TEMOA-ITALY Project

2023.03.06

Yuwei SHI, S288123
Qifan ZHU, S288338

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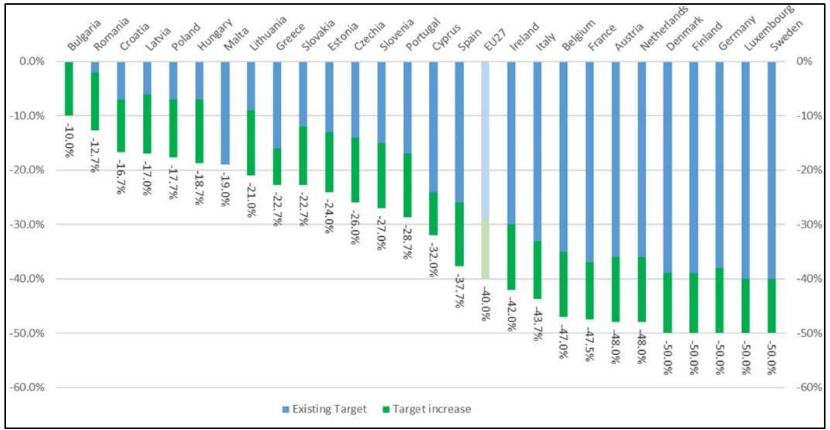

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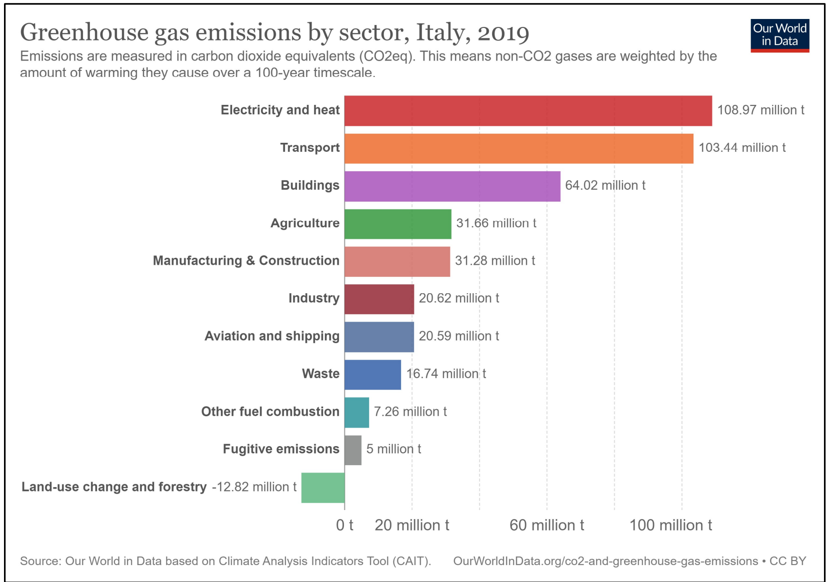


[Source 2]

Introduction & Background

Under the Paris Agreement and the EU effort-sharing legislation, Italy has committed to reducing its GHG emissions by 33% by 2030 compared to 2005 levels. In addition, a long-term goal of achieving climate neutrality by 2050 has been set.

To meet these targets, Italy has implemented a range of policies and initiatives aimed at promoting renewable energy sources, improving energy efficiency, and reducing GHG emissions, such as the National Energy and Climate Plan (NECP), the National Recovery and Resilience Plan (NRRP).

In this project, we will focus on some scenarios about Italy that can help to realize the emission target and the carbon neutralization, in future.

And some database simulations based on the TEMOA-Italy would be done to analysis these scenarios and try to find a best solution for the target.

Source:
[1] The Effort Sharing Regulation (Regulation (EU) 2018
[2] Hannah Ritchie, Max Roser and Pablo Rosado (2020) - "CO₂ and Greenhouse Gas Emissions". Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/co2-and-greenhouse-gas-emissions' [Online Resource]

Scenario Definition

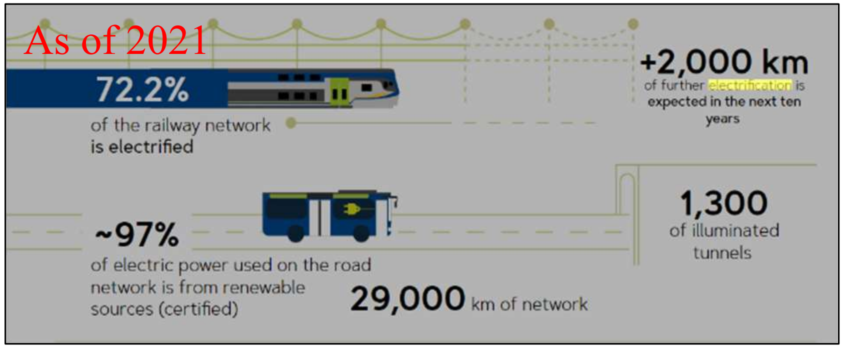
1. Technological Scenario
2. Emission Scenario

Technological Scenario

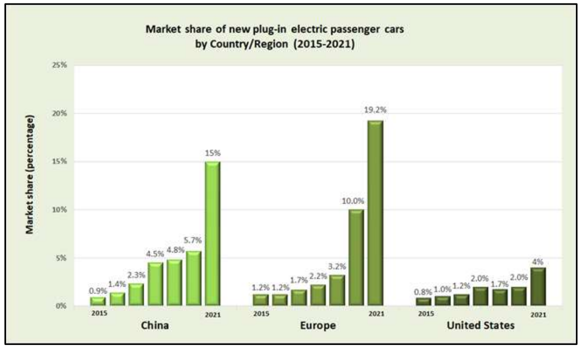
1. Introduce hydrogen-based technology to optimize the IT transport structure.

2. Improve the electrification level for the IT railway system.

3. Improve the hybrid powering technology to optimize the hybrid vehicles.



[Source 1]



[Source 2]

Source:
[1] Ferrovie dello Stato Italiane (2021). Sustainability Report 2021
[2] By Mariordo (Mario Roberto Durán Ortiz) - Own work, CC BY-SA 4.0, Link

