BEE 4750/5750 Homework 4

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Problem 1

Problem 1.1

```
Components = ["Food Wastes","Paper & Cardboard","Plastics","Textiles","Rubber and Leath
"Aluminum","Other Metal","Misc"]

percent_mass = [0.15,0.4,0.05,0.03,0.02,0.05,0.18,0.04,0.02,0.02,0.01,0.03]
percent_ash = [0.08,0.07,0.05,0.1,0.15,0.02,0.02,1,1,1,1,.7]
recycling_rate = [0,0.55,0.15,0.1,0,0.3,0.4,0.6,0.75,0.8,0.5,0]

overall_recycling = round(sum(percent_mass .* recycling_rate),digits=2)
overall_ash = round(sum(percent_mass .* percent_ash),digits=2)
```

0.16

The overall recycling and ash fraction rates for the two cities are 0.38 and 0.16 respectively.

Problem 1.2

The decision variables are the amount of waste sent to a particular site, W, the residual waste transported from one site to another, R, and the operational status of each plant Y.

We can use subscripts to denote the particular site, (k or j), and the city it is coming from, i.

$$W_{i,j} = \text{Mg of waste sent from city i to site j}$$
$$R_{k,j} = \text{Residual waste transported from site k to site j} \;\; 0$$
$$Y_j = \text{Whether a plant is on or off}$$

Problem 1.3

```
Pkg.add("JuMP")
Pkg.add("HiGHS")
using JuMP
using HiGHS

waste = Model(HiGHS.Optimizer)
I = 1:2; #number of cities
J = 1:3; #number of disposal sites

#Waste transportation costs:
#City 1 ; City 2
#j1 = WTE, j2 = RF, j3 = LF
waste_transport_costs = 1.5.*[(15*60) (5*7) (30*50);(10*60) (15*7) (25*50)]
residual_costs = 1.5*[0 (18*45) 15;0 0 0;0 (18*45) 0]
operation_costs = [2500;1500;2000]

@variable(waste, W[i in I, j in J] >= 0)
@variable(waste, R[k in J, j in J] >= 0)
@variable(waste, Y[j in J], Bin)

@objective(waste, Min, sum(waste_transport_costs .* W) + sum(residual_costs .* R) + sum
```

1350 W[1,1] + 900 W[2,1] + 52.5 W[1,2] + 157.5 W[2,2] + 2250 W[1,3] + 1875 W[2,3] + 1215 R[1,2] + 1215 R[3,2] + 22.5 R[1,3] + 2500 Y[1] + 1500 Y[2] + 2000 Y[3]

Problem 1.4

A realistic problem involves the conservation of mass this means that the summation of all wastes from a certain city should be equal to the its total output per day. This can be represented as:

$$\sum_{W_{[i,:]}} = \text{output of city i}_0$$

Where W is the amount of waste released by city i, and the output of city i represents its daily waste production (kg/day)

Each site also has to be constrained on the waste they can process per day based on their total capacity. The sum of the amount of waste they take in and the amount recycled waste should not exceed their capacity.

$$\sum W_{i,j} + R_{i,j} \leq \text{plant capacity}\, 0$$

The residual waste also needs to be constrained to ensure that waste sites aren't sending residual waste to one another, that the largest capacity plant isn't sending residual waste to smaller plants, and ensure that the residuals for the recycling and waste to energy conversion plant have the correct ratio.

