PLVB/EXAMPLES





BRAZILIAN GREEN LOGISTICS PROGRAM (PLVB)

STRENGTHENING LOGISTICS SUSTAINABILITY THROUGH BEST PRACTICES IN ROAD FREIGHT TRANSPORT

Márcio de Almeida D´Agosto

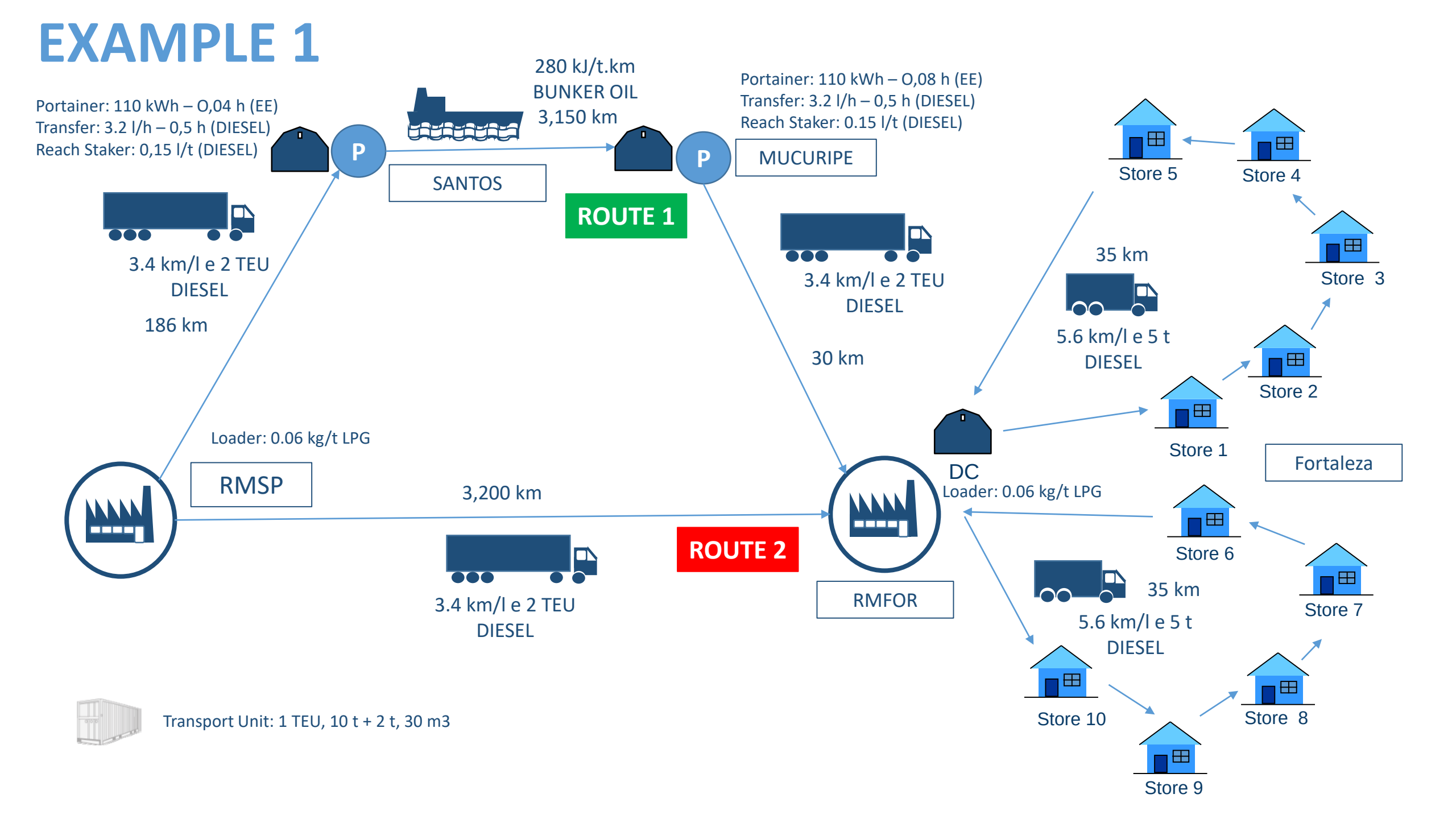
FREIGH TRANSPORT LABORATORY (LTC)/FREIGHT TRANSPORT PROGRAM (PET)
FEDERAL UNIVERSITY OF RIO DE JANEIRO (UFRJ)

SUMARY

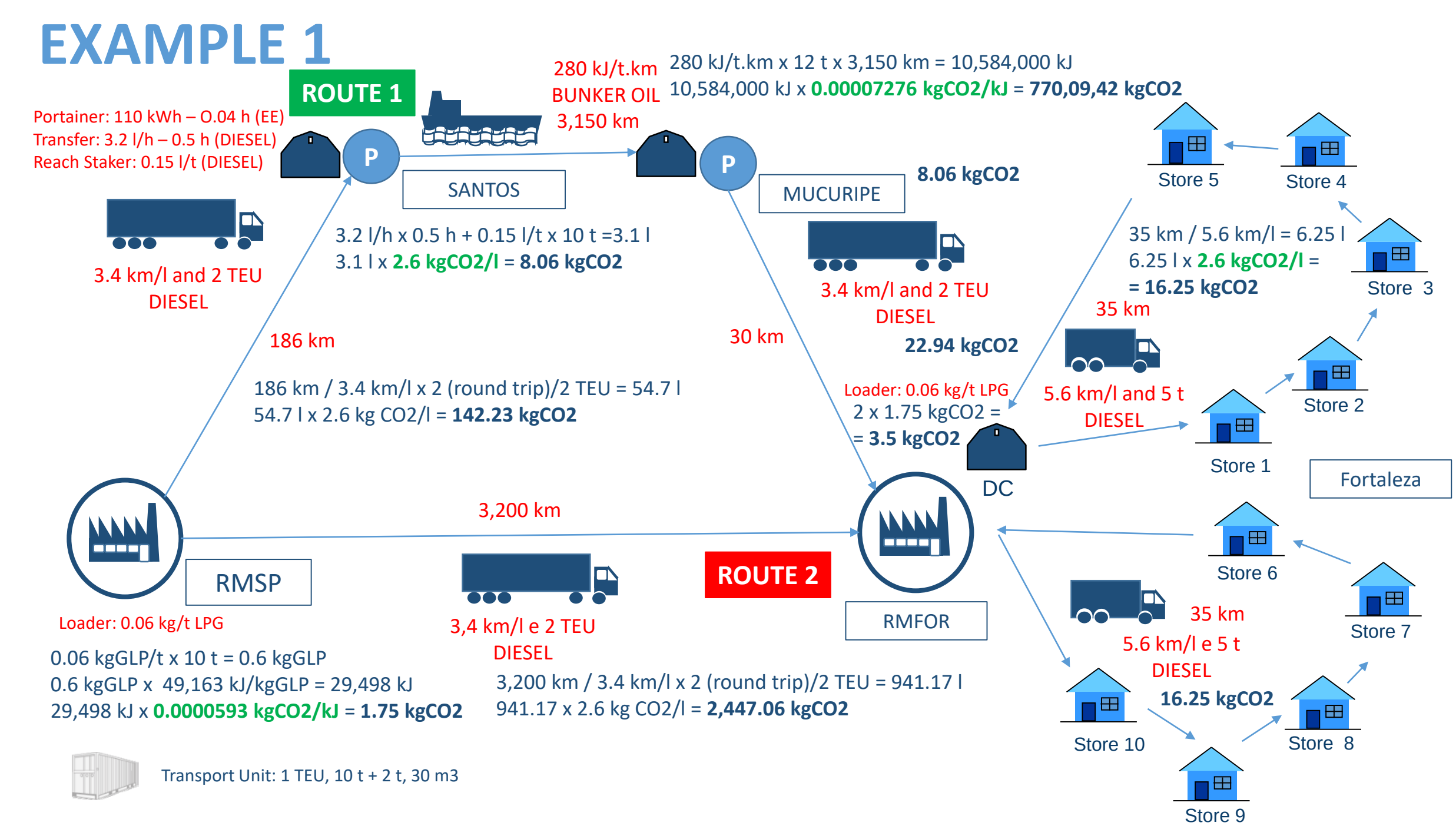
1. EXAMPLE 1 – ROAD X ROAD + COASTAL MARITIME TRANSPORT
2. EXAMPLE 2 – ROAD X ROAD + RAIL
3. EXAMPLE 3 - LONG-DISTANCE MARITIME TRANSPORT X AIR TRANPORT
4. EXAMPLES OF PARAMETERS AND INTERNATIONAL FACTORS

COVERAGE: FOCUS WILL BE GIVEN TO CARBON DIOXIDE (CO_2) EMISSIONS. FOR ANY OTHER GHG, THE PROCEDURE IS THE SAME.

