Determining the Optimal Transmission System Usage Contracts for a Distribution Company

THE UNIVERSITY OF TEXAS AT AUSTIN

CAPES

IEEE PES Power & Energy Society®

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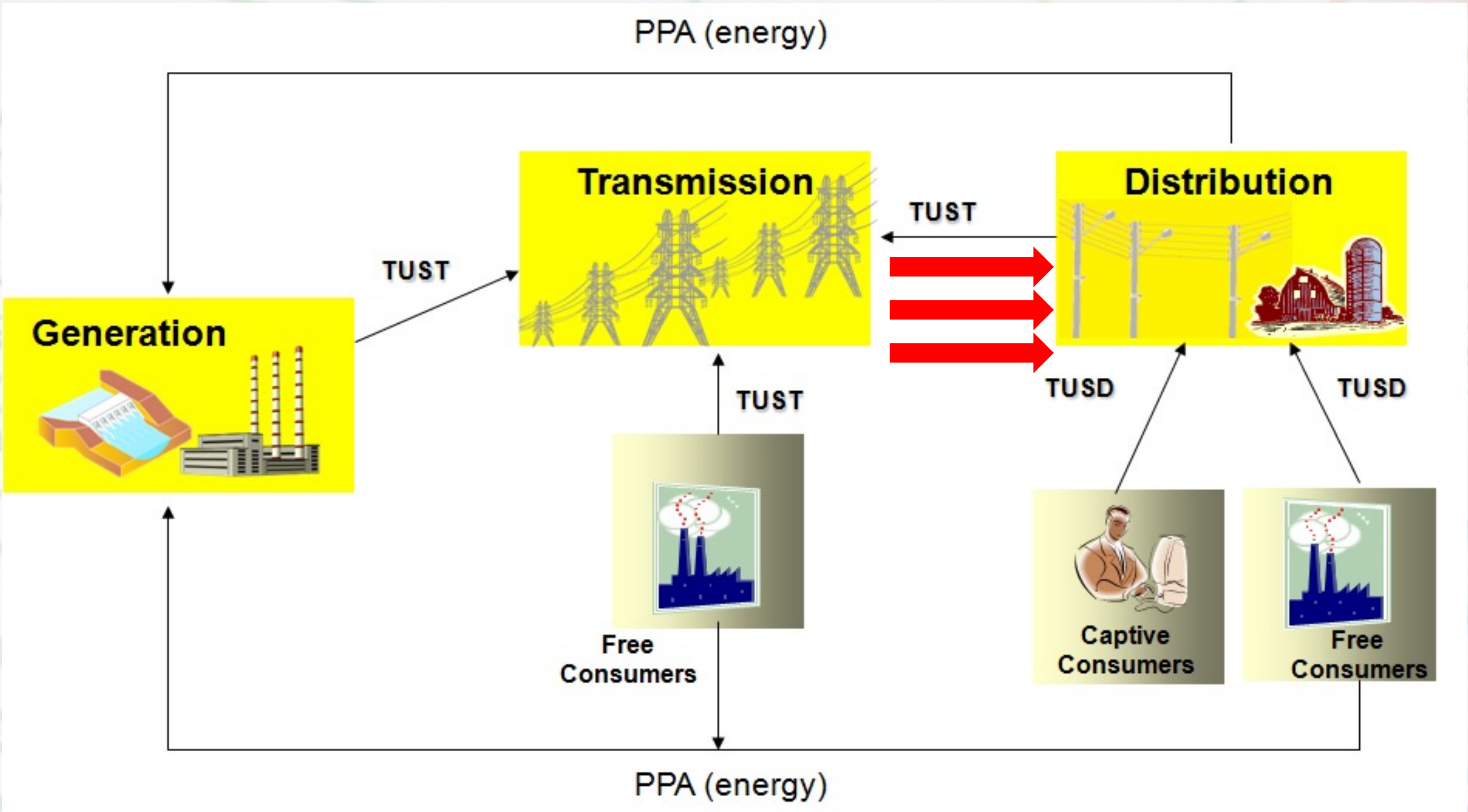
Light