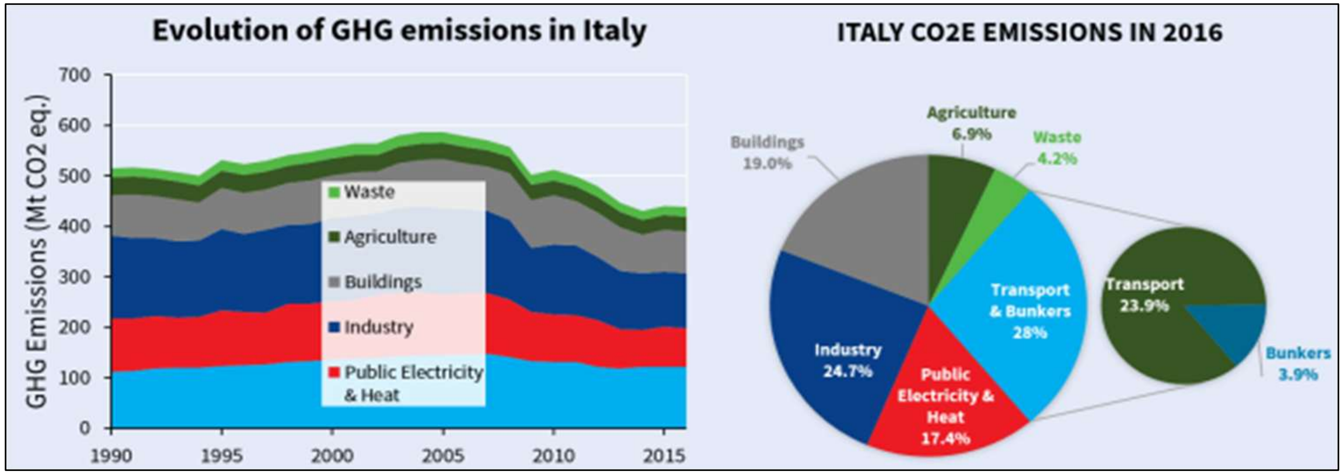
Emission Scenario

Italy's Target: Reduce the GHG emission by 33% by 2030 compared to 2005 levels.

Considering some constraints from the cost, technology, and exceptional circumstances, we put an elasticity on target.

1. GHG emission is decreased by 25% by 2030 and reach the final 33% reduction goal by 2040 at least.

The objective : to show how Italy can decrease its transport emission to realize the decarbonization, finally, by transferring its transport structure.



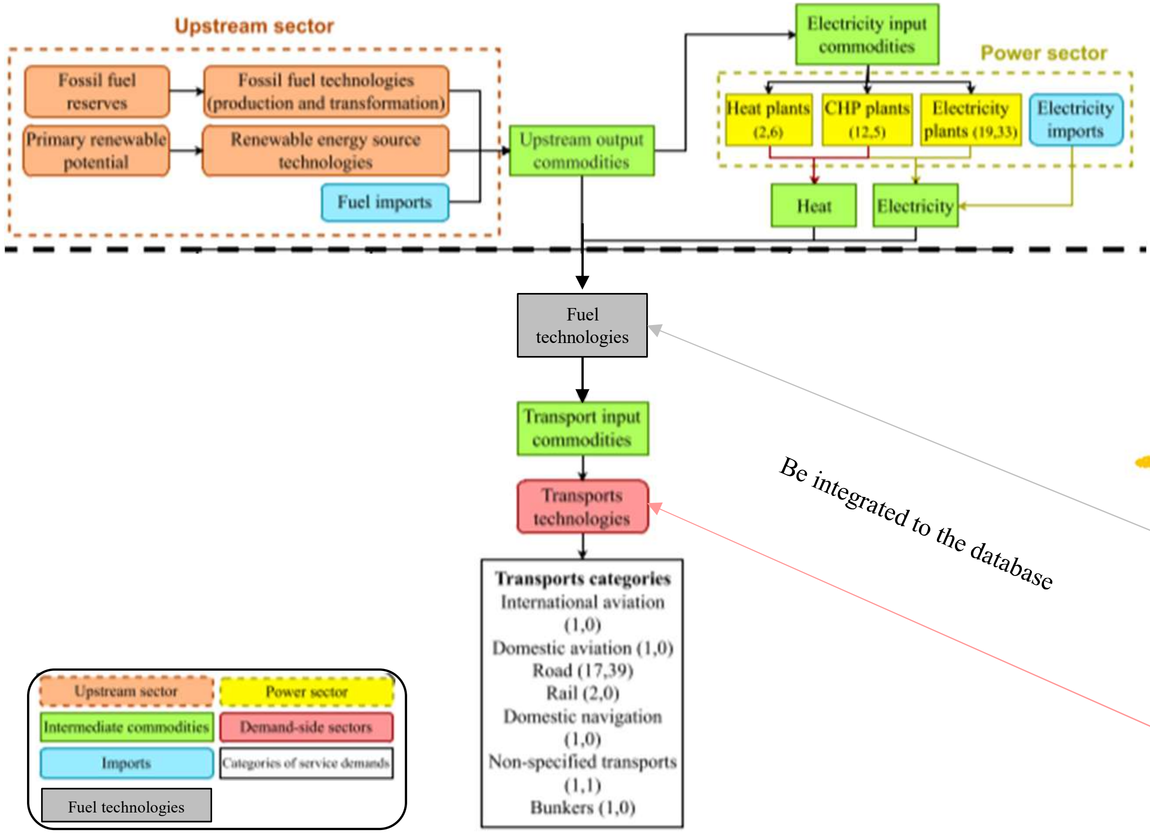
[Source 1]

Source:
[1] Transport & Environment (T&E), (2019) Emissions reduction strategies for the transport sector in Italy

Description of the RES

1. RES and New Technology
2. Techno-Economic Characterization
3. Some Modifications

RES & New Technology



In our topic, it is only focused on The Transport Sector on the demand side.

Time Pieces: From 2006 (base year) To 2050

Region: Italy

New Technology

Fuel technology: the hydrogen fuel cell technology 'TRA_FT_FC_N'

Transport technologies:

1. hydrogen fuel cell-based car: 'TRA_ROA_CAR_FC_N'
2. hydrogen fuel cell-based bus: 'TRA_ROA_BUS_FC_N'
3. hydrogen fuel cell-based passenger train: 'TRA_RAIL_PAS_FC_N'

Techno-Economic Characterization

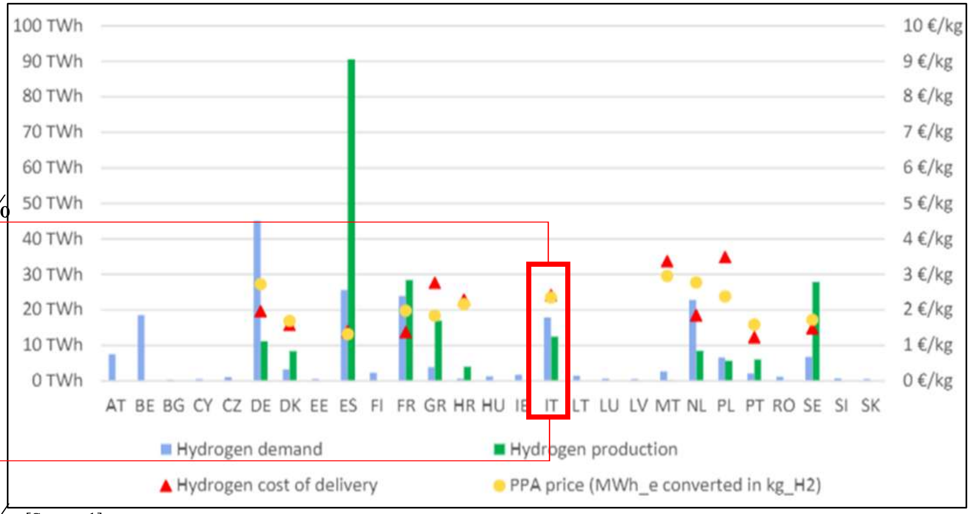
	Fuel technology
Name	TRA_FT_FC_N
Efficiency	1 PJ/PJ @2020
Min/Max capacity installation	0.32*45 PJ 0.32*63 PJ @2020
Min/Max activity	/
Lifetime	20
Fixed and variable O&M	1.0 @2020
Investment cost	50 @2020

The value highlighted in yellow is an assumption value.