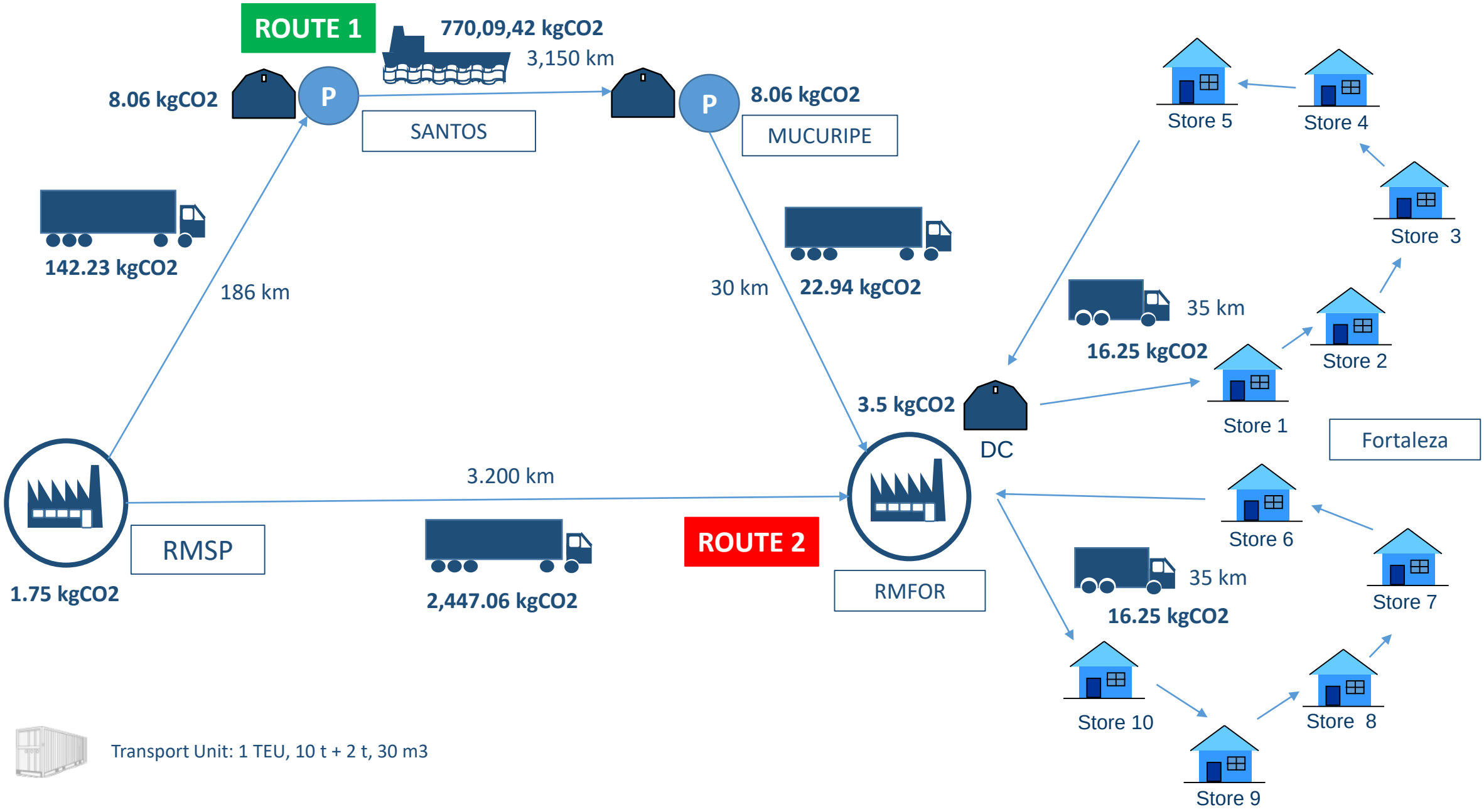
EXAMPLE 1


Portainer: 110 kWh – O,04 h (EE)
Transfer: 3.2 l/h – 0,5 h (DIESEL)
Reach Staker: 0,15 l/t (DIESEL)
280 kJ/t.km
BUNKER OIL
3,150 km
Portainer: 110 kWh – O,08 h (EE)
Transfer: 3.2 l/h – 0,5 h (DIESEL)
Reach Staker: 0.15 l/t (DIESEL)
P
SANTOS
P
MUCURIPE
ROUTE 1
3.4 km/l e 2 TEU
DIESEL
186 km
3.4 km/l e 2 TEU
DIESEL
30 km
Store 5
Store 4
Store 3
35 km
5.6 km/l e 5 t
DIESEL
Store 2
Store 1
Fortaleza
DC
Loader: 0.06 kg/t LPG
Loader: 0.06 kg/t LPG
RMSP
3,200 km
ROUTE 2
RMFOR
Store 6
Store 7
35 km
5.6 km/l e 5 t
DIESEL
3.4 km/l e 2 TEU
DIESEL
Store 10
Store 8
Store 9
Transport Unit: 1 TEU, 10 t + 2 t, 30 m3

EXAMPLE 1


ROUTE 1
Portainer: 110 kWh – 0.04 h (EE)
Transfer: 3.2 l/h – 0.5 h (DIESEL)
Reach Staker: 0.15 l/t (DIESEL)
280 kJ/t.km
BUNKER OIL
3,150 km
280 kJ/t.km x 12 t x 3,150 km = 10,584,000 kJ
10,584,000 kJ x 0.00007276 kgCO2/kJ = 770,09,42 kgCO2
P
SANTOS
P
MUCURIPE
8.06 kgCO2
3.4 km/l and 2 TEU
DIESEL
3.2 l/h x 0.5 h + 0.15 l/t x 10 t =3.1 l
3.1 l x 2.6 kgCO2/l = 8.06 kgCO2
3.4 km/l and 2 TEU
DIESEL
22.94 kgCO2
186 km
30 km
186 km / 3.4 km/l x 2 (round trip)/2 TEU = 54.7 l
54.7 l x 2.6 kg CO2/l = 142.23 kgCO2
Loader: 0.06 kg/t LPG
2 x 1.75 kgCO2 =
= 3.5 kgCO2
DC
35 km / 5.6 km/l = 6.25 l
6.25 l x 2.6 kgCO2/l =
= 16.25 kgCO2
35 km
5.6 km/l and 5 t
DIESEL
Store 5
Store 4
Store 3
Store 2
Store 1
Fortaleza
3,200 km
RMSP
ROUTE 2
RMFOR
Loader: 0.06 kg/t LPG
3,4 km/l e 2 TEU
DIESEL
0.06 kgGLP/t x 10 t = 0.6 kgGLP
0.6 kgGLP x 49,163 kJ/kgGLP = 29,498 kJ
29,498 kJ x 0.0000593 kgCO2/kJ = 1.75 kgCO2
3,200 km / 3.4 km/l x 2 (round trip)/2 TEU = 941.17 l
941.17 x 2.6 kg CO2/l = 2,447.06 kgCO2
Store 6
Store 7
35 km
5.6 km/l e 5 t
DIESEL
16.25 kgCO2
Store 10
Store 8
Store 9
Transport Unit: 1 TEU, 10 t + 2 t, 30 m3

EXAMPLE 1

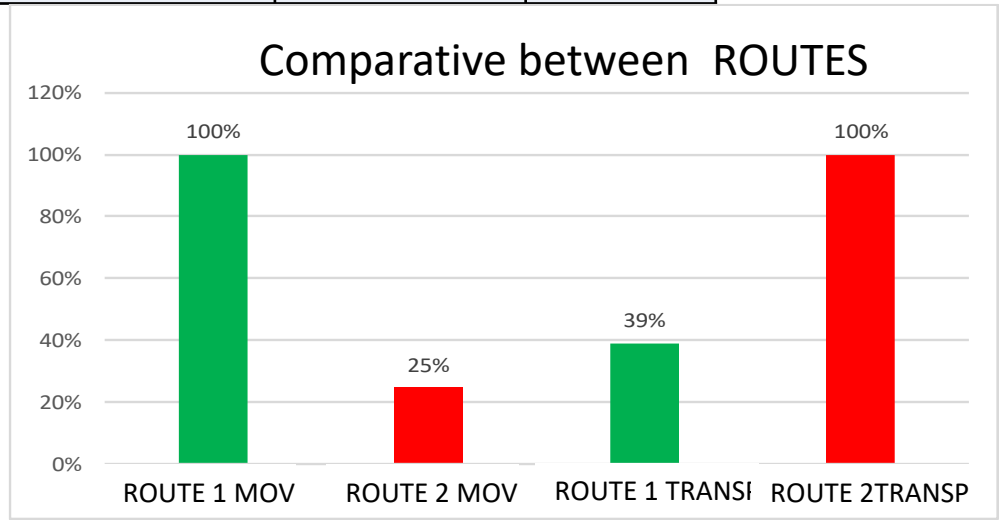

ROUTE 1
770,09,42 kgCO2
3,150 km
8.06 kgCO2
P
SANTOS
P
8.06 kgCO2
MUCURIPE
142.23 kgCO2
186 km
30 km
22.94 kgCO2
Store 5
Store 4
Store 3
35 km
16.25 kgCO2
Store 2
Store 1
3.5 kgCO2
DC
Fortaleza
3.200 km
RMSP
1.75 kgCO2
2,447.06 kgCO2
ROUTE 2
RMFOR
Store 6
35 km
16.25 kgCO2
Store 7
Store 10
Store 8
Store 9
Transport Unit: 1 TEU, 10 t + 2 t, 30 m3