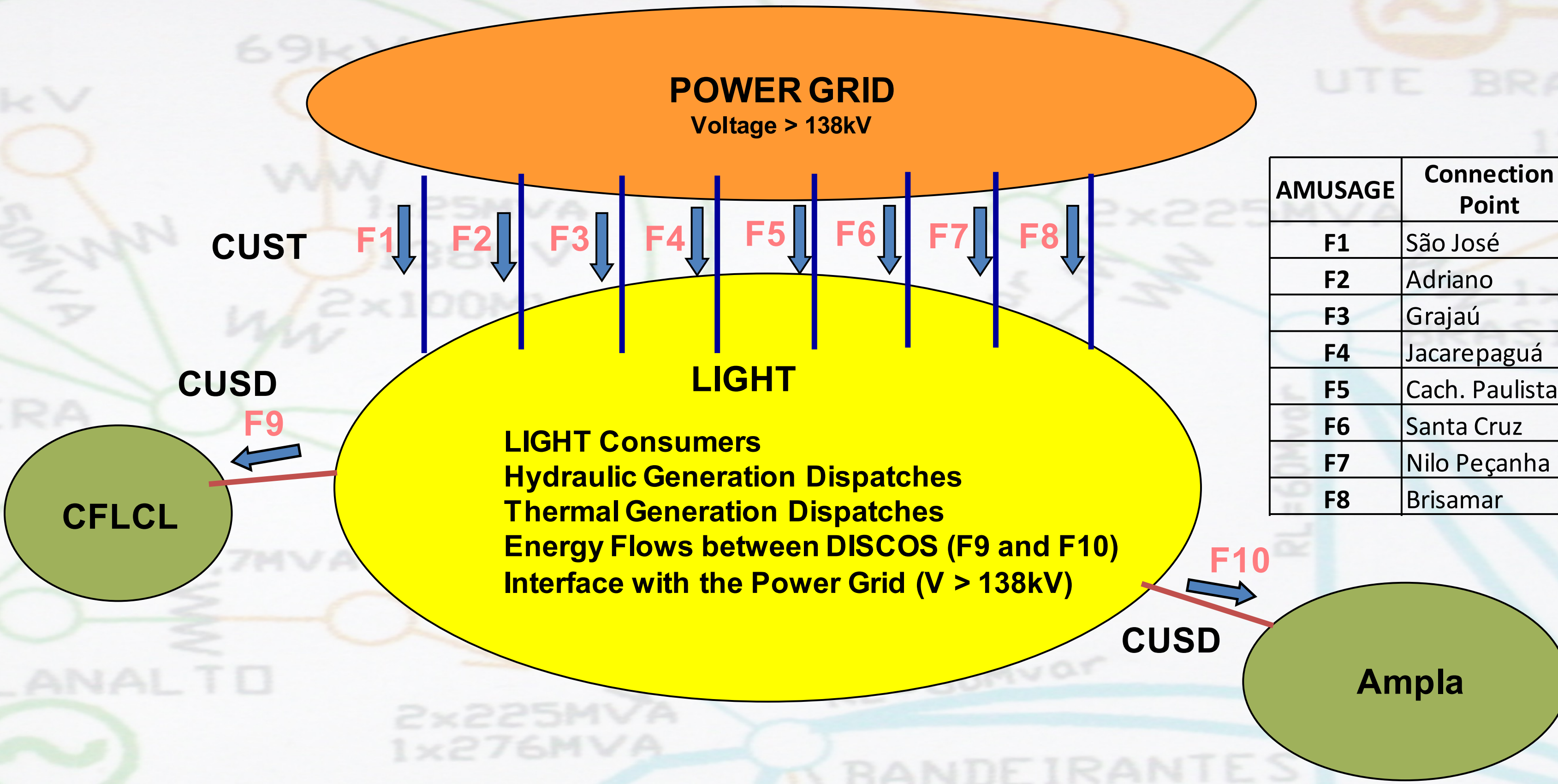
Minneapolis - 29th July 2010

Introduction



- ***The monthly transmission system usage*** has to be contracted by the DISCO for each connection point with the TRANSCO grid.

Problem Description - Light DISCO



AMUSAGE	Connection Point
F1	São José
F2	Adriano
F3	Grajaú
F4	Jacarepaguá
F5	Cach. Paulista
F6	Santa Cruz
F7	Nilo Peçanha
F8	Brisamar

84 Substations
02 Small Discos Connected
11 Power Generators
Large Distribution Grid

Proposed Methodology

- Because of the ***large number of substations*** (84) and the ***correlation*** existent among them, it is used a ***clustering method*** to reduce the size of the problem.

- Generate the probability density function for the power flow at each grid connection using ***Monte Carlo Simulation***.

- ***Stochastic optimization*** is used in order to determine the optimal amount to be contracted at each connection point.

