



Optimize a sustainable Capture and offloading of CO2 onboard a vehicle

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Introduction/Background

• Problem Statement:

Optimize a sustainable capture of CO2 onboard a truck using adsorption-desorption, while considering safe storage and offloading methods.

• Constraints:

- Energy Supply
- Weight limitation
- Economic viability
- Vehicle spacing 2.6x2.5x1.1m

• Target Specifications:

- 1- Capturing 50% of the emitted CO2.
- 2- Storage tanks pressure below 20 bar.
- 3- Maximum travel of 650 km.
- 4- 25-30 minutes overall time spent at offloading stations.

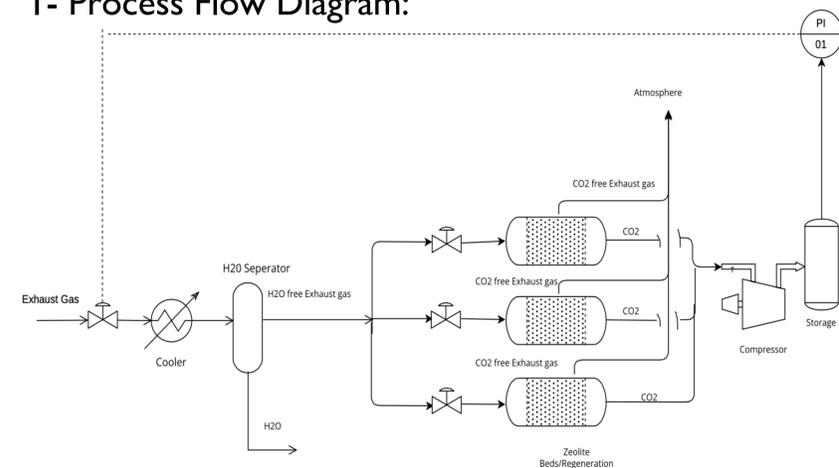
• Project Impact:

- 1- Green planet.
- 2- Reduce GHG to Net Zero.
- 3- Reduce the potential CO2 taxes.

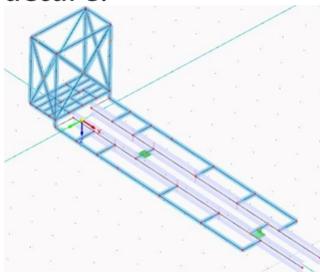
Methodology

• Phase I: CO2 Capture system,

1- Process Flow Diagram:



2- Frame structure:



3- Storage tank optimization

- Parameters:

E : CO2 amount per liter of Diesel.

F : Fuel Consumption in L/km.

D : Distance travel in km.

h : Cylinder height in m

- Decision Variable:

V = Volume of storage tank.

- Objective Function:

$$V_{Max} = \frac{E \times F \times D \times A}{P}$$

$$S.t. \quad D \geq 320 \quad R \leq 0.3$$

$$P \leq 20 \quad V \geq 0$$

$$h \leq 2.6$$

Phase II: offloading station,

1- Identifying the location of station

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Location model
Parameters
Tk = max travel distance of truck k -> = 640 km
dij = Distance between city i to city j, i ∈ I, j ∈ J
I = set of city i
J = set of city j
K = set of road k

D.V:
xik = {1, if truck i travel using road k,
        0, o/w
    }
yij = {1, if truck i uses 640 km using road j
        0, o/w
    }

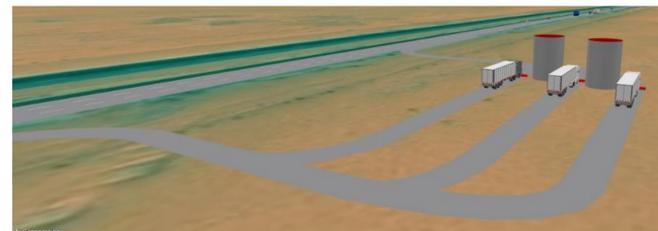
Dik = distance between the start of road i to the location of station j, where j ∈ J, k ∈ K

Obj:
min Σ xik Dik
(i ∈ I), (k ∈ K)

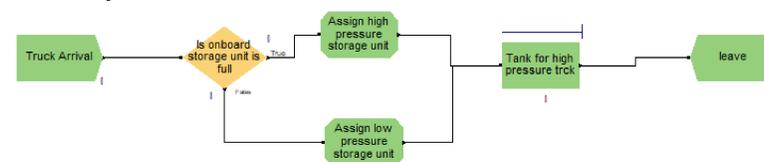
Assume
capacity of truck with 100% when start + travel.

