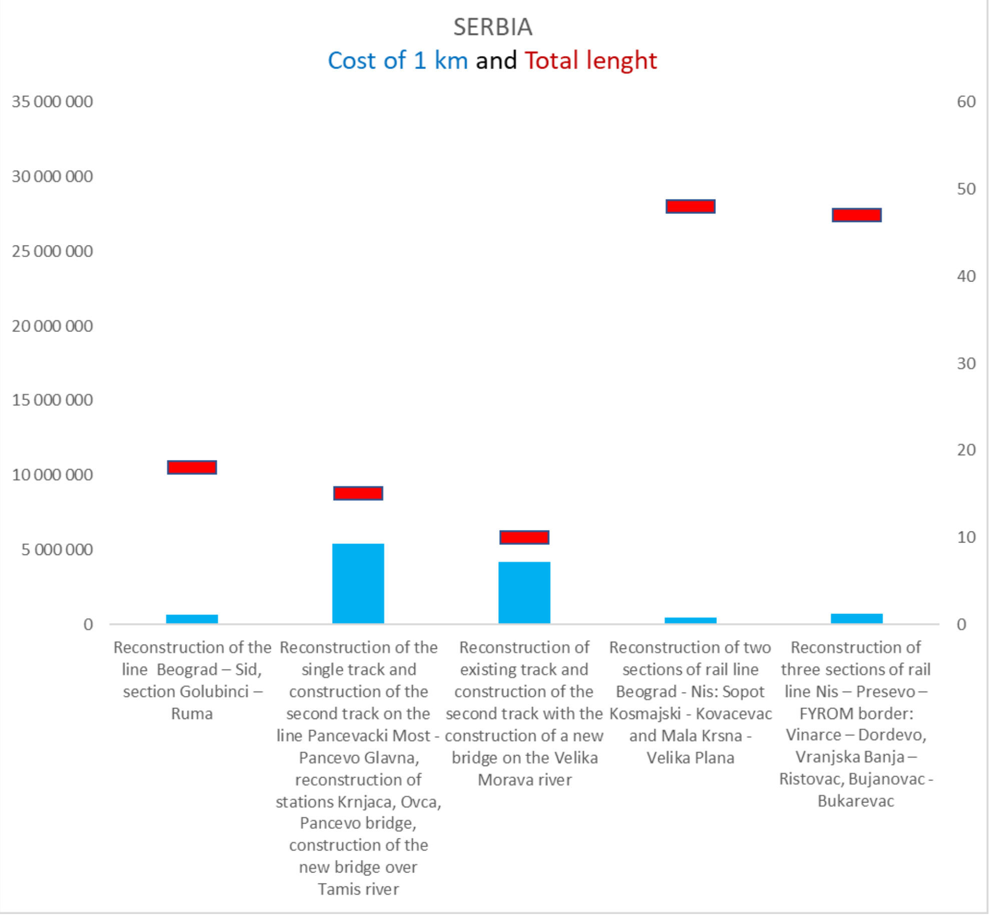
- Modernization of E30 line (Bielawa Dolna - Horka section) construction of bridge on Nysa Luzycka + electrification phase II;
- Modernization of E30/CE30 line (Krakow - Rzeszow section) phase III phase I;
- Modernization of E59 line Wroclaw - Poznan phase III (Czempin - Poznan section) phase I;
- Modernization of E59 line Wroclaw – Poznan phase II (Wroclaw - Dolnoslaskie Voivodeship border section).

104. The first one is of relatively high cost when it comes to its length. The other three are cost-efficient when their length is accounted for.