EXAMPLE 1

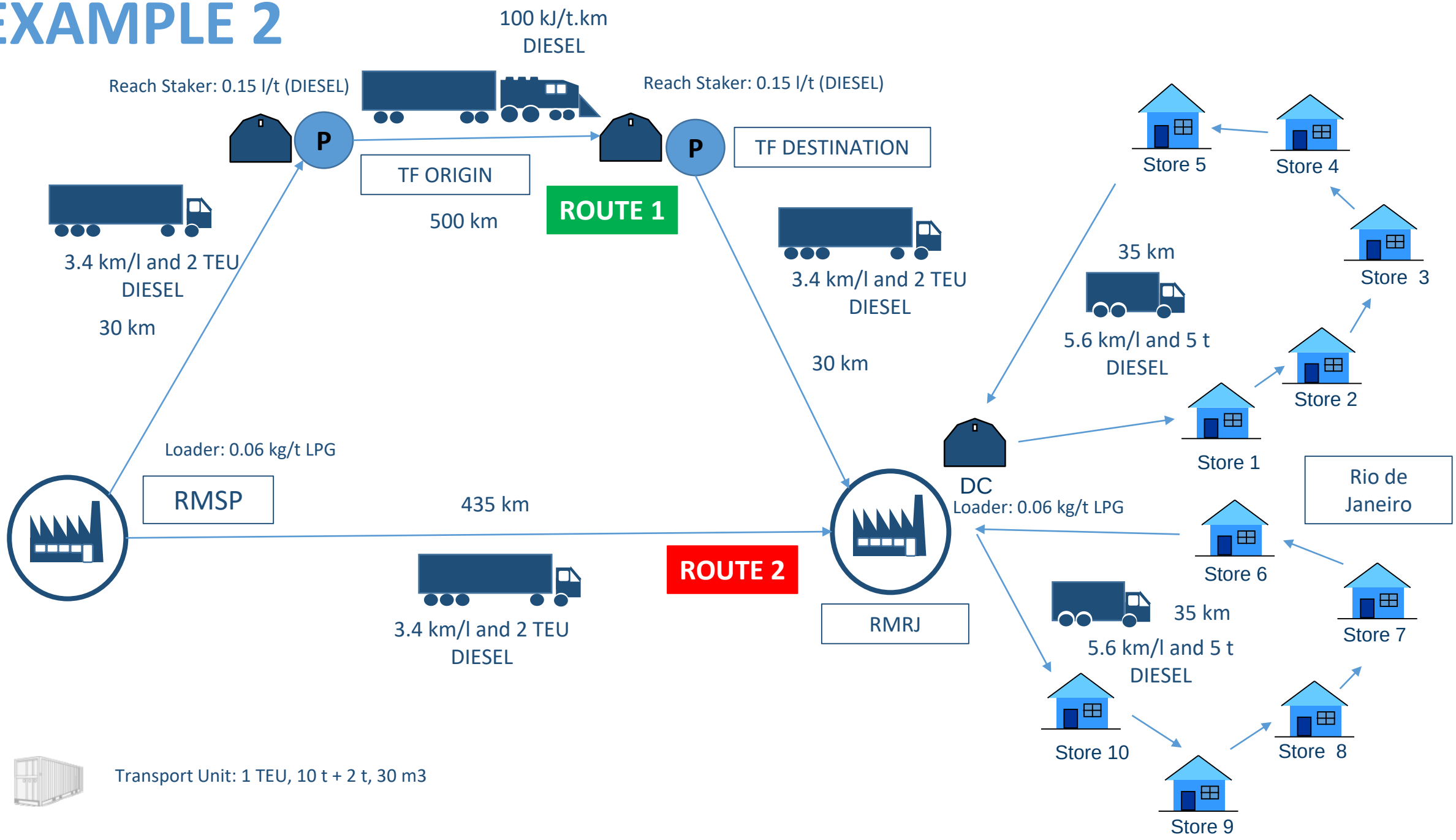
ROUTE 1	Kg CO2/unit	Kg CO2/t	Km	KgCO2/t.km
Factory Movement Origin	1.75	0.18		
Road Transport Origin	142.23	14.22	186.00	0.08
Port Movement Origin	8.06	0.81		
Maritime Transportation	770.09	77.01	3150.00	0.02
Port Movement Destination	8.06	0.81		
Transference Road Destination	22.94	2.29	30.00	0.08
DC Movement Destination	3.50	0.35		
Road Distribution Destination	32.50	3.25	35.00	0.09
TOTAL ROUTE 1	989.13	98.92		
ROUTE 1 Movement	21.37	21.60%		
ROUTE 2 Transportation	967.76	97.84%		

ROUTE 2	Kg CO2/unit	KgCO2/t	Km	KgCO2/t.km
Factory Movement Origin	1.75	0.18		
Road Transportation	2447.03	244.70	3200.00	0.08
DC Movement Destination	3.50	0.35		
Road Distribution Destination	32.50	3.25	35.00	0.09
TOTAL ROUTE 2	2484.78	248.48		
ROUTE 2 Movement	5.25	0.21%		
ROUTE 2 Transportation	2479.53	99.79%		

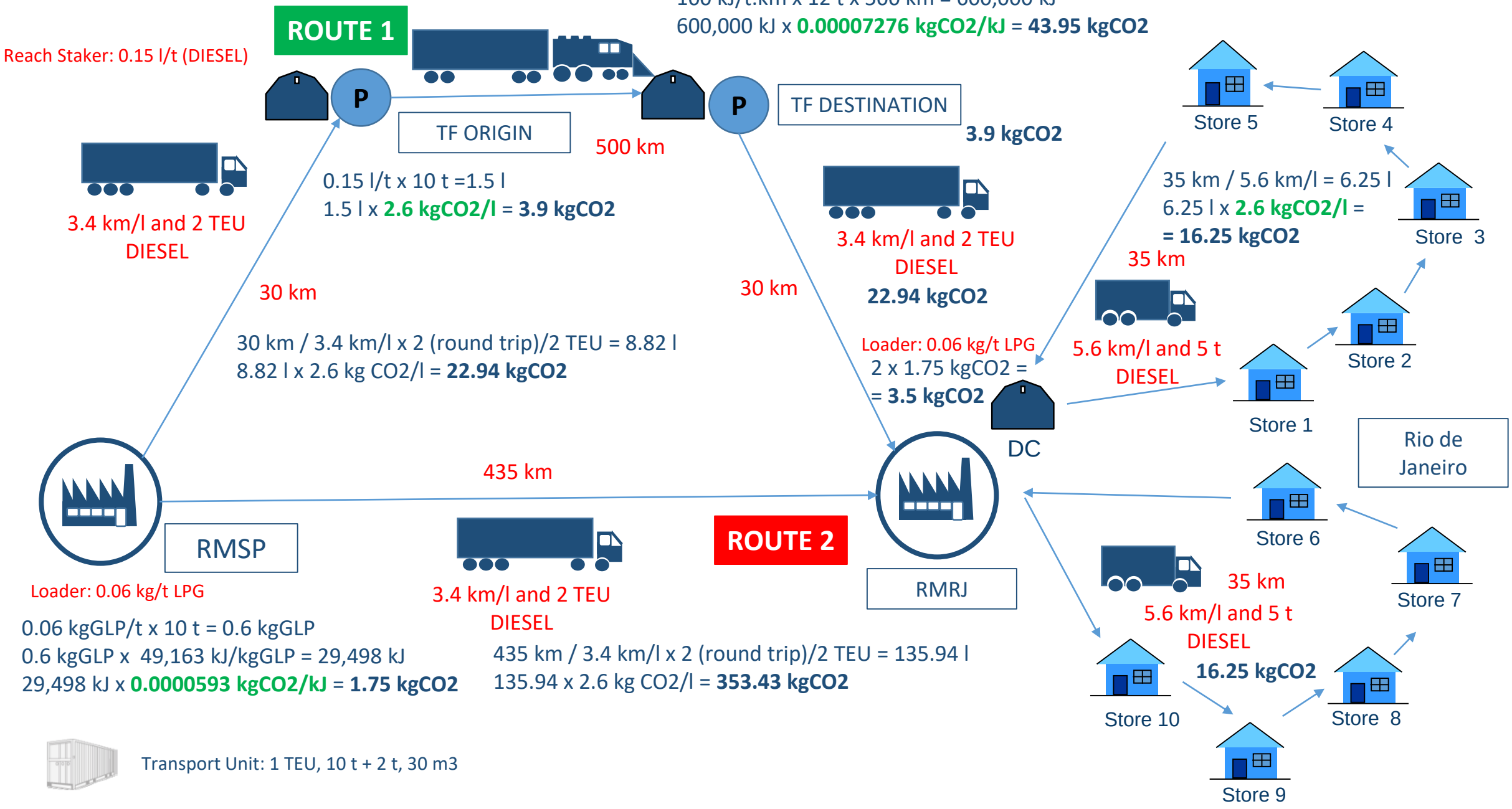
ROUTE 1 Mov	21.37	100%
ROUTE 2 Mov	5.25	25%
ROUTE 1 Transp	967.76	39%
ROUTE 2 Transp	2479.53	100%



