

Global efficiency of Brazilian road and rail transport systems

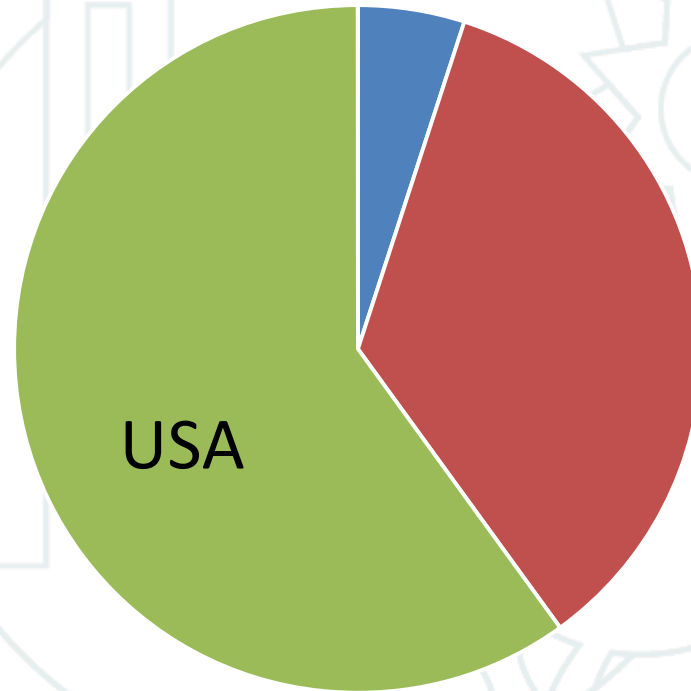
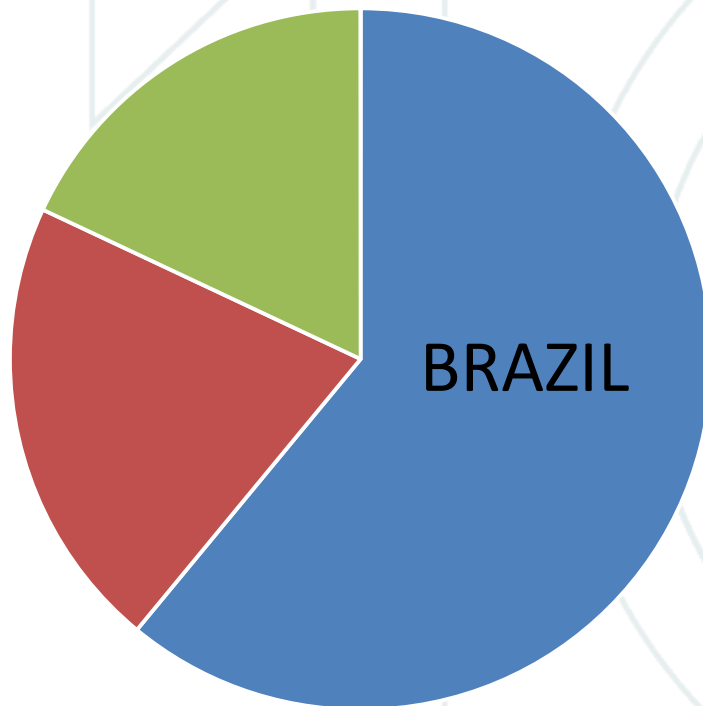
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Transportation Matrix of Brazil and USA



■ road ■ railway ■ waterway ■

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Brazilian soybean

- Most of the soybeans produced in the Brazilian state of Mato Grosso (MT) are exported by the ports of the southeast region with main destination to China
- The 20 million ton deficit in the storage capacity within the state of Mato Grosso intensifies the need for the use of the road and rail, especially in the harvest period

Objective

- Specifically for the Brazilian soybean production from MT to the port of Santos, there are doubts about the actual global efficiency in energy that the railroad system has
- In this sense, this work aims to use environmental accounting in energy to evaluate the overall efficiency of the road and rail transportation systems of soybean from the producing region to the port of Santos.

Emergy

- Emergy is the available energy of a type used directly and indirectly to make a service or product and his unit is sej(Odum, 1996)
- According to Brown and Ulgiati (2004), inputs of a system such as sunlight, fuel, electricity and human services can be placed on a common basis expressed in solar energy emjoules(sej) required to produce each of them.