Max Capacity =
17.5TWh * 3.6PJ/TWh * 32%

As constraints

Min Capacity =
12.5TWh * 3.6PJ/TWh * 32%



[Source 1]

Max Capacity = F(Hydrogen demand, r, t)
Min Capacity = F(Hydrogen production, r, t)
32%: transportation sector's percentage in total energy consumption in IT

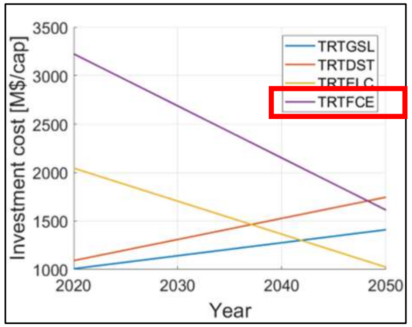
```
INSERT INTO "MaxCapacity" VALUES ('IT',2020,'TRA_FT_FC_N',0.32*63,'PJ','') -- self_insert- 32% OF 63PJ,17twh
INSERT INTO "MaxCapacity" VALUES ('IT',2030,'TRA_FT_FC_N',0.1052*383,'PJ','') -- self_insert- 10.52% OF 2050
INSERT INTO "MaxCapacity" VALUES ('IT',2050,'TRA_FT_FC_N',383,'PJ','') -- self_insert- 0.32*63/0.0526
```


Source:
[1] European Commission, Directorate-General for Energy, Vautrin, A., Bossmann, T., Beaussant, O. (2021). METIS study on costs and benefits of a pan-European hydrogen infrastructure: in assistance to the impact assessment for designing a regulatory framework for hydrogen: METIS 3, Study S3, Publications Office

Techno-Economic Characterization

	GSL	DST	FCE
TRT	0.39	0.47	0.70
TRC	0.30	0.34	-
TRL	0.35	0.42	-
TRW	1.19	1.40	-
TRE	1.12	1.35	-
TRM	0.09	0.11	-
TRH	0.04	0.05	-
TRB	0.05	0.06	0.10

[Source 1]



[Source 2]

Transport technology			
Name	TRA_ROA_CAR_FC_N	TRA_POA_BUS_FC_N	TRA_RAIL_PAS_FC_N
Efficiency	0.7 Bvkm/PJ @2020[1] 0.91 Bvkm/PJ @2050	0.1 Bvkm/PJ @2020[1] 0.12 Bvkm/PJ @2050	1.0 PJ/PJ @2020 1.2 PJ/PJ @2050
Min/Max capacity installation	/	/	/
Min/Max activity	/	/	/
Lifetime	12 [2]	12[2]	/
Fixed and variable O&M	66.7 M€/Bvkm @2020	66.7 M€/Bvkm @2020	/
Investment cost	2636 M€/Bvkm @2020 [2]	3515 M€/Bvkm @2020 [2]	/

The value highlighted in yellow is an assumption value.

```
INSERT INTO "Efficiency" VALUES ('IT','TRA_FC','TRA_ROA_CAR_FC_N',2020,'TRA_ROA_CAR',0.7,'Bvkm/PJ'); -- SELF_INSERT
INSERT INTO "Efficiency" VALUES ('IT','TRA_FC','TRA_ROA_CAR_FC_N',2050,'TRA_ROA_CAR',0.91,'Bvkm/PJ'); -- SELF_INSERT WITH
```

Source:

[1] Lerede, D., Bustreo, C., Gracceva, F., Lechón, Y., & Savoldi, L. (2020). Analysis of the Effects of Electrification of the Road Transport Sector on the Possible Penetration of Nuclear Fusion in the Long-Term European Energy Mix. Energies, 13(14), 3634.
[2] Lerede, D. (2019). Effect of Electrification of the transport sector for the EUROfusion TIMES Model [Tesi di Laurea Magistrale]. Politecnico di Torino.

Some Modifications

1. Increase the electrification level of Passenger trains.

```
INSERT INTO "TechInputSplit" VALUES ('IT',2020,'TRA_DST','TRA_RAIL_PAS_E',0.07,''); -- SELF_INSERT FOR SCEN
INSERT INTO "TechInputSplit" VALUES ('IT',2020,'TRA_ELC','TRA_RAIL_PAS_E',0.93,''); -- SELF_INSERT FOR SCEN
INSERT INTO "TechInputSplit" VALUES ('IT',2030,'TRA_DST','TRA_RAIL_PAS_E',0.00,''); -- SELF_INSERT FOR SCEN
INSERT INTO "TechInputSplit" VALUES ('IT',2030,'TRA_ELC','TRA_RAIL_PAS_E',1.00,''); -- SELF_INSERT FOR SCEN
```

2. Improve the Plug-in-Hybrid technology in hybridization ratio.

```
INSERT INTO "TechInputSplit" VALUES ('IT',2030,'TRA_GSL','TRA_ROA_CAR_PIHYB_N',0.50,''); -- SELF_INSERT FOR SCEN
INSERT INTO "TechInputSplit" VALUES ('IT',2030,'TRA_ELC','TRA_ROA_CAR_PIHYB_N',0.50,''); -- SELF_INSERT FOR SCEN
```