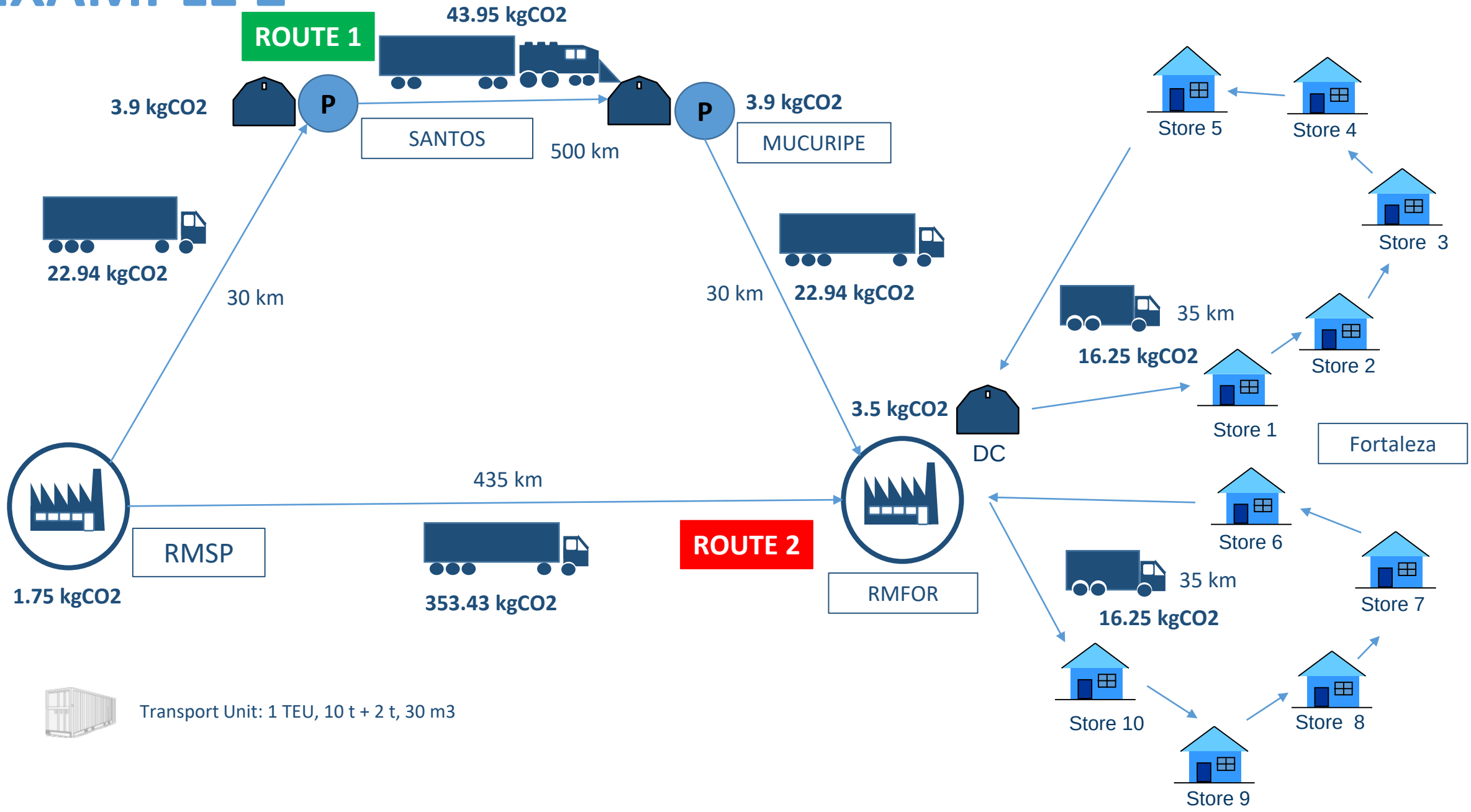
EXAMPLE 2


100 kJ/t.km
DIESEL
Reach Staker: 0.15 l/t (DIESEL)
Reach Staker: 0.15 l/t (DIESEL)
P
P
TF ORIGIN
TF DESTINATION
500 km
ROUTE 1
3.4 km/l and 2 TEU
DIESEL
30 km
3.4 km/l and 2 TEU
DIESEL
30 km
Loader: 0.06 kg/t LPG
RMSP
435 km
ROUTE 2
3.4 km/l and 2 TEU
DIESEL
RMRJ
DC
Loader: 0.06 kg/t LPG
35 km
5.6 km/l and 5 t
DIESEL
Store 5
Store 4
Store 3
Store 2
Store 1
Rio de
Janeiro
Store 6
Store 7
35 km
5.6 km/l and 5 t
DIESEL
Store 10
Store 8
Store 9
Transport Unit: 1 TEU, 10 t + 2 t, 30 m3

EXAMPLE 2


ROUTE 1
Reach Staker: 0.15 l/t (DIESEL)
100 kJ/t.km x 12 t x 500 km = 600,000 kJ
600,000 kJ x 0.00007276 kgCO2/kJ = 43.95 kgCO2
P
TF ORIGIN
500 km
P
TF DESTINATION
3.9 kgCO2
3.4 km/l and 2 TEU
DIESEL
0.15 l/t x 10 t =1.5 l
1.5 l x 2.6 kgCO2/l = 3.9 kgCO2
30 km
30 km / 3.4 km/l x 2 (round trip)/2 TEU = 8.82 l
8.82 l x 2.6 kg CO2/l = 22.94 kgCO2
3.4 km/l and 2 TEU
DIESEL
22.94 kgCO2
30 km
Loader: 0.06 kg/t LPG
2 x 1.75 kgCO2 =
= 3.5 kgCO2
DC
Store 5
Store 4
35 km / 5.6 km/l = 6.25 l
6.25 l x 2.6 kgCO2/l =
= 16.25 kgCO2
Store 3
35 km
5.6 km/l and 5 t
DIESEL
Store 2
Store 1
Rio de
Janeiro
435 km
RMSP
Loader: 0.06 kg/t LPG
0.06 kgGLP/t x 10 t = 0.6 kgGLP
0.6 kgGLP x 49,163 kJ/kgGLP = 29,498 kJ
29,498 kJ x 0.0000593 kgCO2/kJ = 1.75 kgCO2
3.4 km/l and 2 TEU
DIESEL
ROUTE 2
RMRJ
435 km / 3.4 km/l x 2 (round trip)/2 TEU = 135.94 l
135.94 x 2.6 kg CO2/l = 353.43 kgCO2
Store 6
Store 7
35 km
5.6 km/l and 5 t
DIESEL
16.25 kgCO2
Store 10
Store 8
Store 9
Transport Unit: 1 TEU, 10 t + 2 t, 30 m3

EXAMPLE 2

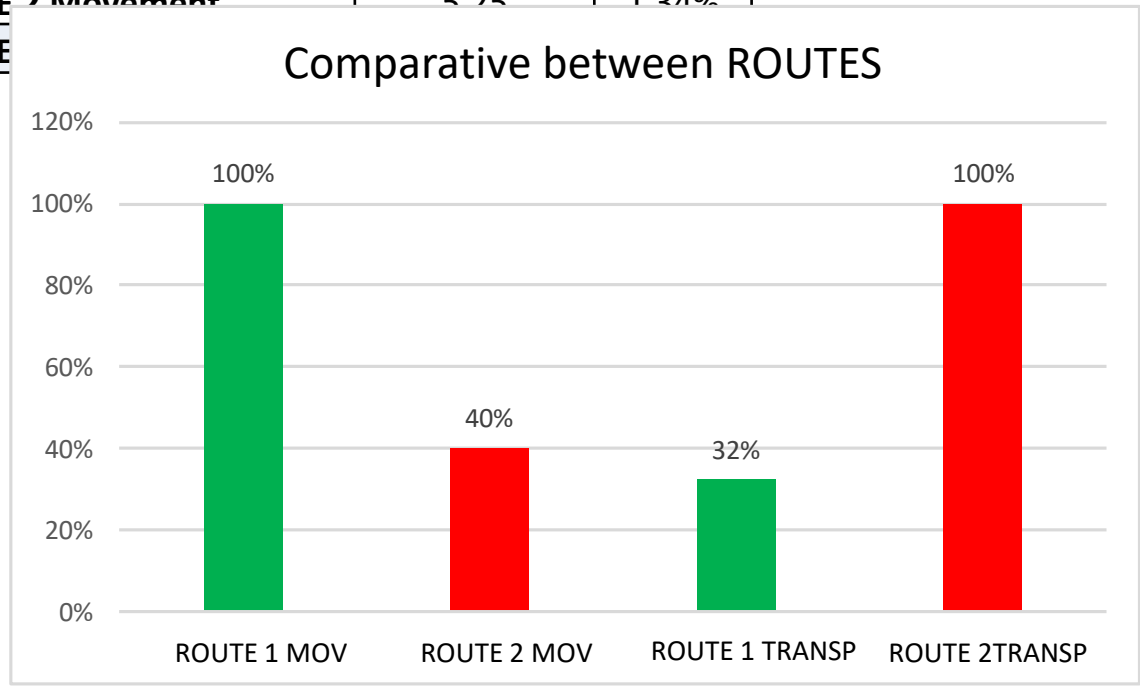

ROUTE 1
43.95 kgCO2
3.9 kgCO2
P
SANTOS
500 km
P
3.9 kgCO2
MUCURIPE
22.94 kgCO2
30 km
30 km
22.94 kgCO2
Store 5
Store 4
Store 3
35 km
16.25 kgCO2
Store 2
Store 1
3.5 kgCO2
DC
Fortaleza
435 km
RMSP
1.75 kgCO2
353.43 kgCO2
ROUTE 2
RMFOR
Store 6
35 km
16.25 kgCO2
Store 7
Store 10
Store 8
Store 9
Transport Unit: 1 TEU, 10 t + 2 t, 30 m3

