

Yeo Ying Xuan 1003835

40.014 Engineering Systems Architecture

Spring 2020

Lecture 18 Activity

Q1

Formulate the problem as a Multi-Objective Linear Program (specify decision variables, objective functions and ALL constraints). Attach a screenshot of the formulation page after you have completed it.

$$\min f(x) = [f_1(x), f_2(x), f_3(x)]$$

$$= [0.52 x_1 + 1.4 x_2 + 2.1 x_3 + 4.51 x_4,$$

$$0.2 x_1 + 4 x_2 + 1.2 x_3 + 0.3 x_4,$$

$$0.03 x_1 + 0.08 x_2 + 0.1 x_3 + 0.06 x_4]$$

$$\text{s.t. } x_1 + x_2 + x_3 + x_4 \geq 250\,000$$

$$0 \leq x_1 \leq 70\,000$$

$$0 \leq x_2 \leq 100\,000$$

$$0 \leq x_3 \leq 120\,000$$

$$x_4 \geq 0$$

where $x^T = [x_1, x_2, x_3, x_4]$ is a vector of four decision variables representing groundwater, surface water, imported water and desalinated water.

Name of the problem

WaterSupplyPortfolioPlanning

Description of the problem

Minimise the use of energy, chemicals and manpower while meeting all constraints

Objective functions

Name	Function	Ideal Criterion Vector (estim.)	Nadir (estim.)
Min Energy	$0.52*x1 + 1.4*x2 + 2.1*x3 + 4.51*x4$	0.0	848200.1
Min Chemicals	$0.20*x1 + 4*x2 + 1.2*x3 + 0.3*x4$	0.0	384091.0
Min Manpower	$0.03*x1 + 0.08*x2 + 0.1*x3 + 0.06*x4$	0.0	250000.0

Starting points and bounds of the variables

variable	lower bound	<= starting point	<= upper bound	Integer values
x1	0	<= 1000	<= 70000	No
x2	0	<= 1000	<= 100000	No
x3	0	<= 1000	<= 120000	No
x4	0	<= 1000	<= 5000000	No

No nonlinear constraint functions defined

Linear constraint functions

Name	Function
No1	$-1 * x1 - 1 * x2 - 1 * x3 - 1 * x4 \leq -250000$

Q2

What is the value of the objective functions obtained at the first iteration?

Energy x1 = 529057.5

Chemicals x2 = 211623.0

Manpower x3 = 17892.56

Q3

For each iteration, report the selected alternative(s) and the corresponding classification for each objective function. For the second iteration, attach a screenshot of the “Analyse Results” page and visualize the alternatives using bar charts (attach screenshot as well).

1st Iteration

Classification of Objective Functions

Function	Current solution	Class:	<	<=	=	>=	>
Min Energy	529057.5		<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Min Chemicals	211623.0		<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Min Manpower	17892.56		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>

2nd Iteration

Selected Alternative

☒ **Alternative3** : Energy : 384091.0
Chemicals : 384091.0
Manpower : 18824.82

Classification of Objective Functions

Function	Current solution	Class:	<	<=	=	>=	>
Min Energy	384091.0		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Min Chemicals	384091.0		<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Min Manpower	18824.82		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>

Function	Lowest Value	Highest Value
Min Energy	0.0	800000.0
Min Chemicals	0.0	384091.0
Min Manpower	0.0	250000.0

Upper and lower bound functions

Enter boundary values

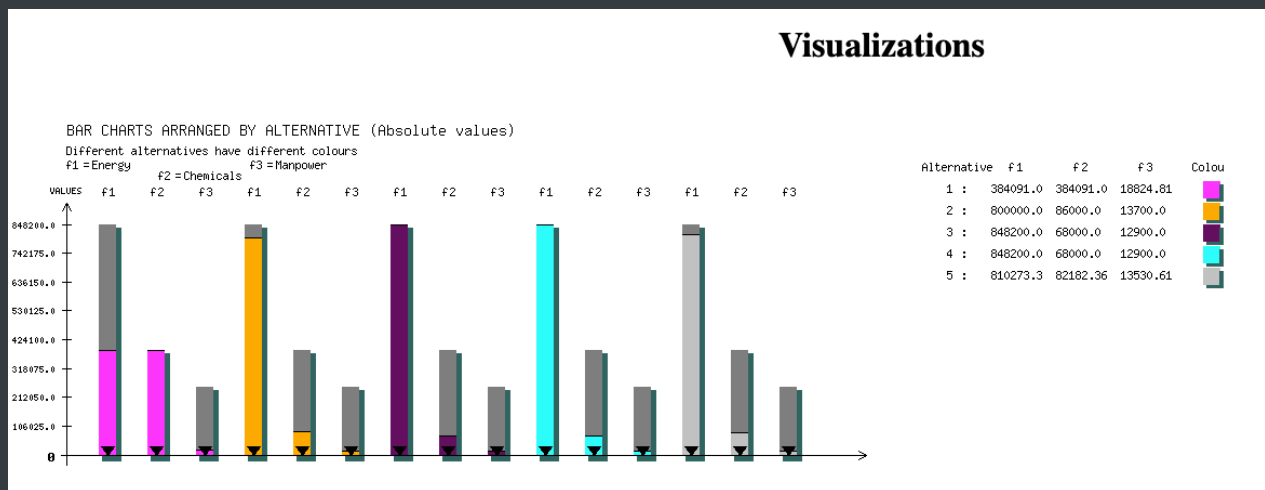
Min Energy 384091.0 <= 800000 <= 848200.1

Select operation

- ☐ Another problem
- ☐ Remove a saved problem
- ☐ Correct Highest or Lowest values
- ☐ Save the current problem
- ☒ Calculate a new solution (continue)
- ☐ Show the whole problem

3rd Iteration

Visualisation



Selected Alternatives

- ☒ **Alternative1** : Energy : 384091.0
Chemicals : 384091.0
Manpower : 18824.82
- ☒ **Alternative2** : Energy : 800000.0
Chemicals : 86000.0
Manpower : 13700.0

Generate a solution between the two alternatives in the next iteration.

4th Iteration

Selected Alternative

✓ **Alternative5** : Energy : 716817.4
Chemicals : 145614.3
Manpower : 14725.03

Q4

For the last iteration, report the value of objective functions and decision variables. Provide a brief description/interpretation of your results.

The final solution is

Function name	Value
Energy	716817.4
Chemicals	145614.3
Manpower	14725.03

Variable name	Value
x1	70000.0
x2	11246.51
x3	40002.46
x4	128751.0

All groundwater available is used.

Only a fraction of surface and imported water is used.

Main source of water is desalinated water, hence the high energy usage.