Problem Formulation I - MILP

$$\min \quad |M| * \sum_{i \in I}(t_i * x_i) + \sum_{i \in I}(3 * t_i * \sum_{m \in M} P_{im}) \qquad (III)$$

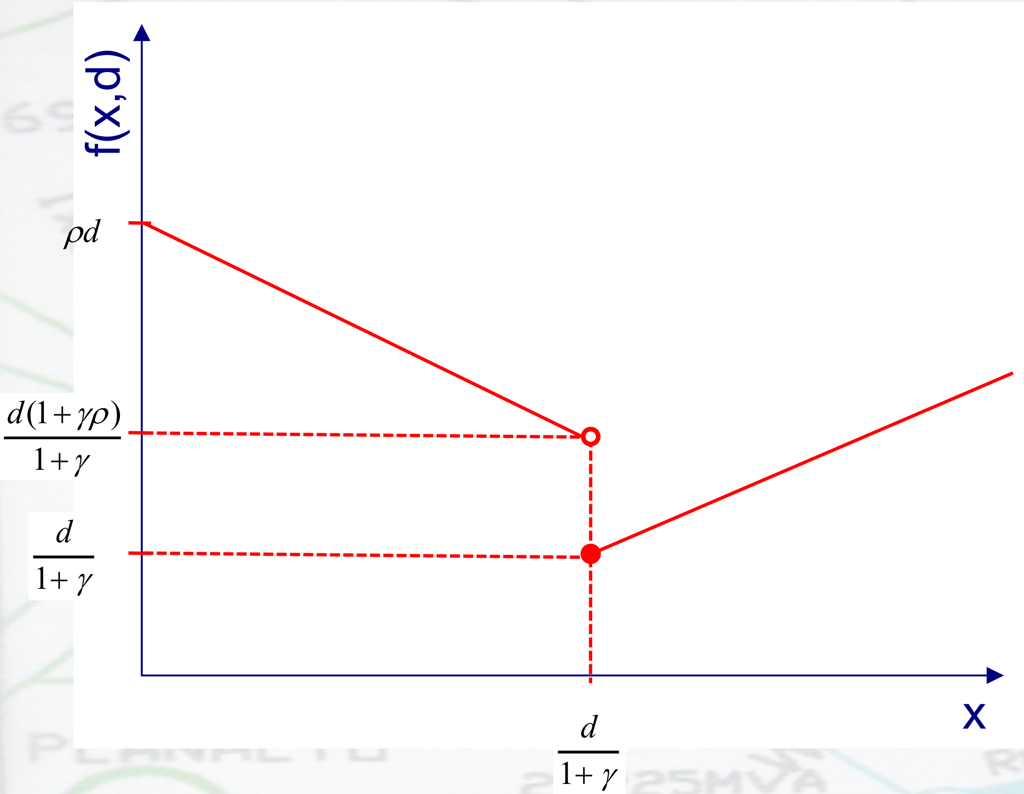
$$S.t. \quad C * y_{im} \geq d_{im} - 1.05 * x_i \qquad \forall\, i \in I, \forall m \in M \qquad (III.1)$$

$$P_{im} \geq d_{im} - x_i - C * (1 - y_{im}) \qquad \forall\, i \in I, \forall m \in M \qquad (III.2)$$

$$P_{im} \geq 0, x_i \geq 0, y_{im} \in \{0,1\} \qquad \forall\, i \in I, \forall m \in M \qquad (III.3)$$

- **Huge size**! (192,008 Variables and 288,000 Constraints)
- Simulate ***only one scenario*** with deterministic substation demands
- In this case ***will not depend on cluster analysis***, because we don't generate demand scenarios
- Usefull for ***specific study cases***