EXAMPLE 2

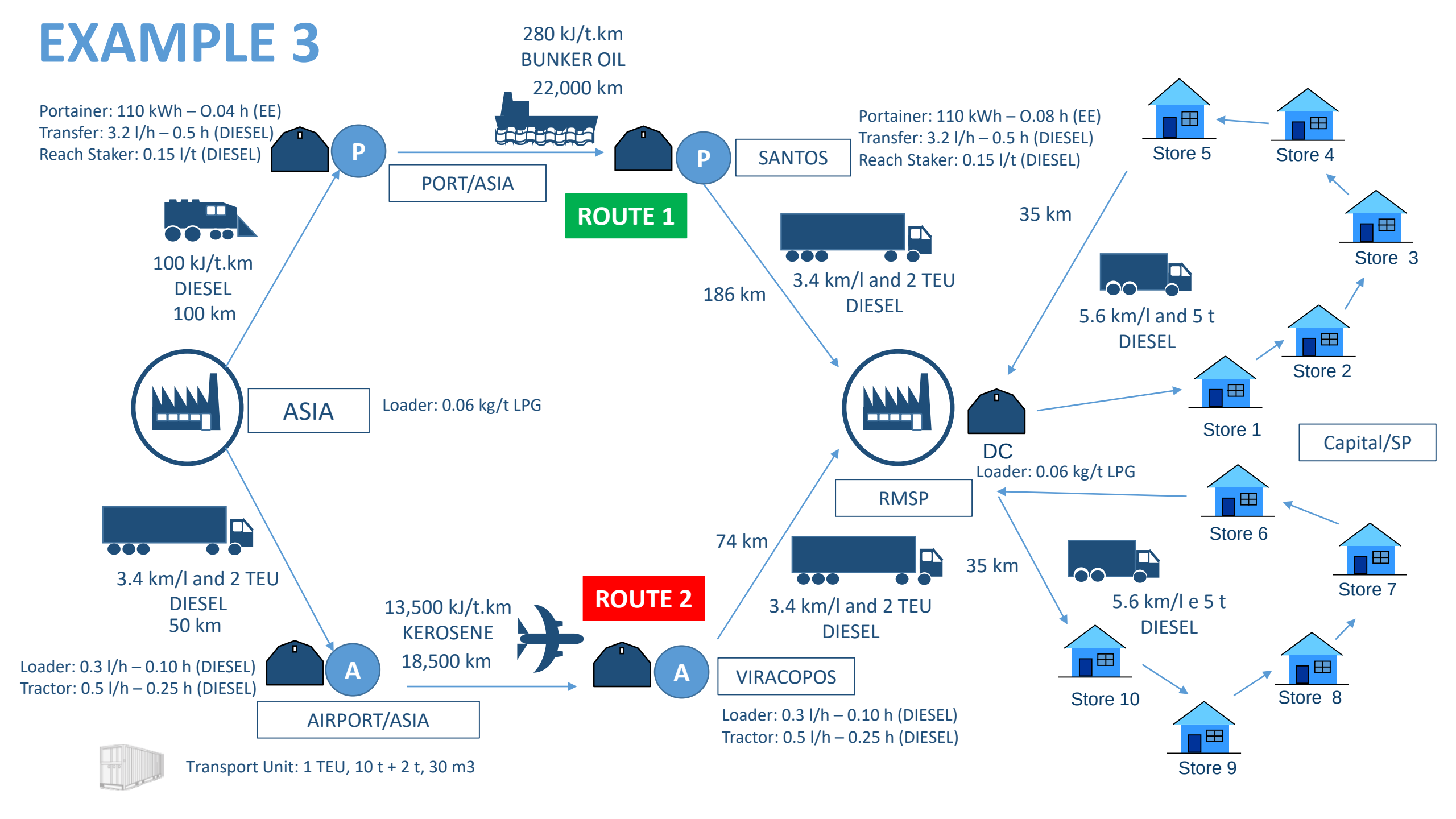
ROUTE 1	Kg CO2/unit	Kg CO2/t	Km	KgCO2/t.km
Factory Movement Origin	1.75	0.18		
Road Transport Origin	24.94	2.49	30.00	0.08
Port Movement Origin	3.90	0.39		
Rail Transportation	43.95	4.40	500.00	0.01
Port Movement Destination	3.90	0.39		
Transference Road Destination	22.94	2.29	30.00	0.08
DC Movement Destination	3.50	0.35		
Road Distribution Destination	32.50	3.25	35.00	0.09
TOTAL ROUTE 1	137.38	13.74		
ROUTE 1 Movement	13.05	9.50%		
ROUTE 2 Transportation	124.33	90.50%		

ROUTE 2	Kg CO2/unit	KgCO2/t	Km	KgCO2/t.km
Factory Movement Origin	1.75	0.18		
Road Transportation	353.43	35.34	435.00	0.08
DC Movement Destination	3.50	0.35		
Road Distribution Destination	32.50	3.25	35.00	0.09
TOTAL ROUTE 2	391.18	39.12		
ROUTE 2 Movement	5.25	1.34%		
ROUTE				

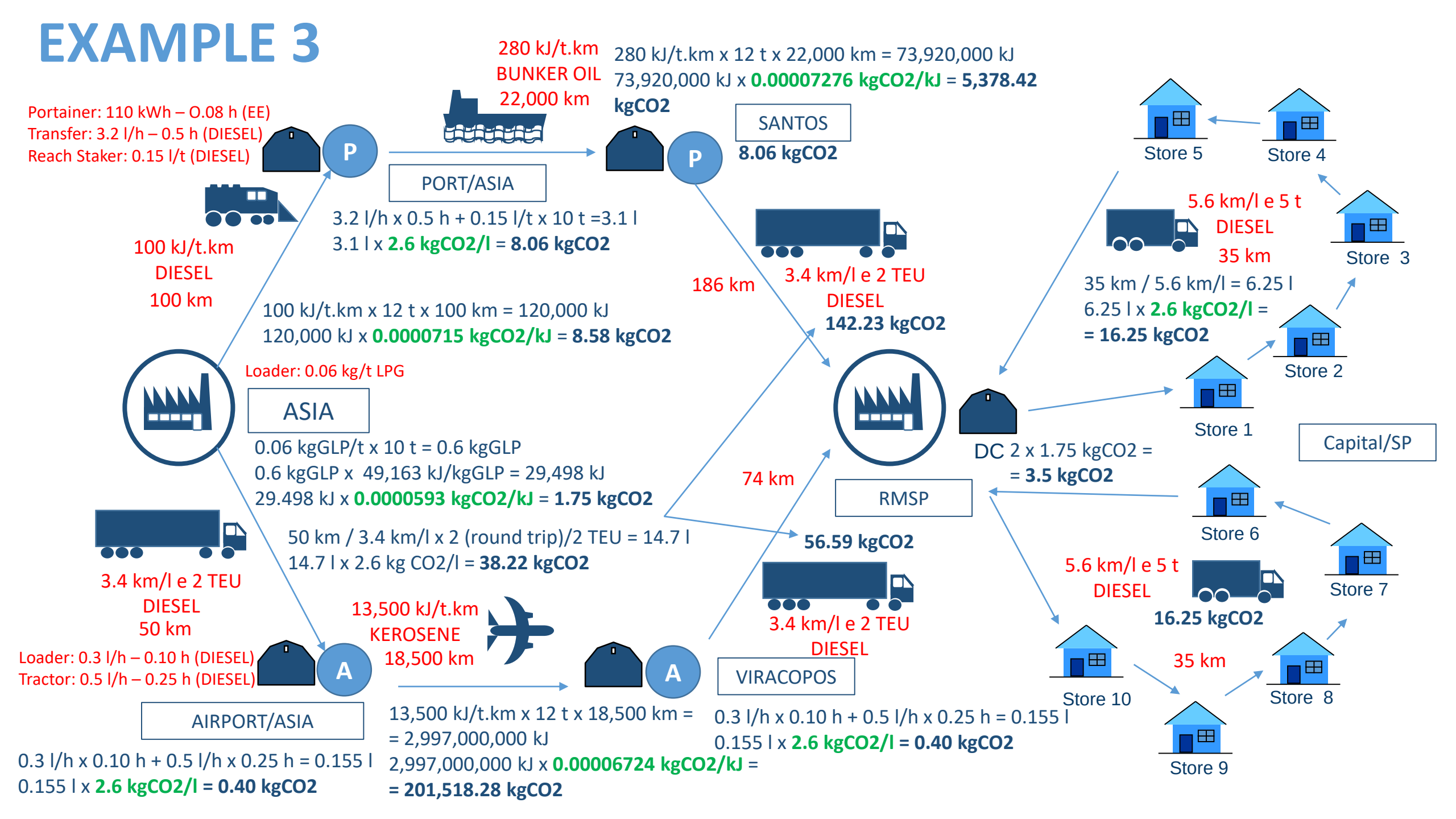
ROUTE 1 Mov	13.05	100%
ROUTE 2 Mov	5.25	40%
ROUTE 1 Transp	124.33	32%
ROUTE 2 Transp	385.93	100%