Table 27
Cost of projects put into operation by TER country - Serbia - in 2016

Country	Project description	Length (in km)	Construction cost in USD	Cost of 1 km
SERBIA	Reconstruction of the line Beograd – Sid, section Golubinci – Ruma	18	13 279 200	666 667
SERBIA	Reconstruction of the single track and construction of the second track on the line Pancevacki Most - Pancevo Glavna, reconstruction of stations Krnjaca, Ovca, Pancevo bridge, construction of the new bridge over Tamis river	15	89 634 600	5 400 000
SERBIA	Reconstruction of existing track and construction of the second track with the construction of a new bridge on the Velika Morava river	10	46 477 200	4 200 000
SERBIA	Reconstruction of two sections of rail line Beograd - Nis: Sopot Kosmajski - Kovacevac and Mala Krsna - Velika Plana	48	26 558 400	500 000
SERBIA	Reconstruction of three sections of rail line Nis – Presevo – FYROM border: Vinarce – Dordevo, Vranjska Banja – Ristovac, Bujanovac - Bukarevac	47	36 517 800	702 128

Figure 50
Cost of projects put into operation by TER country - Serbia - in 2016 vs. length



105. There were five Serbian projects put into operation in 2016:

- Reconstruction of the line Beograd – Sid section Golubinci – Ruma;
- Reconstruction of the single track and construction of the second track on the line Pancevacki Most - Pancevo Glavna reconstruction of stations Krnjaca Ovca Pancevo bridge construction of the new bridge over Tamis river;

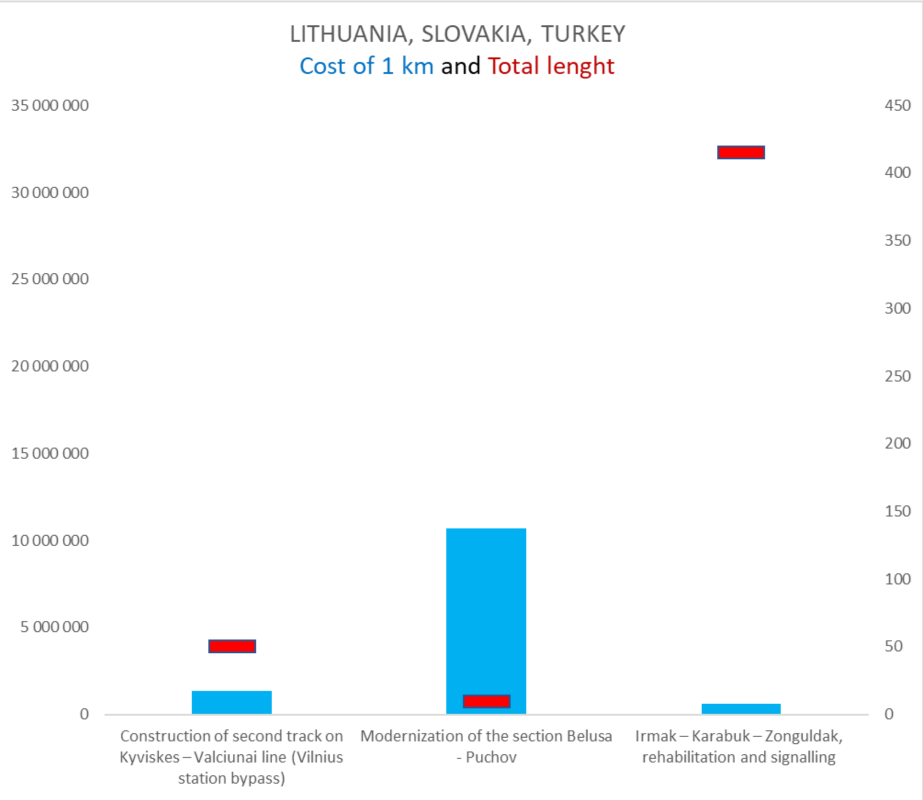
- Reconstruction of existing track and construction of the second track with the construction of a new bridge on the Velika Morava river;
- Reconstruction of two sections of rail line Beograd - Nis: Sopot Kosmajski - Kovacevac and Mala Krsna - Velika Plana;
- Reconstruction of three sections of rail line Nis – Presevo – North Macedonia border: Vinarce – Dordevo Vranjska Banja – Ristovac Bujanovac – Bukarevac.