3. Set 'CommodityEmissionFactor' for new technology.
In our case, it is zero.

4. Insert some emission limits to support our scenarios.

```
INSERT INTO "EmissionLimit" VALUES ('IT',2025,'TRA_CH4',5473,'Kt',''); -- SELF_INSERT --SCEN-12%GWP
INSERT INTO "EmissionLimit" VALUES ('IT',2025,'TRA_CO2',126606,'Kt',''); -- SELF_INSERT --SCEN-12%GWP
INSERT INTO "EmissionLimit" VALUES ('IT',2025,'TRA_N2O',7961,'Kt',''); -- SELF_INSERT --SCEN-12%GWP
INSERT INTO "EmissionLimit" VALUES ('IT',2030,'TRA_CH4',4666,'Kt',''); -- SELF_INSERT --SCEN-25%GWP
INSERT INTO "EmissionLimit" VALUES ('IT',2030,'TRA_CO2',108005,'Kt',''); -- SELF_INSERT --SCEN-25%GWP
INSERT INTO "EmissionLimit" VALUES ('IT',2030,'TRA_N2O',6784,'Kt',''); -- SELF_INSERT --SCEN-25%GWP
INSERT INTO "EmissionLimit" VALUES ('IT',2040,'TRA_CH4',4179,'Kt',''); -- SELF_INSERT --SCEN-33%GWP
INSERT INTO "EmissionLimit" VALUES ('IT',2040,'TRA_CO2',96265,'Kt',''); -- SELF_INSERT --SCEN-33%GWP
INSERT INTO "EmissionLimit" VALUES ('IT',2040,'TRA_N2O',6060,'Kt',''); -- SELF_INSERT --SCEN-33%GWP
INSERT INTO "EmissionLimit" VALUES ('IT',2050,'TRA_CH4',3809,'Kt',''); -- SELF_INSERT --SCEN-40%GWP
INSERT INTO "EmissionLimit" VALUES ('IT',2050,'TRA_CO2',84805,'Kt',''); -- SELF_INSERT --SCEN-40%GWP
INSERT INTO "EmissionLimit" VALUES ('IT',2050,'TRA_N2O',5426,'Kt',''); -- SELF_INSERT --SCEN-40%GWP
```

Year	Template year:2007	2025	2030	2040	2050
%	0	-12%	-25%	-33%	-40%
CO_2-eq (kt)	3041036	2652351	2260527	2019404	1808421

GHG Emission in 2007 @RES (CO2_eq): 3041036

↓

Emission target value of specific year:
e.g.2019404 @2040

↓

The percentage of emission (CO2-eq) for each GHG in each year @RES:
e.g.CH4:CO2:N2O ≈ 6:5:89 @2040

↓

Allocate the total target value (CO2_eq) to each GHG, based on the percentage.
e.g. CH4 ↓41341, CO2 ↓34176, N2O ↓639783

↓

Convert the emission limit (CO2-eq) of each GHG back to real physical amount.

Result Analysis

GHG Emission

The results generated under the base scenario (RES) and our scenarios:

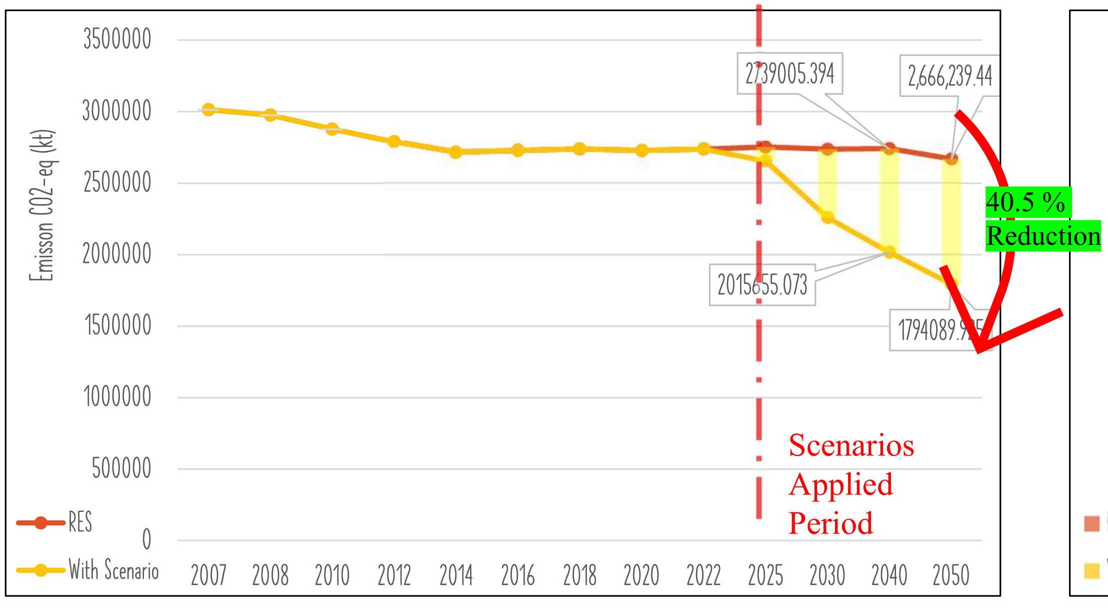


Figure1. GHG Emission trend of RSE and with scenarios

Figure2. GHG Emission among different transport technologies @ 2050

<u>The effort of vehicle electrification and 'hydrogen fuel cell' based technologies.</u>