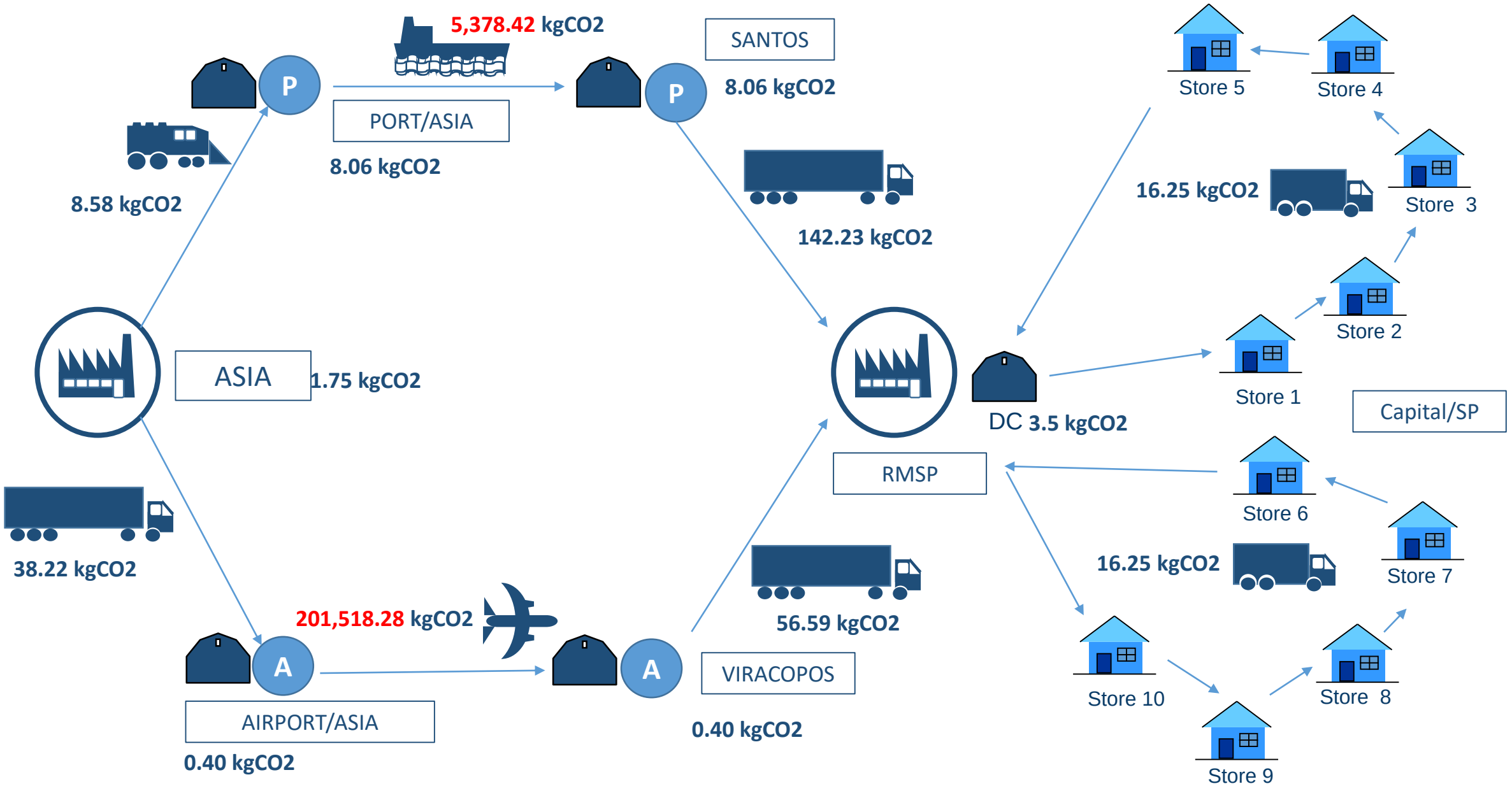
EXAMPLE 3


280 kJ/t.km
BUNKER OIL
22,000 km
Portainer: 110 kWh – O.04 h (EE)
Transfer: 3.2 l/h – 0.5 h (DIESEL)
Reach Staker: 0.15 l/t (DIESEL)
P
PORT/ASIA
ROUTE 1
P
SANTOS
Portainer: 110 kWh – O.08 h (EE)
Transfer: 3.2 l/h – 0.5 h (DIESEL)
Reach Staker: 0.15 l/t (DIESEL)
Store 5
Store 4
Store 3
35 km
100 kJ/t.km
DIESEL
100 km
186 km
3.4 km/l and 2 TEU
DIESEL
5.6 km/l and 5 t
DIESEL
Store 2
ASIA
Loader: 0.06 kg/t LPG
Store 1
Capital/SP
DC
Loader: 0.06 kg/t LPG
RMSP
3.4 km/l and 2 TEU
DIESEL
50 km
74 km
35 km
Store 6
Store 7
5.6 km/l e 5 t
DIESEL
13,500 kJ/t.km
KEROSENE
18,500 km
ROUTE 2
3.4 km/l and 2 TEU
DIESEL
Loader: 0.3 l/h – 0.10 h (DIESEL)
Tractor: 0.5 l/h – 0.25 h (DIESEL)
A
A
VIRACOPOS
AIRPORT/ASIA
Loader: 0.3 l/h – 0.10 h (DIESEL)
Tractor: 0.5 l/h – 0.25 h (DIESEL)
Store 10
Store 8
Store 9
Transport Unit: 1 TEU, 10 t + 2 t, 30 m3

EXAMPLE 3


280 kJ/t.km
BUNKER OIL
22,000 km
280 kJ/t.km x 12 t x 22,000 km = 73,920,000 kJ
73,920,000 kJ x 0.00007276 kgCO2/kJ = 5,378.42 kgCO2
SANTOS
8.06 kgCO2
Portainer: 110 kWh – 0.08 h (EE)
Transfer: 3.2 l/h – 0.5 h (DIESEL)
Reach Staker: 0.15 l/t (DIESEL)
P
PORT/ASIA
3.2 l/h x 0.5 h + 0.15 l/t x 10 t =3.1 l
3.1 l x 2.6 kgCO2/l = 8.06 kgCO2
100 kJ/t.km
DIESEL
100 km
100 kJ/t.km x 12 t x 100 km = 120,000 kJ
120,000 kJ x 0.0000715 kgCO2/kJ = 8.58 kgCO2
186 km
3.4 km/l e 2 TEU
DIESEL
142.23 kgCO2
Loader: 0.06 kg/t LPG
ASIA
0.06 kgGLP/t x 10 t = 0.6 kgGLP
0.6 kgGLP x 49,163 kJ/kgGLP = 29,498 kJ
29.498 kJ x 0.0000593 kgCO2/kJ = 1.75 kgCO2
74 km
RMSP
DC 2 x 1.75 kgCO2 =
= 3.5 kgCO2
Capital/SP
Store 5
Store 4
Store 3
5.6 km/l e 5 t
DIESEL
35 km
35 km / 5.6 km/l = 6.25 l
6.25 l x 2.6 kgCO2/l =
= 16.25 kgCO2
Store 2
Store 1
50 km / 3.4 km/l x 2 (round trip)/2 TEU = 14.7 l
14.7 l x 2.6 kg CO2/l = 38.22 kgCO2
56.59 kgCO2
3.4 km/l e 2 TEU
DIESEL
50 km
3.4 km/l e 2 TEU
DIESEL
Store 6
Store 7
5.6 km/l e 5 t
DIESEL
16.25 kgCO2
13,500 kJ/t.km
KEROSENE
18,500 km
Loader: 0.3 l/h – 0.10 h (DIESEL)
Tractor: 0.5 l/h – 0.25 h (DIESEL)
A
AIRPORT/ASIA
A
VIRACOPOS
Store 10
35 km
Store 8
Store 9
0.3 l/h x 0.10 h + 0.5 l/h x 0.25 h = 0.155 l
0.155 l x 2.6 kgCO2/l = 0.40 kgCO2
13,500 kJ/t.km x 12 t x 18,500 km =
= 2,997,000,000 kJ
2,997,000,000 kJ x 0.00006724 kgCO2/kJ =
= 201,518.28 kgCO2
0.3 l/h x 0.10 h + 0.5 l/h x 0.25 h = 0.155 l
0.155 l x 2.6 kgCO2/l = 0.40 kgCO2