106. All of these projects are costly efficient in regard to their length.

Table 28
Cost of projects put into operation by TER countries - Lithuania Slovakia Turkey - in 2016

Country	Project description	Length (in km)	Construction cost in USD	Cost of 1 km
LITHUANIA	Construction of second track on Kyviskes – Valciunai line (Vilnius station bypass)	50	67 502 600	1 350 052
SLOVAKIA	Modernization of the section Belusa - Puchov	9	96 274 200	10 697 133
TURKEY	Irmak – Karabuk – Zonguldak, rehabilitation and signalling	415	243 452 000	586 631

Figure 51
Cost of projects put into operation by TER countries - Lithuania Slovakia Turkey - in 2016 vs. length



107. This figure reveals three projects of different countries put into operation in 2016:

- Construction of second track on Kyviskes – Valciunai line (Vilnius station bypass) (Lithuania);
- Modernization of the section Belusa – Puchov (Slovakia);

• Irmak – Karabuk – Zonguldak rehabilitation and signalling (Turkey).

108. The project of Turkey is the costliest efficient in this group of countries whilst the project of Slovakia is the most expensive in regard to the length.

IV. Inland Waterways Costs

109. For the purpose of works conducted by the Group of Experts on Benchmarking Transport Infrastructure Construction Costs data from various European countries that have operational inland waterways has been used. It is greatly important to have up-to-date knowledge on the development of IW network and information on IW ports. In this document we received gathered and analysed data from the following countries: Austria Croatia Czechia Luxemburg Poland and Slovakia. Questionnaire was sent out to public administrations port authorities Harbour Master`s Offices river commissions etc. with inquiry about inland waterways infrastructure and IWW ports infrastructure construction updates and maintenance costs. The data isn`t as extensive and detailed as we had hoped to gather. With that being said our benchmarking analysis is not as thorough as the Group intended it to be; most of the data provided by enumerated countries is unfortunately incomparable.

Table 29
Maintenance costs of inland waterways infrastructure in Austria and Luxemburg

Breakdown Costs	*Unit Cost*	*Breakdown Costs*	*Average AT*	*Average LUX*
ENGINEERING WORKS	$/lump sum	ENGINEERING WORKS ($/lump sum)	110 714.59	6 155.00
AIDS TO NAVIGATION	$/Lump sum	AIDS TO NAVIGATION ($/Lump sum)	211 496.22	54 284.00
BANK & BOTTOM PROTECTION Imperviousness	$/m2	BANK & BOTTOM PROTECTION Imperviousness ($/m2)	34.32	30.00
MOORING PLACES	$/m2	MOORING PLACES ($/m2)	1.49	66.83
DREDGING REMEDIAL WORK SWEEPING HYDROGRAPHIC SURVEYS (INCLUDING TRANSPORTATION AND DISPOSAL)	$/m3	DREDGING REMEDIAL WORK SWEEPING HYDROGRAPHIC SURVEYS (INCLUDING TRANSPORTATION AND DISPOSAL)($/m3)	8.99	105.00
QUAY WALLS	$/m2	QUAY WALLS ($/m2)	9 321.62	66.00

110. As show in the table 19 we can see that Austria as a country quite oriented on inland waterways invests quite a sum for maintenance of its IW in general but the prices in comparison to Luxemburg are more favourable. Luxemburg on the other hand invests smaller amounts on its IW maintenance operations but the prices for it are much higher.

Table 30
Construction costs of inland waterways infrastructure in Austria and Croatia

Breakdown Costs	*Unit Cost*	*Breakdown Costs*	*Average AT*	*Average HR*
Dredging	$/m3	Dredging ($/m3)	10.52	8.00
Pilots building Operation towers including radar VHF etc	$/Unit	Pilots building Operation towers including radar VHF etc ($/Unit)	108 400.00	769 231.00