GHG Emission per Bvkm

A ratio= $\dfrac{\boldsymbol{GHG\ Emission\ (CO2\_eq)}}{\boldsymbol{Bvkm}}$

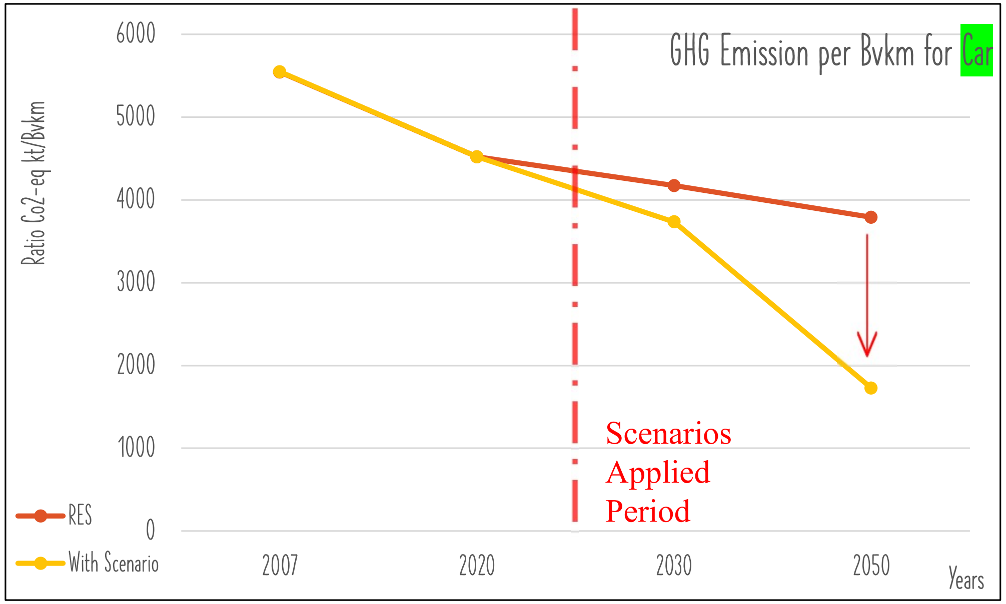


Figure3. GHG Emissions per Bvkm for Car

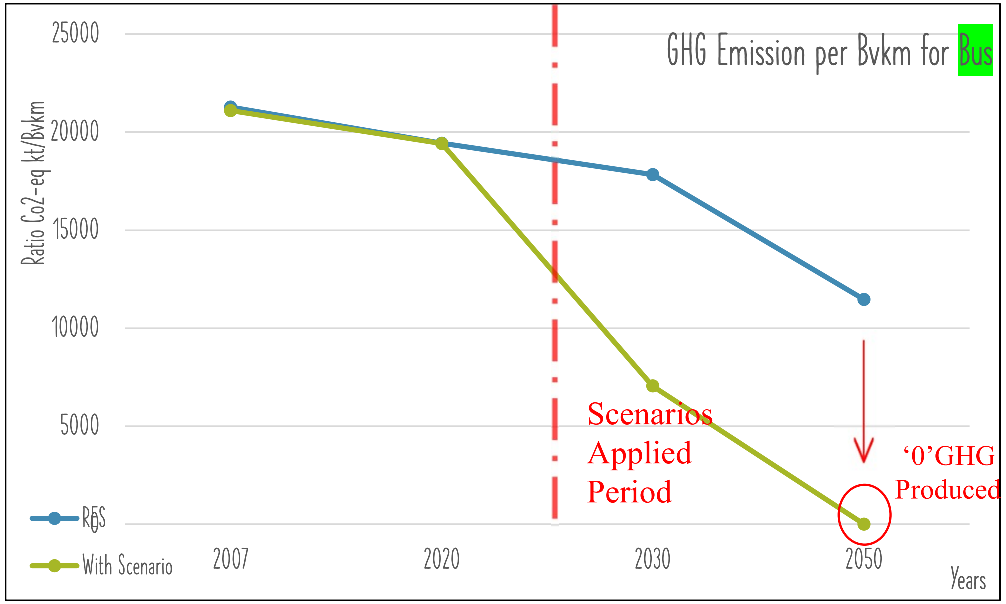


Figure4. GHG Emissions per Bvkm for Bus

The ratio is decreasing along the timeline meaning:

For the same length (in Bvkm) of driving demand, less GHG emission would be produced in the process.