EXAMPLE 3

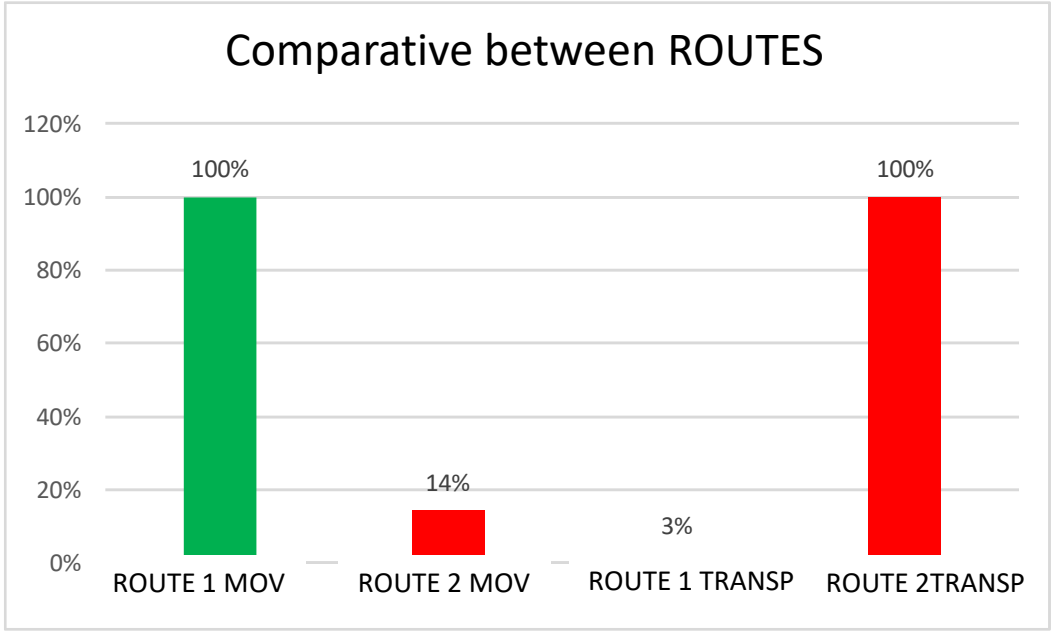

5,378.42 kgCO2
SANTOS
8.06 kgCO2
P
P
PORT/ASIA
8.06 kgCO2
8.58 kgCO2
142.23 kgCO2
Store 5
Store 4
16.25 kgCO2
Store 3
Store 2
Store 1
ASIA
1.75 kgCO2
DC 3.5 kgCO2
Capital/SP
RMSP
38.22 kgCO2
Store 6
16.25 kgCO2
Store 7
201,518.28 kgCO2
56.59 kgCO2
A
A
VIRACOPOS
AIRPORT/ASIA
0.40 kgCO2
0.40 kgCO2
Store 10
Store 8
Store 9

EXAMPLE 3

ROUTE 1	Kg CO2/unit	Kg CO2/t	Km	KgCO2/t.km
Factory Movement Origin	1.75	0.18		
Rail Transport Origin	8.58	0.86	100.00	0.01
Port Movement Origin	8.06	0.81		
Maritime Transportation	5,378.42	537.84	22,000.00	0.02
Port Movement Destination	8.06	0.81		
Transference Road Destination	142.23	14.22	186.00	0.08
DC Movement Destination	3.50	0.35		
Road Distribution Destination	32.50	3.25	70.00	0.05
TOTAL ROUTE 1	5,583.10	558.31		
ROUTE 1 MOVEMENT	17.87	0.32%		
ROUTE 2 TRANSPORTATION	5,561.73	99.62%		

ROUTE 2	Kg CO2/unit	KgCO2/t	Km	KgCO2/t.km
Factory Movement Origin	1.75	0.18		
Road Transport Origin	38.22	3.82	50.00	0.08
Airport Transport Origin	0.40	0.04		
Air Transportation	201,518.28	20,151.83	18,500.00	0.08
Airport Movement Destination	0.40	0.04		
Transference Road Destination	56.59	5.66	74.00	
DC Movement Destination	3.50	0.35		
Road Distribution Destination	32.50	3.25	70.00	0.09
TOTAL ROUTE 2	201,651.64	20,165.16		
ROUTE 2 MOVEMENT	2.55	0.0013%		
ROUTE 2 TRANSPORTATION	201,645.64	99.9970%		

ROUTE 1 MOV	17.87
ROUTE 2 MOV	2.55
ROUTE 1 TRANSP	5,561.73
ROUTE 2 TRANSP	201,645.59



EXAMPLES OF PARAMETERS AND INTERNATIONAL FACTORS

WORLD RESOURCES INSTITUTE

World Business Council for Sustainable Development

SMART FREIGHT CENTRE

$$\text{Consumption factor} = \frac{\sum \text{fuel}}{\sum (\text{tonne} * \text{km})}$$

Greenhouse gas emissions = fuel x fuel emission factor

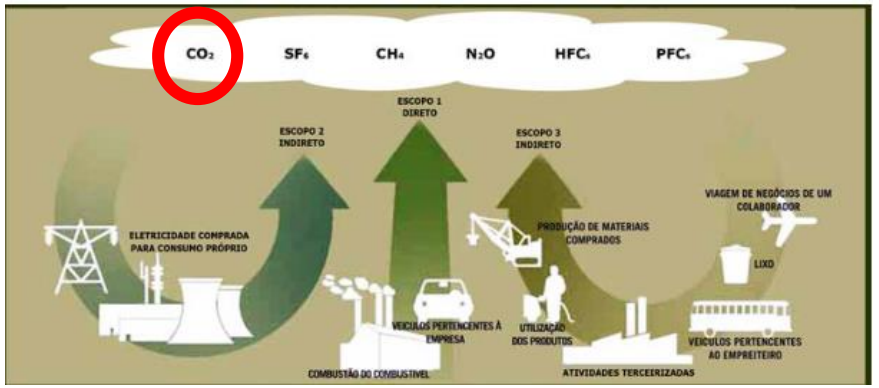
Greenhouse Gas Protocol

1. Define the organizational boundaries
2. Define operational limits
3. Select calculation methodology and emission factors
4. Collect Data
5. Calculate emissions
6. Elaborate GHG emission Report

Scope 1: GHG direct emissions

Scope 2: GHG indirect emissions from eletricity

Scope 3: Other GHG indirect emissions



EXAMPLES OF PARAMETERS AND INTERNATIONAL FACTORS

Pollutants	Otto cycle cars and light commercials		Motorcycles		Diesel cycle vehicles	NGV vehicles
	Gasoline c	Hydrous ethanol	Gasoline c	Hydrous ethanol		
Exhaust emissions						
Carbon monoxide (CO)	✓	✓	✓	✓	✓	✓
Nitrogen oxides (NOx)	✓	✓	✓	✓	✓	✓
Particulate matter (PM)	✓		✓		✓	
Aldehydes (RCHO)	✓	✓				✓
Non-methane hydrocarbons (NMHC exhaust)	✓	✓	✓	✓	✓	✓
Methane (CH4)	✓	✓	✓	✓	✓	✓
Carbon dioxide (CO2)	✓	✓	✓	✓	✓	✓
Nitrous oxide (N2O)	✓	✓	✓	✓	✓	✓
Evaporative emissions (NMHC evap)	✓	✓				
Exhaust emissions from brakes and tires (MP)	✓	✓	✓	✓	✓	✓
Track wear emissions (MP)	✓	✓	✓	✓	✓	✓

EXAMPLES OF PARAMETERS AND INTERNATIONAL FACTORS

Category	Engine
Motorcycles	Otto / Gasoline
	Otto / Flex Fuel
Automobiles	Otto / Gasoline
	Otto / Ethanol
	Otto / Flex Fuel
	Otto / GNV
Light commercials	Otto / Gasoline
	Otto / Ethanol
	Otto / Flex Fuel
	Diesel
Micro bus	Diesel
City buses	Diesel
Road buses	Diesel
Semi-trailer trucks (PBT> 3.5 t. <6 t.)	Diesel
Light Trucks (PBT> 6 t. <10 t.)	Diesel
Medium Trucks (PBT> 10 t. <15 t.)	Diesel
Light duty trucks (PBT> 15 t, PBTC <40 t.)	Diesel
Heavy Duty Trucks (PBT> 15t, PBTC> 40t.)	Diesel