Constrains:
Dik ≤ (640 - dij)
xik ≥ 0 for all i ∈ I, k ∈ K
yij ≥ 0 for all i ∈ I, j ∈ J
Dik ≥ 0 for all i ∈ I, k ∈ K
    
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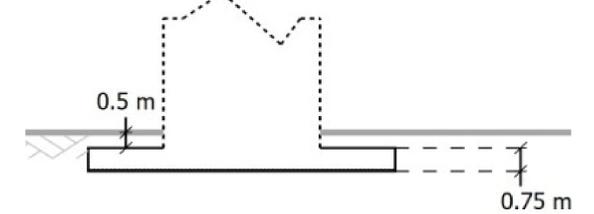
2- Vissim Simulation:



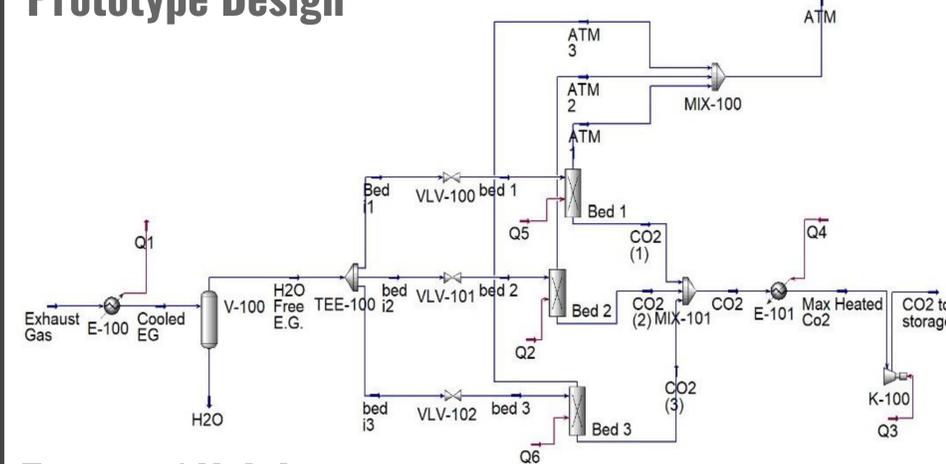
3- Identify the number of tank in each station



4- Determine offloading tank structure + Foundation:



Prototype Design



Testing / Validation:

Name	Exhaust Gas	CO2	ATM	CO2 to storage
Vapour Fraction	1.0000	1.0000	0.9977	1.0000
Temperature [C]	300.0	25.00	25.00	300.0
Pressure [kPa]	101.3	101.3	101.3	1700
Molar Flow [kgmole/h]	16.94	1.016	14.37	1.016
Mass Flow [kg/h]	492.8	44.73	420.1	44.73
Liquid Volume Flow [m3/h]	0.5822	5.419e-002	0.5000	5.419e-002
Heat Flow [kJ/h]	-1.143e+006	-4.003e+005	-5.176e+005	-3.649e+005

Name	ATM	CO2
Comp Mole Frac (CO2)	0.0707	1.0000
Comp Mole Frac (Oxygen)	0.1061	0.0000
Comp Mole Frac (H2O)	0.0333	0.0000
Comp Mole Frac (Nitrogen)	0.7898	0.0000

Conclusion

Based on the assumption that 12% CO2 by mol (2 kmol/h) will be emitted. The stream 'CO2', proves that ~1 kmol/h is captured. Hence, achieving our first specification. Moreover, the last stream 'CO2 to Storage' indicates that the gas will be compressed to a max value of 20 bar, while the mass flowrate is 44.73 kg/h (400 kg/ 8hrs stored) or a travel distant of 650 km, achieving the second and third specification.