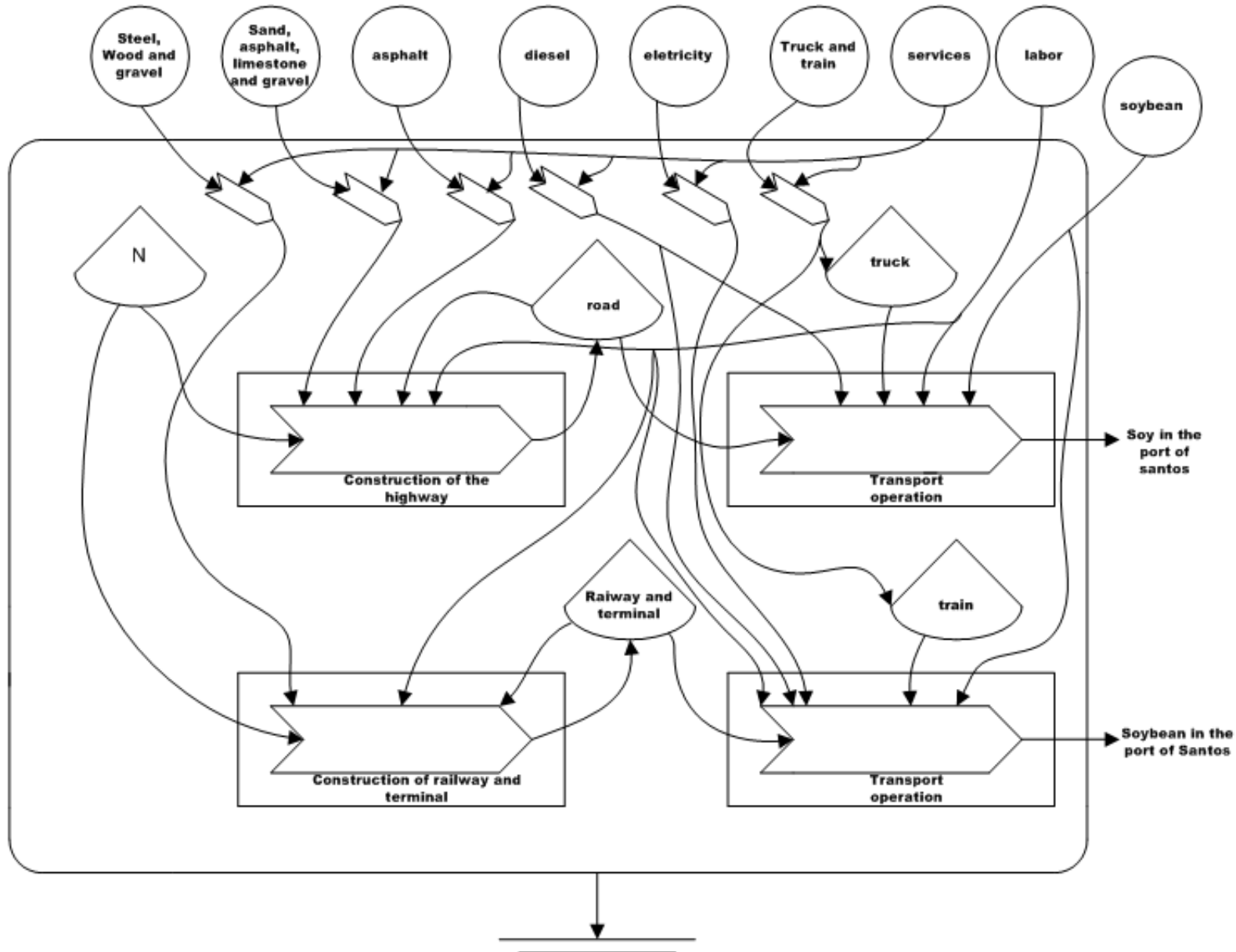
- Unlike the economic indicators that consider market values through a view of the recipient (willingness to pay that contemplates subjectivity), environmental accounting in emergy considers biophysical indicators through the donor side of resources (objectives). Thus, environmental accounting in emergy can be considered as a scientific method capable of providing subsidies towards sustainability (Giannetti et al., 2013).