Fuel Technology Activities

UP Stream Commodities (p). e.g. UPS_NGA

The LINK between supply side and demand side

DOWN Stream TRA Sector Commodities (p). e.g. TRA_NGA

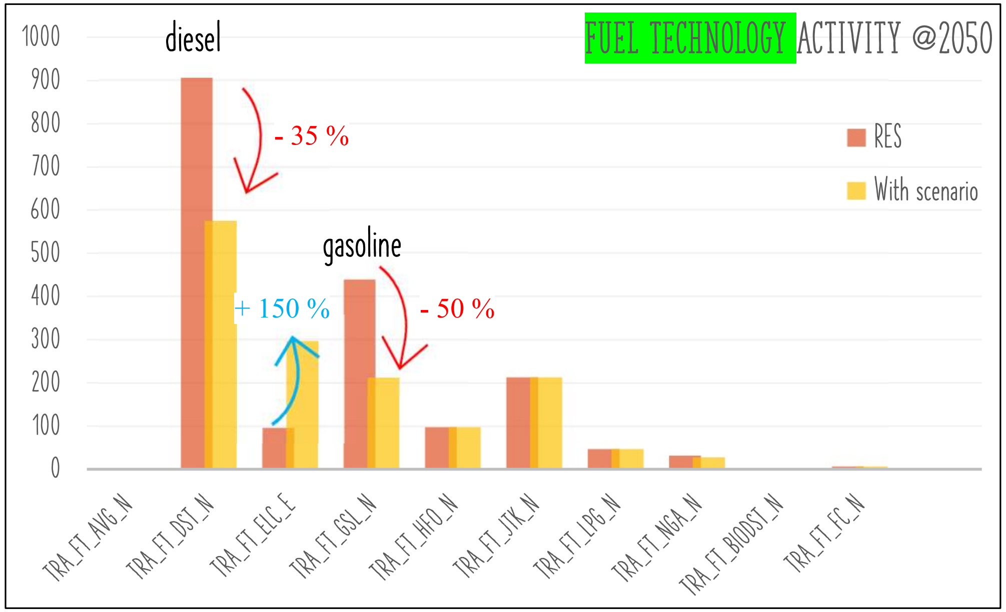


Figure5. Activity of Fuel technology @ 2050

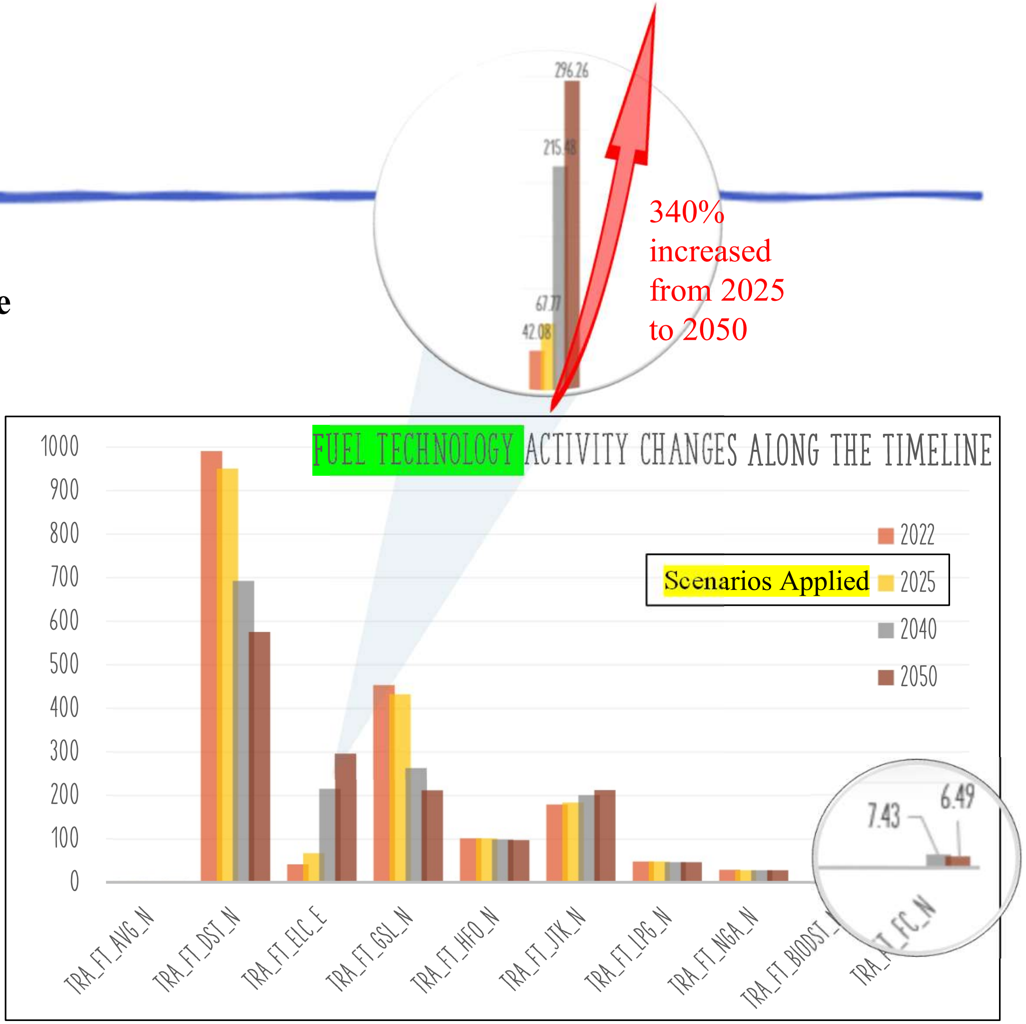


Figure6. Fuel Technology Activity Changes along the timeline

<u>Result in:</u>

the amount of diesel and gasoline commodities would be decreased, while the electricity commodity would be increased, which would flow into the related transport technologies

Transport Technology Activities(CAR)

TRA Sector Commodities (p). e.g. TRA_NGA

TRA Technologies (CAR)

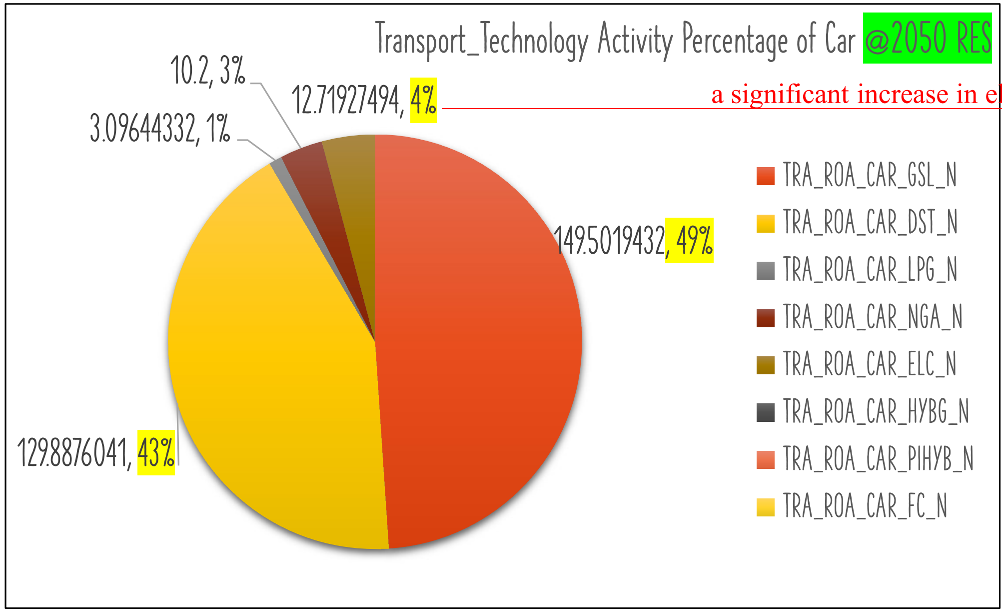


Figure7. Activity of TRA technologies (CAR) @ 2050

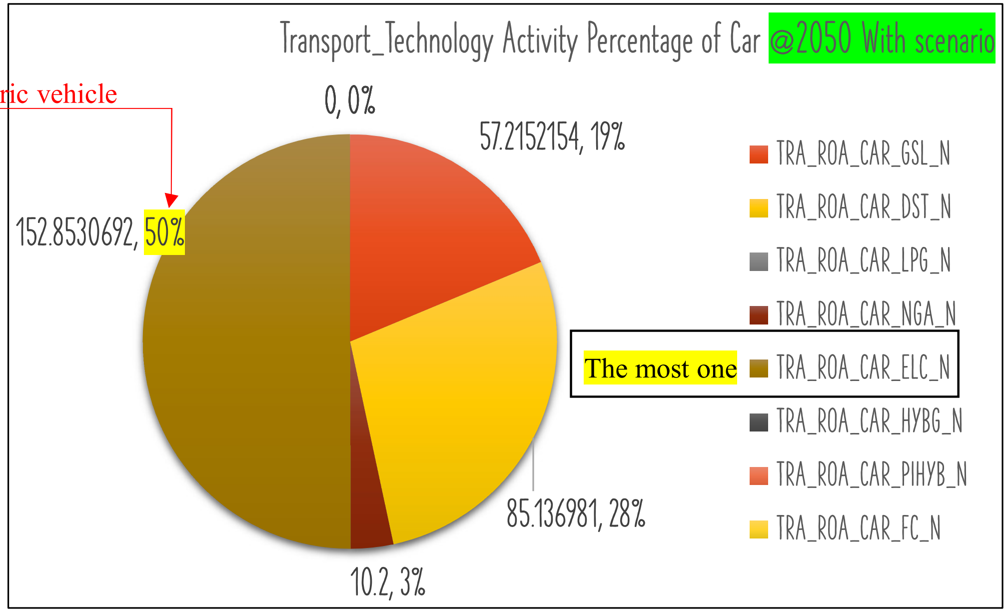


Figure8. GHG Emission among different TRA technologies (CAR) @ 2050

@ 2050

In RES condition, Fossil fuel vehicles still occupy a dominant position.

In scenarios combined condition, Electric vehicles will occupy the dominant position.