The on/off condition also has to be added as a constraint.

```
city_out = [100; 170]
@constraint(waste, city[i in I], sum(W[i,:]) == city_out[i])
#j1 = WTE, j2 = RF, j3 = LF
#waste to energy
@constraint(waste, wte, W[1,1] + W[2,1] + R[2,1] <= 150)
#recycling facility
```

```
@constraint(waste, rf, W[1,2] + W[2,2]  <= 350)
#landfill facility
@constraint(waste, lf, W[1,3] + W[2,3] + R[2,3] + R[1,3] <= 200)

#residuals: k,j from site k to site j

@constraint(waste, resid1, R[1,3] == overall_ash .* (W[1,1] + W[2,1] + R[2,1]))
@constraint(waste, resid2, R[2,1] + R[2,3] == (1-overall_recycling) .* (W[1,2] + W[2,2]
@constraint(waste, resid3, sum(R[3,:]) == 0)
@constraint(waste, noresiddiag, sum(R[i, i] for i in I) == 0)
@constraint(waste, noresid, R[1,2] == 0)

#commitment
#Y = 1 -> ON, Y=0 -> OFF
@constraint(waste, commit1, W[1,1] + W[2,1] + R[2,1] - (10000*Y[1])<= 0)
@constraint(waste, commit2, W[1,2] + W[2,2] - (10000*Y[2]) <=0)
@constraint(waste, commit3, Y[3] == 1)
```

commit3 : Y[3] = 1.0

Problem 1.5

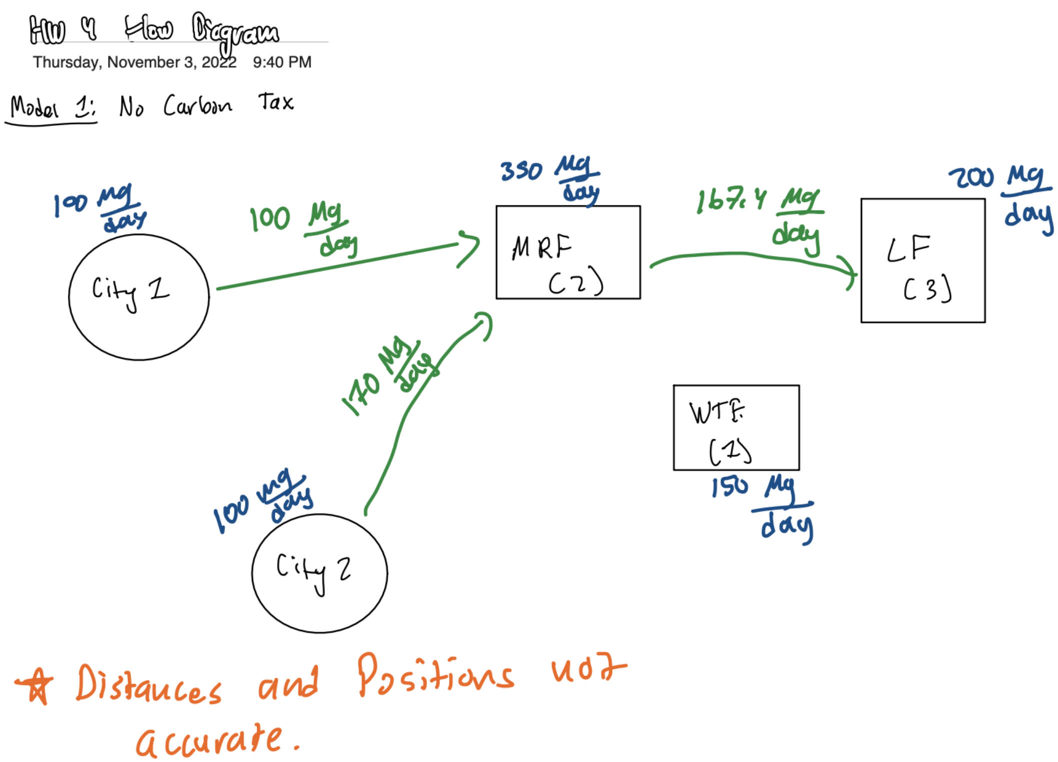
```
set_silent(waste)
optimize!(waste)
objective_value(waste)
value.(Y)
value.(W)
value.(R)

#j1 = WTE, j2 = RF, j3 = LF
```

2-dimensional DenseAxisArray{Float64,2,...} with index sets: Dimension 1, 1:3 Dimension 2, 1:3 And data, a 3×3 Matrix{Float64}: 0.0 0.0 0.0 0.0 0.0 167.4 0.0 0.0 0.0

Problem 1.6

The optimal objective value is 35525. The facility that wont be used is the waste to energy facility. A diagram is below, the locations and distances of each site are not accurate.