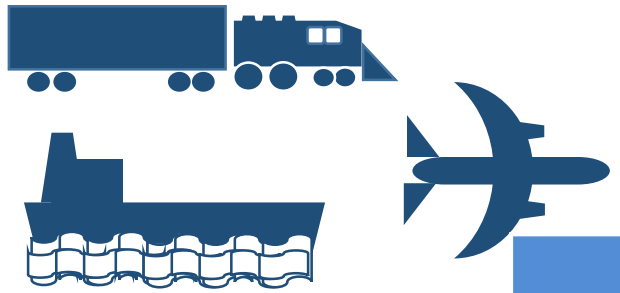
EXAMPLES OF PARAMETERS AND INTERNATIONAL FACTORS

WE NEED TO IMPROVE THE KNOWLEDGE OF IN-USE VEHICLE FUEL ECONOMY (km/l)

BRAZILAIN CO_2 EMISSION FACTORS

Calendar year	Automotive Gasoline (kg/l)	Hydrated Ethanol (kg/l)	Anhydrous Ethanol (kg/l)	Diesel Mineral (kg/l)	Biodiesel (kg/l)	CNG (kg/m³)
1980	2.209			2.631		
1981	2.209			2.646		
1982	2.212			2.656		
1983	2.261			2.649		
1984	2.258			2.674		-
1985	2.278			2.665		
1986	2.275			2.686		
1987	2.261			2.680		
1988	2.281	1.457	1.526	2.671	-	
1989	2.266			2.686		
1990	2.261			2.686		
1991-1997	2.261			2.674		
1998	2.243			2.646		1.999
1999	2.232			2.631		
2000	2.220			2.613		
2001-2004	2.212			2.603		
2005-2012	2.212			2.603	2.431	

EXAMPLES OF PARAMETERS AND INTERNATIONAL FACTORS



$$\frac{\text{kg } CO_2}{\text{L}} = \frac{\text{ton C}}{\text{TJ}} \times \frac{\text{TJ}}{\text{tep}} \times \frac{\text{tep}}{\text{m}^3} \times \%\text{Oxidation} \times \frac{44 \text{ ton } CO_2}{12 \text{ ton C}}$$

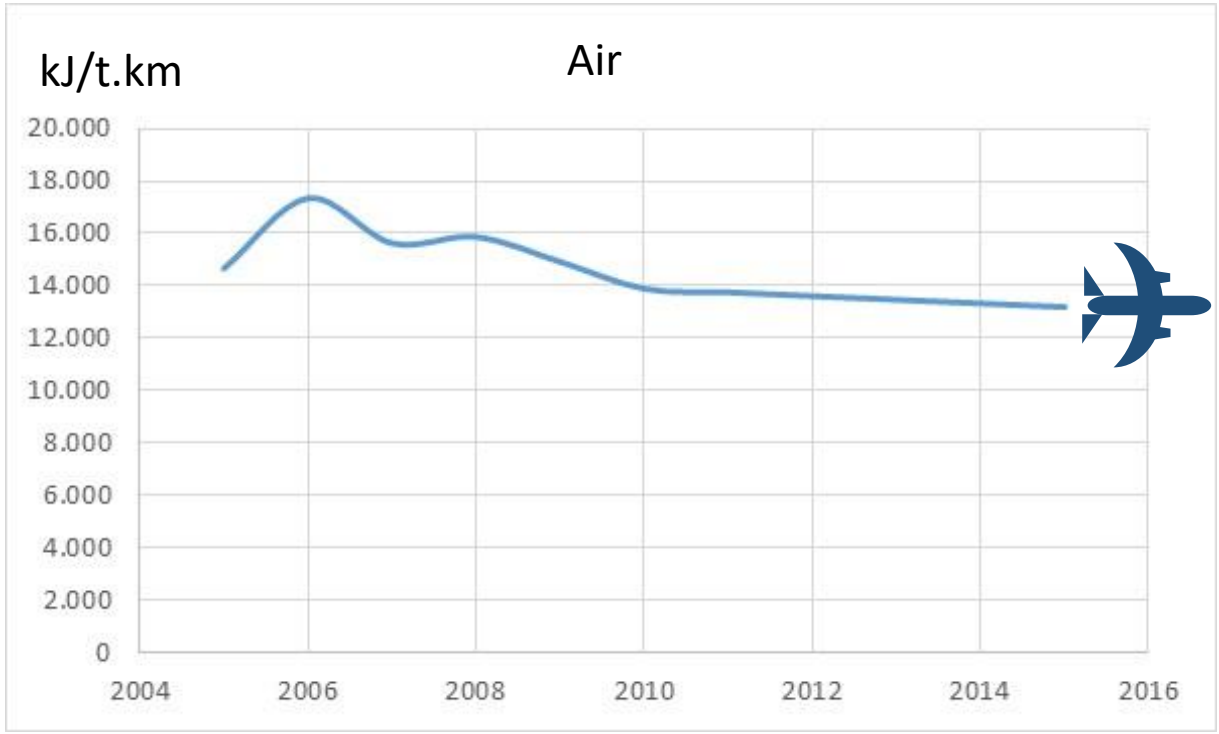
Fuel	Emission Factor (tC / TJ)	TJ / tep	Tep / m³	% Oxidized
Automotive Gasoline	18.9	0.04187	Table 9	99.00%
Anhydrous Ethanol	18.8			
Hydrous ethanol				
Mineral diesel	20.2			
Biodiesel*	20.2			
GNV	15.3			99.50%

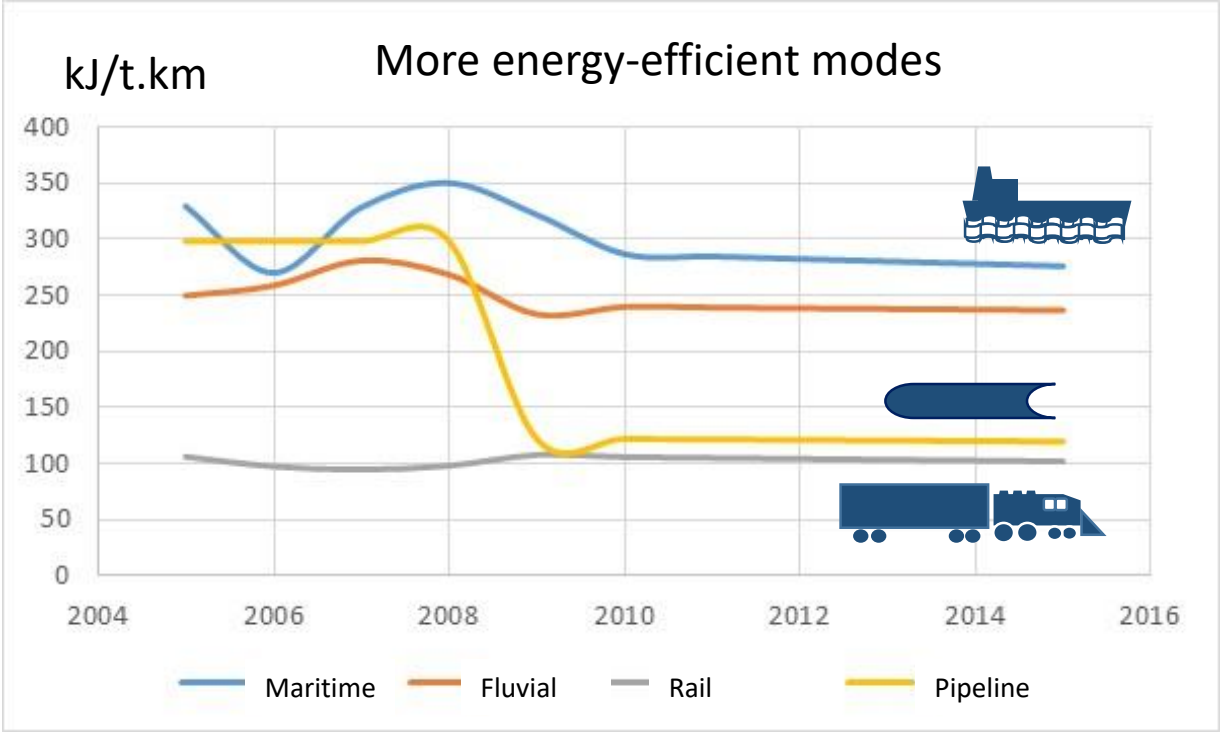
*For biodiesel, the same emission factor, in tC / TJ, of mineral diesel was considered.

WE NEED TO KNOW WELL THE EFICIENCY [MJ/t.km] OF THE MODES WE USE.

EXAMPLES OF PARAMETERS AND INTERNATIONAL FACTORS

WE NEED TO IMPROVE THE KNOWLEDGE OF THE EFICIENCY [kJ/t.km] OF THE MODES WE USE.





PLVB

Márcio de Almeida D'Agosto

dagosto@pet.coppe.ufrj.br

www.ltc.coppe.ufrj.br

+55 21 3938-8129/8139/ 99367-4494

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