Figure 52
Dredging ($/m3) costs in Austria and Croatia

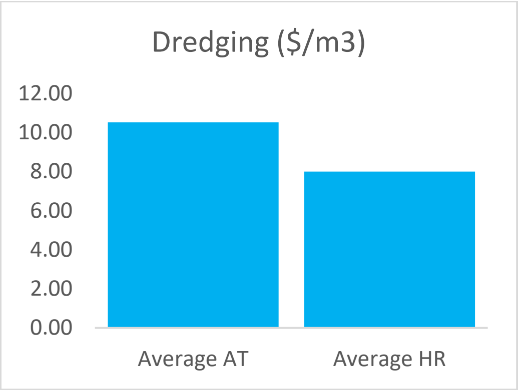
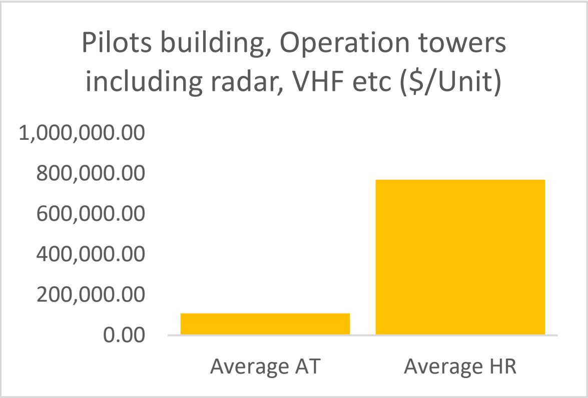


Figure 53
Pilots building operation towers including radar VHF etc ($/Unit) costs in Austria and Croatia



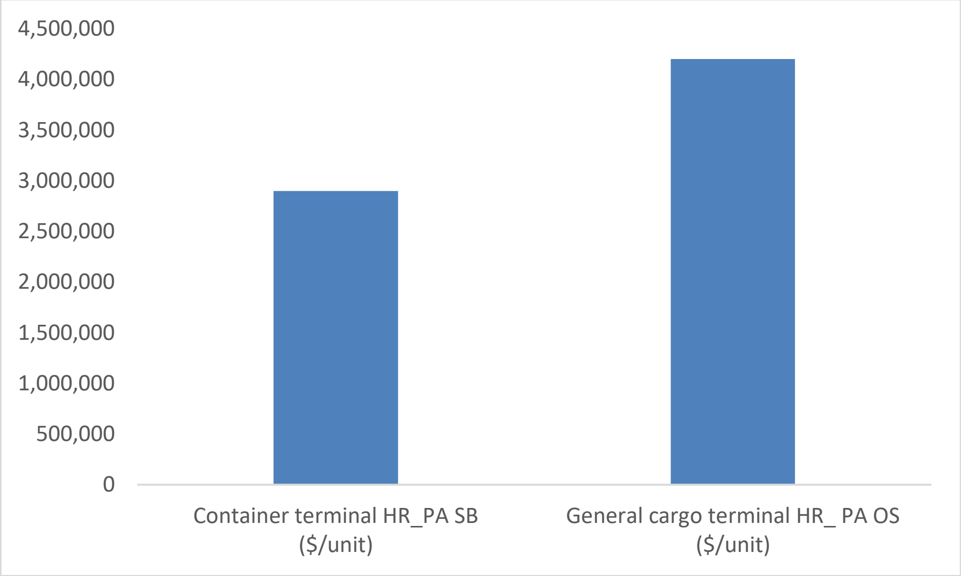
111. As show in Table 30 and Figures 52 and 53 it is visible that Austria spends more in average on dredging operations (along the waterway) than Croatia. As regards to pilots building operation towers including radar VHF etc. prices and costs in Croatia are much higher in average in comparison to Austria.

Table 31
Construction costs of port infrastructure in Port Authority Slavonski Brod and Port Authority Osijek Croatia

Breakdown Items	*Average*
Container terminal HR_PA SB ($/unit)	2 900 000
General cargo terminal HR_ PA OS ($/unit)	4 200 000

Figure 54

Construction costs of port infrastructure in Port Authority Slavonski Brod and Port Authority Osijek Croatia



112. In Table 31 and Figure 54 we have shown some port construction costs in Croatian port authorities Slavonski Brod and Osijek. PA Slavonski Brod is situated on Sava river and PA Osijek on Drava river both tributaries to the Danube. It`s visible that costs ($/unit) are higher for construction of general cargo terminal in Osijek than for container terminal in Slavonski Brod.