Case study

- In relation to road transportation, soybeans are loaded in 14 producing municipalities and continue by direct truck to Santos
- In rail transportation, the soybean is transported from these municipalities to the terminal of Rondonópolis with the transshipment of soybeans to wagons and their subsequent rail transportation to the port of Santos

- A conceptual model of the system operation is represented in order to provide the best possible understanding of the system, presenting the main drivers, their interactions, products and co-products

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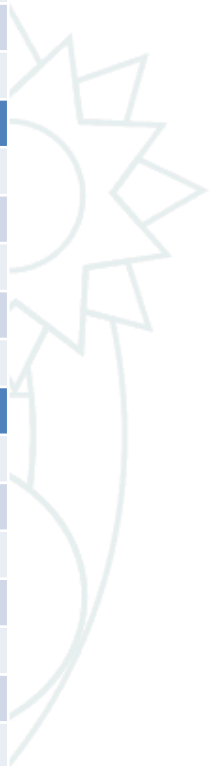
Results

- The environmental accounting in emergy provides a series of indicators that can be used by decision makers in search of sustainable development
- The study considered 13 million ton been transported by truck and by rail during a period of 7 months

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Note	Item	Quantity	Unit./year	UEV (sej/Unit.)	Energy (sej/year)	Energy (%)
Infra-structure: Locomotive and wagons						
1	Steel	1,47E+09	g	7,81E+09	1,15E+19	1,7
2	Iron	7,71E+07	g	5,78E+09	4,46E+17	<1
3	Services	8,56E+07	USD	4,24E+12	3,63E+20	53,8
Infra-structure: Railway						
4	Gravel	3,90E+10	g	1,68E+09	6,55E+19	9,7
5	Iron	2,19E+10	g	5,78E+09	1,27E+20	18,8
6	Wood	7,23E+09	g	8,80E+08	6,36E+18	<1
7	Soil	3,12E+07	g	1,68E+09	5,24E+16	<1
8	Services	1,41E+07	USD	4,24E+12	5,98E+19	8,9
Infra-structure: Terminal ferroviário						
9	Steel	4,40E+06	g	7,81E+09	3,44E+16	<1
10	Concrete	6,68E+06	g	2,42E+09	1,62E+16	<1
11	Fiber ciment	1,78E+06	g	2,07E+09	3,68E+15	<1
12	Asphalt	1,21E+08	g	2,55E+10	3,09E+18	<1
13	Rubber	3,61E+06	g	7,22E+09	2,61E+16	<1
14	Aluminium	7,10E+04	g	2,13E+10	1,51E+15	<1
15	Services	2,06E+06	USD	4,24E+12	8,73E+18	1,3
Operation						
16	Diesel	8,04E+13	J	1,85E+05	1,46E+19	2,2
17	Labor	1,23E+11	J	1,24E+07	1,53E+18	<1
18	Eletricity	1,74E+13	J	1,45E+05	2,56E+18	<1
19	Services	2,47E+06	USD	4,24E+12	1,05E+19	1,6
				Total =	6,74E+20	100,0



