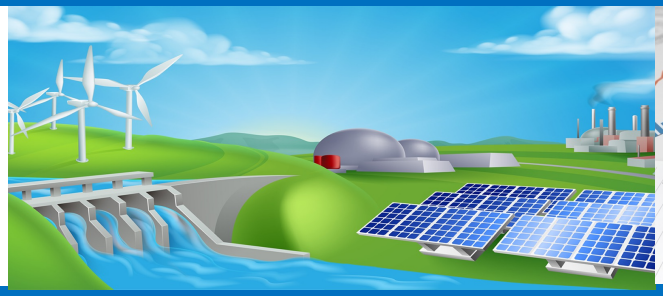


MODELING FOR ENERGY SYSTEMS

Labs 5&6- LPs in Python with Pyomo and glpk

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Agenda

- Quiz #6
- Recall matrix/vector notation versus indexed set notation
- Recall UDFs and Loops in Python
- Finish script for Lab 5
- Explore script for Lab 6

LP Formulation

Maximizing profits in the chemical solutions' production plant

$$\max_{x_1, x_2} \quad z = \$800\, x_1 + \$600 x_2$$

$$s.t. \quad 4x_1 + 2x_2 \leq 60$$
$$2x_1 + 4x_2 \leq 48$$
$$x_1, x_2 \geq 0$$

where

z: *profits*

x_1: *number of units of water heater type 1 to produce*

x_2 : *number of units of water heater type 2 to produce*

LP Formulation

Maximizing profits in the chemical solutions' production in **standard matrix/vector form**

$$\max_{x} \quad z = cx$$

$$s.t. \quad Ax \leq b$$

$$x \geq 0$$

where

$$A = \begin{bmatrix} a_{1,1} & a_{1,2} \\ a_{2,1} & a_{2,2} \end{bmatrix} = \begin{bmatrix} 4 & 2 \\ 2 & 4 \end{bmatrix} \qquad b = \begin{bmatrix} b_1 \\ b_2 \end{bmatrix} = \begin{bmatrix} 60 \\ 48 \end{bmatrix}$$

$$c = [c_1 \quad c_2] = [800 \quad 600] \qquad x = \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

Final Formulation

$$\max_{x_1, x_2} \quad z = c_1 * x_1 + c_2 * x_2$$

$$s.t. \quad a_{1,2} * x_1 + a_{1,2} * x_2 \leq b_1$$

$$a_{2,2} * x_1 + a_{2,2} * x_2 \leq b_2$$

$$x_1, x_2 \geq 0$$

Set notation

$$Ax \leq b$$

$$\begin{aligned} a_{1,1} * x_1 + a_{1,2} * x_2 &\leq b_1 \\ a_{2,1} * x_1 + a_{2,2} * x_2 &\leq b_2 \end{aligned}$$

$$a_{j,1} * x_1 + a_{\mathrm{j},2} * x_2 \leq b_{\mathrm{j}} \quad for\ j = 1,2$$

$$\sum_{i \in I} a_{j,i} * x_i \leq b_{\mathrm{j}} \quad for\ j \in J$$

Indexing elements by set

Sets:

$m \in M$: *set of machines A and B*

$p \in P$: *set of water heater types I and II*

Parameters:

$a_{m,p}$: *number of hours on machine* m *needed to produce water heater type* p

H_m: *number of hours available on machine* m

C_p: *profit gained from producing water heater type* p

Decision Variables:

x_p: *number of units of water heater type* p *to produce*

LP formulation using set index

$$\max_{x} \quad \sum_{p \in P} c_{\mathrm{p}} * x_{\mathrm{p}}$$

$$s.t. \quad \sum_{p \in P} a_{m,p} * x_p \leq \mathrm{H_m} \quad \forall \mathrm{m} \in M$$

$$x_p \geq 0 \quad \forall \mathrm{p} \in P$$

UDFs in Python

- In python you define an UDF using def keyword, followed by the function name

```
def function_name(argument1, argument2,…) :
    statements
    …
    return output
```

- Arguments are the inputs and could be a number or variable
- Could also have optional argument that take a default value if not specified
- Statements are the action to be performed in order to get the output
- Output may be numeric or string

Dictionaries in Python

- Similar to a list because it's also a collection of elements
- Dictionaries are associative arrays
  - Maps a key to its associated values
- Structure

```
d = {
    <key> : <value>,
    <key> : <value>,
    …
}
```

For loops in Pyhton

- Used when you need to iterate over an index
- Structure

```
for counter in set/range:
    statements
    …
```