Transport Technology Activities(BUS)

TRA Sector Commodities (p). e.g. TRA_NGA

TRA Technologies (BUS)

a significant increase in electric vehicle

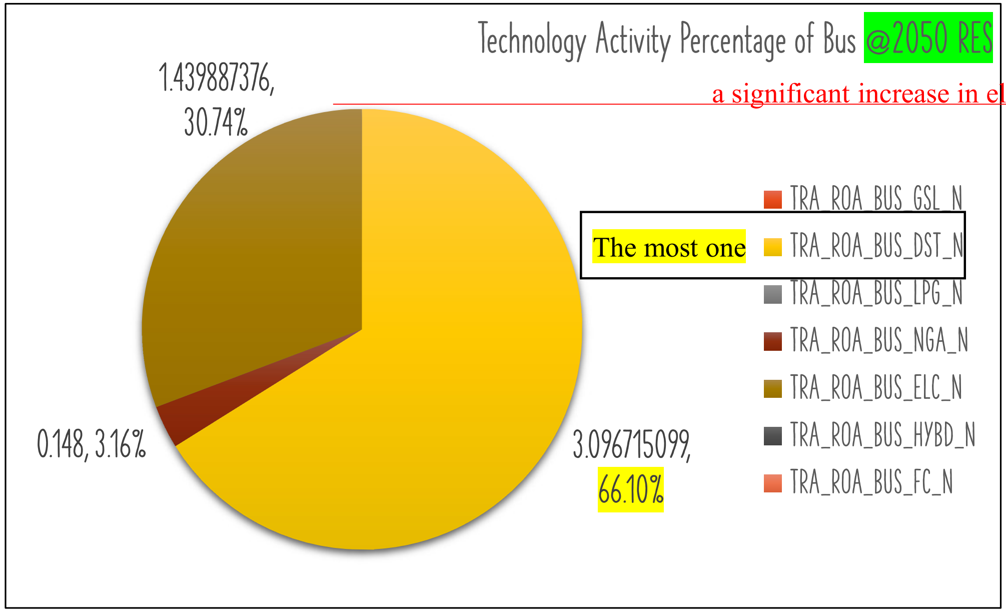


Figure9. Activity of TRA technologies (BUS) @ 2050

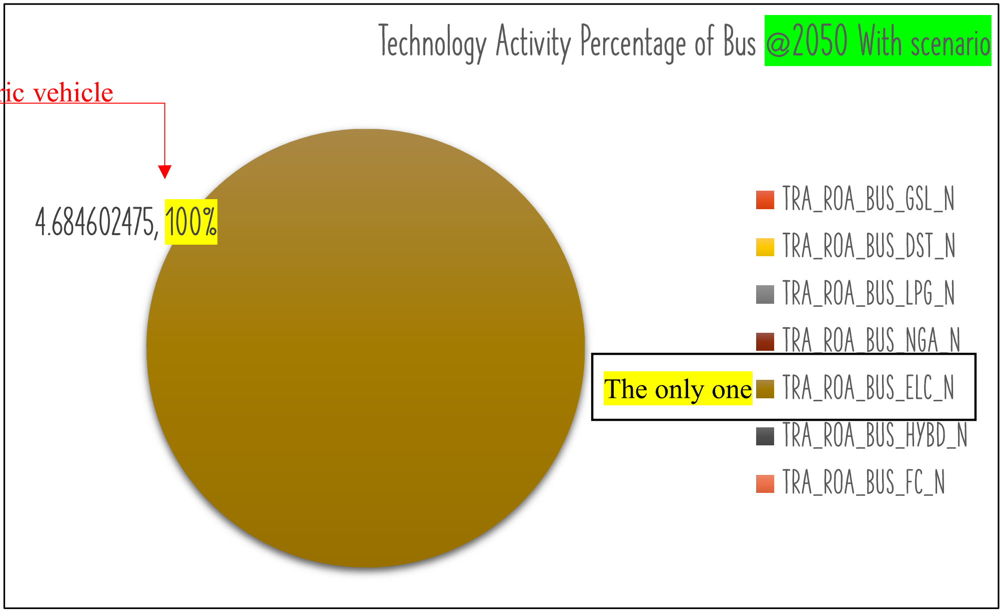


Figure10. GHG Emission among different TRA technologies (BUS) @ 2050

@ 2050
In RES condition, Fossil fuel vehicles still occupy a dominant position.

No more GHG emissions would be produced in this condition.

Transport Technology Activities(RAIL_Passenger)

TRA Sector Commodities (p). TRA_DST :   TRA Sector Commodities (p). TRA_ELC

TRA Technologies (RAIL_Passenger)

A ratio= $\frac{\boldsymbol{GHG\ Emission\ (C02\_eq)}}{\boldsymbol{Demand\ (PJ)}}$

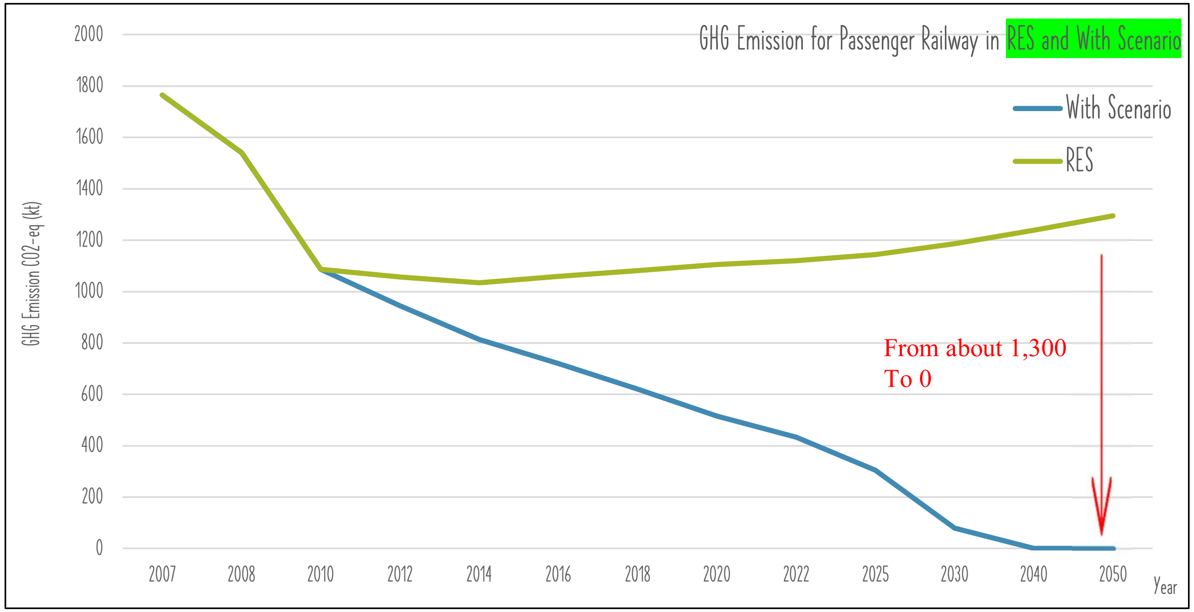


Figure11. GHG Emission trend for Passenger Railway in the condition of RES and with Scenarios