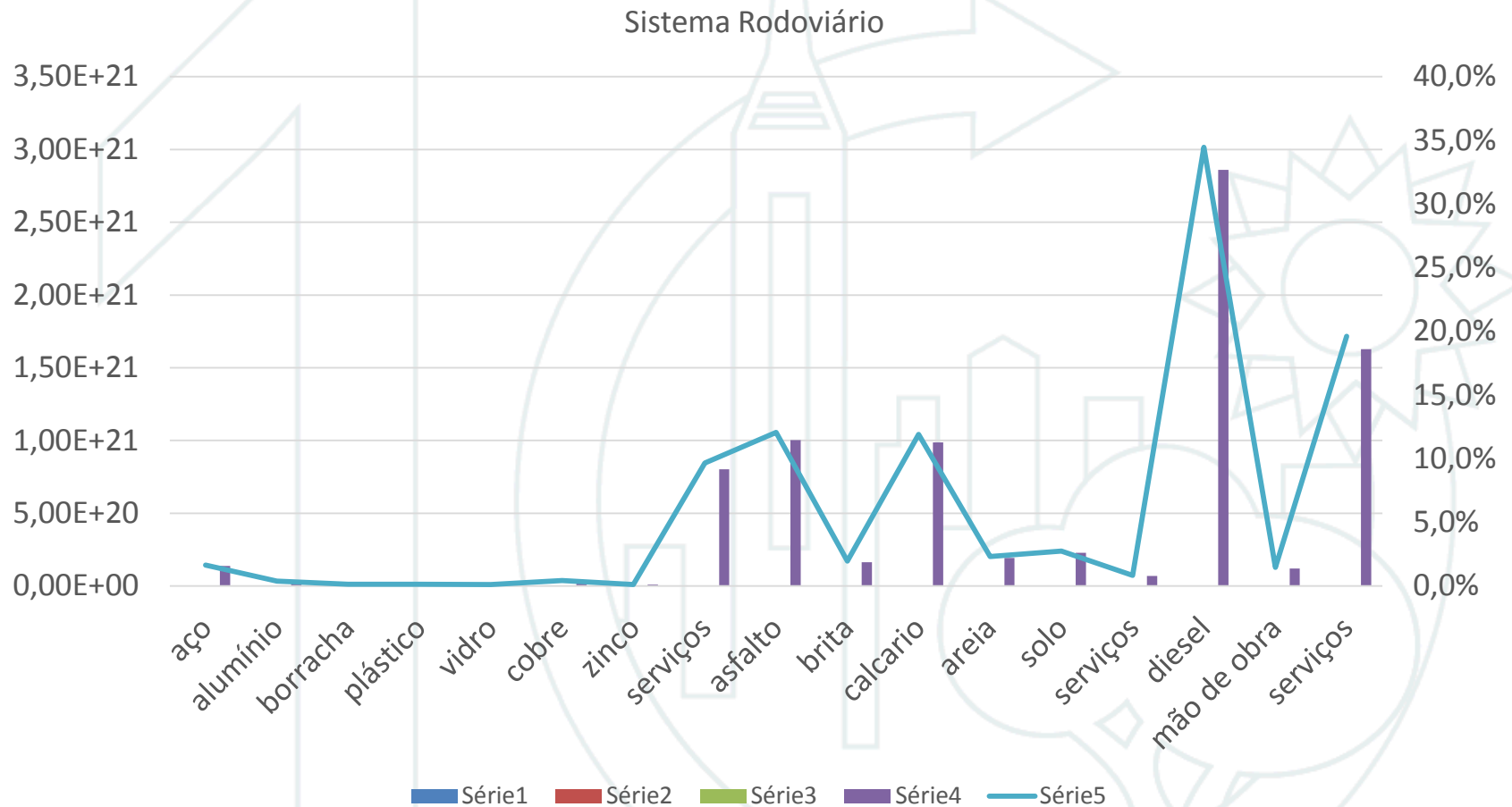
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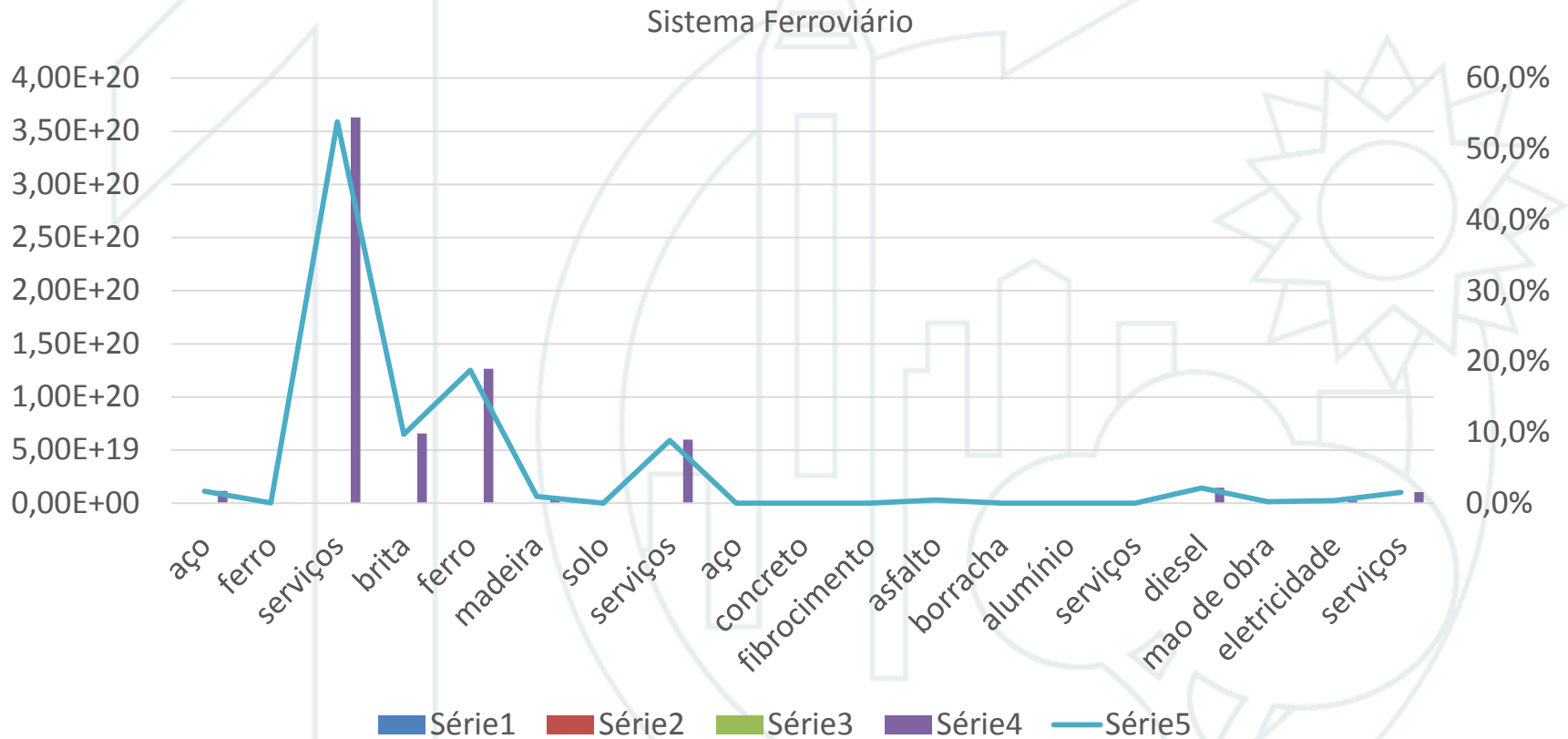
Note	Item	Quantity	Unit./year	UEV (sej/Unit.)	Emergy (sej/year)	Emergy (%)
Infra-structure: Truck						
1	Steel	1,76E+10	g	7,81E+09	1,37E+20	1,7
2	Aluminium	1,51E+09	g	2,13E+10	3,22E+19	<1
3	Rubber	1,49E+09	g	7,22E+09	1,08E+19	<1
4	Plastic	2,01E+09	g	5,51E+09	1,11E+19	<1
5	Glass	7,56E+08	g	1,32E+10	9,98E+18	<1
6	Copper	3,65E+08	g	9,80E+10	3,58E+19	<1
7	Zinc	1,30E+08	g	7,20E+10	9,36E+18	<1
8	Services	1,89E+08	USD	4,24E+12	8,01E+20	9,7
Infra-structure: Road						
9	Asphalt	3.93E+10	g	2,55E+10	1,00E+21	12,1
10	Gravel	9,73E+10	g	1,68E+09	1,63E+20	2,0
11	Limestone	1,03E+11	g	9,59E+09	9,88E+20	11,9
12	Sand	1,15E+11	g	1,68E+09	1,93E+20	2,3
13	Soil	1,36E+11	g	1,68E+09	2,28E+20	2,8
14	Services	1,62E+07	USD	4,24E+12	6,87E+19	<1
Operation						
15	Diesel	1,58E+16	J	1,81E+05	2,86E+21	34,45
16	Labor	9.76E+12	J	1,24E+07	1,21E+20	1,5
17	Services	3,84E+08	USD	4,24E+12	1,63E+21	19,6
				Total =	8,30E+21	100,0



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Including the distance

- The results were $6,25E + 5$ sej / ton.km for the road system and $9,89E + 6$ sej / ton.km for the rail system.
- Including the average of the truck routes from the producing poles to the Rondonópolis Terminal the value becomes $7.39E6$ sej / ton.km for the railway system.

Conclusion

- Considering the primary methods and data used in this work, the results show an energy demand for the road system of 6.25 E5 sej / ton.km, while the rail system demands 73.9 E5 sej / ton.km to transport soy From the State of Mato Grosso to the Port of Santos
- This difference indicates a global efficiency in energy of approximately 12 times higher for the road system, suggesting that this modal should be promoted in relation to the rail

Thanks for watching