Problem 2

Problem 2.1

Changes to the tipping fee only impact the WTE facility, which was not reccomended for use in the first place. The changes will work to make it a much less viable option. However, the slight increase in transportation const could see it gaining viability and seeing use as its moderate distance from cities could give it an advantage over the landfill disposal site under certain conditions.

The optimization problem would have changed waste transport costs and and increased tipping fee for the WTE facility.

Problem 2.2

commit3 : Y[3] = 1.0

Problem 2.3

```
set_silent(waste_carbon)
set_silent(waste_carbon)
optimize!(waste_carbon)
objective_value(waste_carbon)
value.(Y)
value.(W)
value.(R)
```

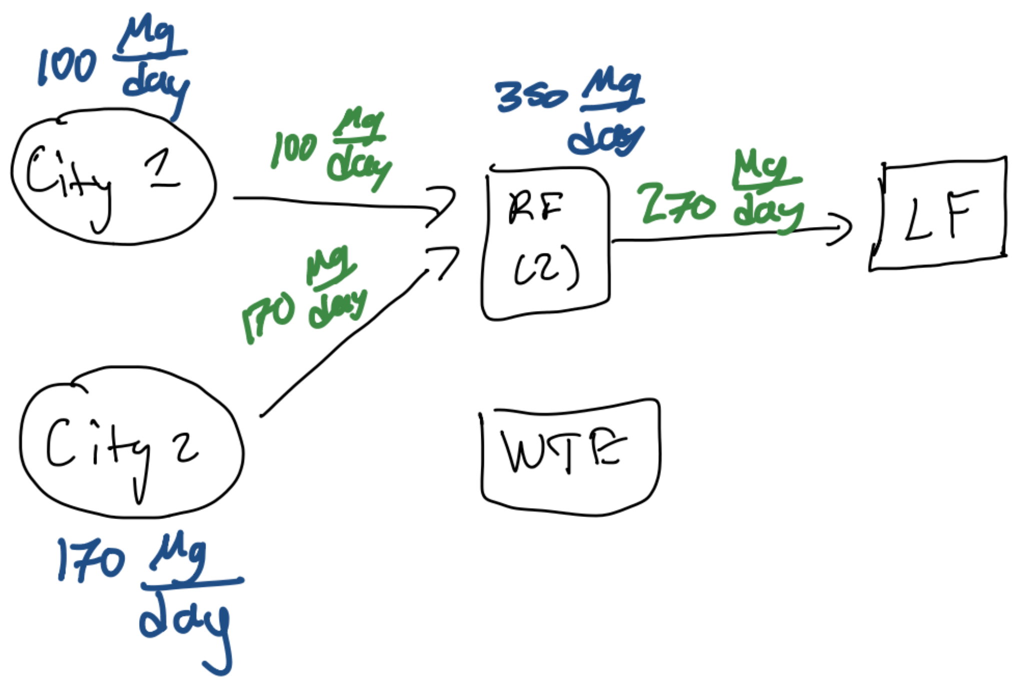
2-dimensional DenseAxisArray{Float64,2,...} with index sets: Dimension 1, 1:3 Dimension 2, 1:3 And data, a 3×3 Matrix{Float64}: 0.0 0.0 0.0 0.0 0.0 167.4 0.0 0.0 0.0

A diagram is below. The distances and positions of the sites are not accurate. The flows are correct. The objective value is 46200.

HW 4 Flow Diagram

Thursday, November 3, 2022 10:42 PM

Model 2: Carbon Tax constraints



References

##include("compile*report.jl") #compile*report("hw4.jmd","html")