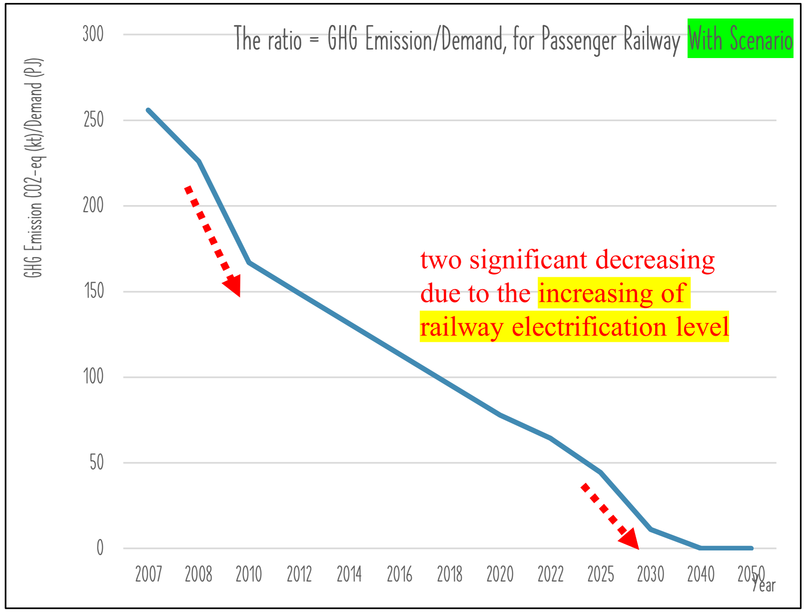


Figure12. GHG Emission among different transport technologies @ 2050

From 2040, the value is '0', it is because of the realization of complete railway electrification and the usage of Hydrogen Fuel Cell based technology.(Our scenarios in Passenger railway)

Improvement

Improvement

1. Increase the **electrification level** for freight railways.

2. More **ambitious emission scenarios** on the transport sector:

- GHG emissions are reduced by 33% by 2030.

- Nearly '0' emission is produced excluding aviation and navigation by 2050.

3. **New technologies.**

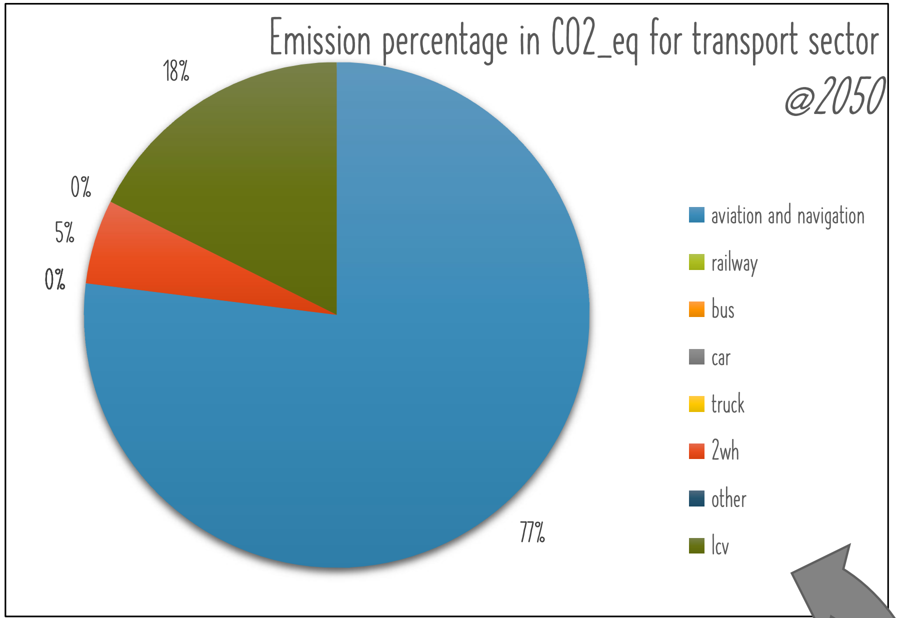


Figure13. Emission percentage in CO2_eq for the transport sector in 2050

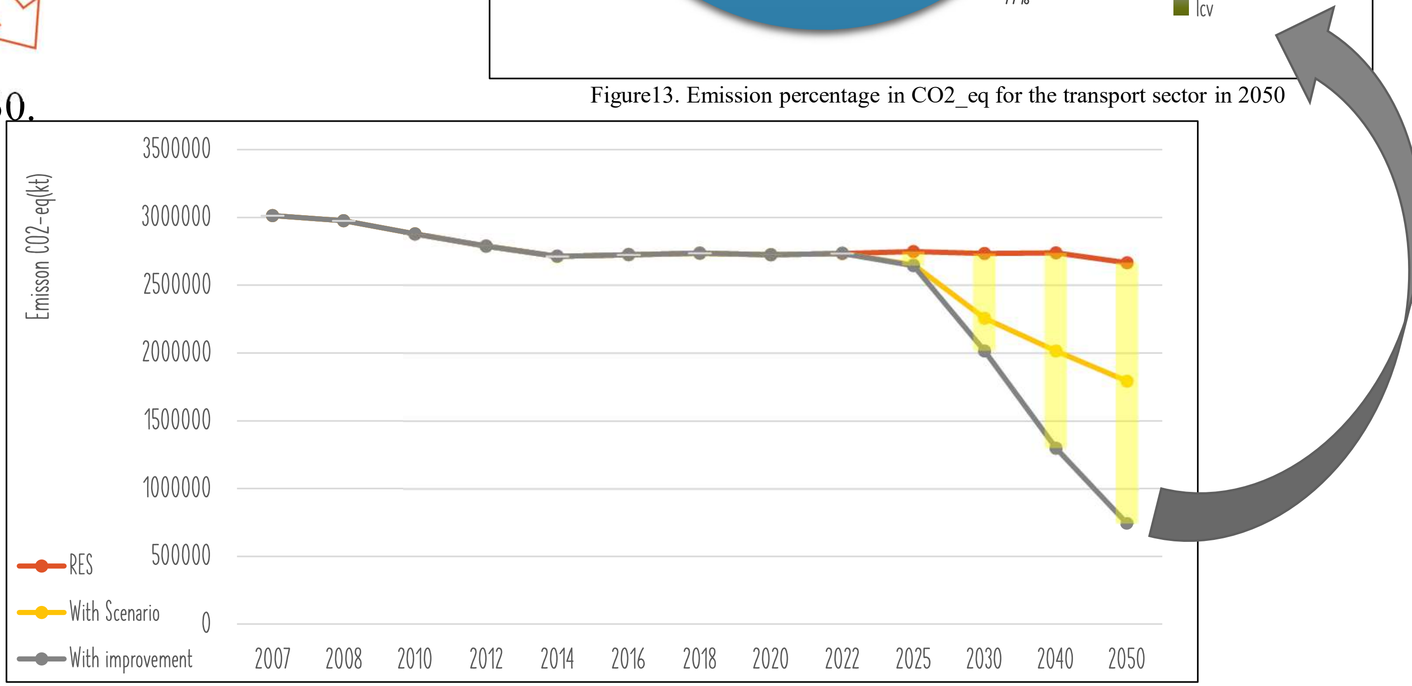


Figure14. GHG Emission trend of RSE and with scenarios and with improvement

THANK YOU

2023.03.06