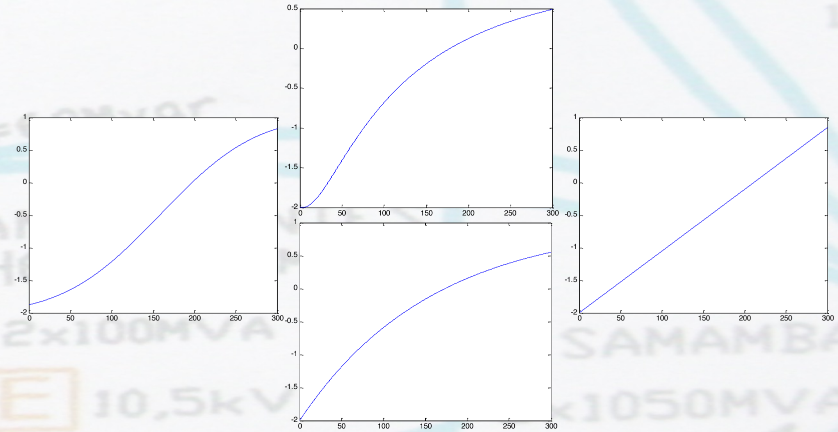
Problem Formulation II - Bisection



$$f(x) = \begin{cases} x & if \quad \frac{d}{(1+\gamma)} \leq x \\ x + \rho(d-x) & if \quad \frac{d}{(1+\gamma)} \geq x \end{cases}$$

Expected Value Function seems to be **continuous** for some distributions.

- Derivative of the function is increasing. The function is Convex for: ***(Normal, Exponential, LogNormal, Uniform)***



Problem Formulation II - Bisection *(cont)*

$$f(x) = cx + \rho c \cdot \left[\int_{(1+\gamma)x}^{\infty} (u - x) \cdot \phi(u) du \right]$$

Solve it by parts

$$f(x) = cx + \rho c \cdot [\int_{(1+\gamma)x}^{\infty} u\phi(u) du - x \int_{(1+\gamma)x}^{\infty} \phi(u) du]$$

It does not depend on c
Just a constant

$$f(x) = cx - \rho cx - \rho cx\gamma \cdot \Phi[(1+\gamma)x] - \rho c \int_{(1+\gamma)x}^{\infty} \Phi(u) du]$$

$$f'(x) = 1 - \rho - \rho\gamma \cdot \Phi[(1+\gamma)x] - \rho x\gamma(1+\gamma)\phi[(1+\gamma)x] + \rho(1+\gamma)\Phi[(1+\gamma)x]$$

Setting the derivative = 0 →

$$0 = 1 - \rho - \rho x\gamma \cdot (1+\gamma) \cdot \phi[(1+\gamma)x] + \rho \cdot \Phi[(1+\gamma)x]$$

Dividing by ρ and using real values →

$$\Phi[(1+\gamma) \cdot \mathrm{x}] = 1 - 1/\rho + \mathrm{x} \cdot \gamma \cdot (1+\gamma)\phi[(1+\gamma) \cdot \mathrm{x}]$$

$$\Phi[(1.05) \cdot \mathrm{x}] = 2/3 + 0.0525 \cdot \mathrm{x} \cdot \phi[(1.05) \cdot \mathrm{x}]$$

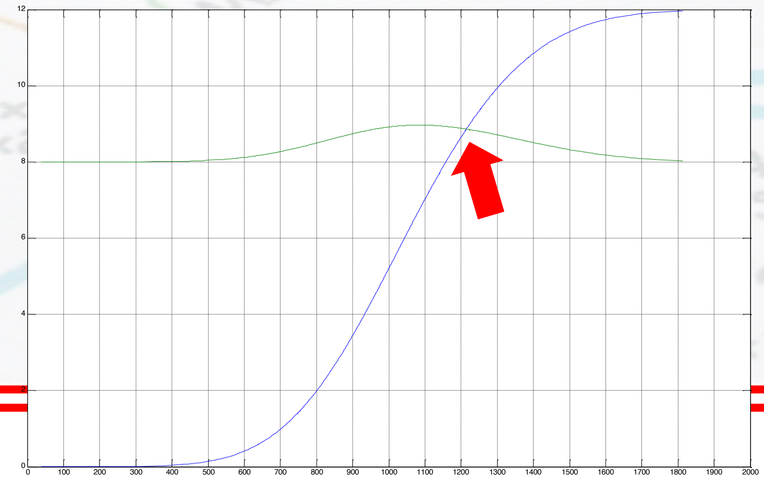
Problem Formulation II - Bisection *(cont)*

- Independence over months.

$$\sum_{m=1}^{12} \Phi_m[(1.05)\cdot \mathrm{x}] = 8 + 0.0525\cdot \mathrm{x}\cdot \sum_{m=1}^{12} \phi_m[(1.05)\cdot \mathrm{x}]$$

- Also independence over connection points.

$$\left(\sum_{m=1}^{12} \Phi_{im}[(1.05)\cdot \mathrm{x_i}]\right) = \left(8 + 0.0525\cdot \mathrm{x_i}\cdot \sum_{m=1}^{12} \phi_{im}[(1.05)\cdot \mathrm{x_i}]\right)$$



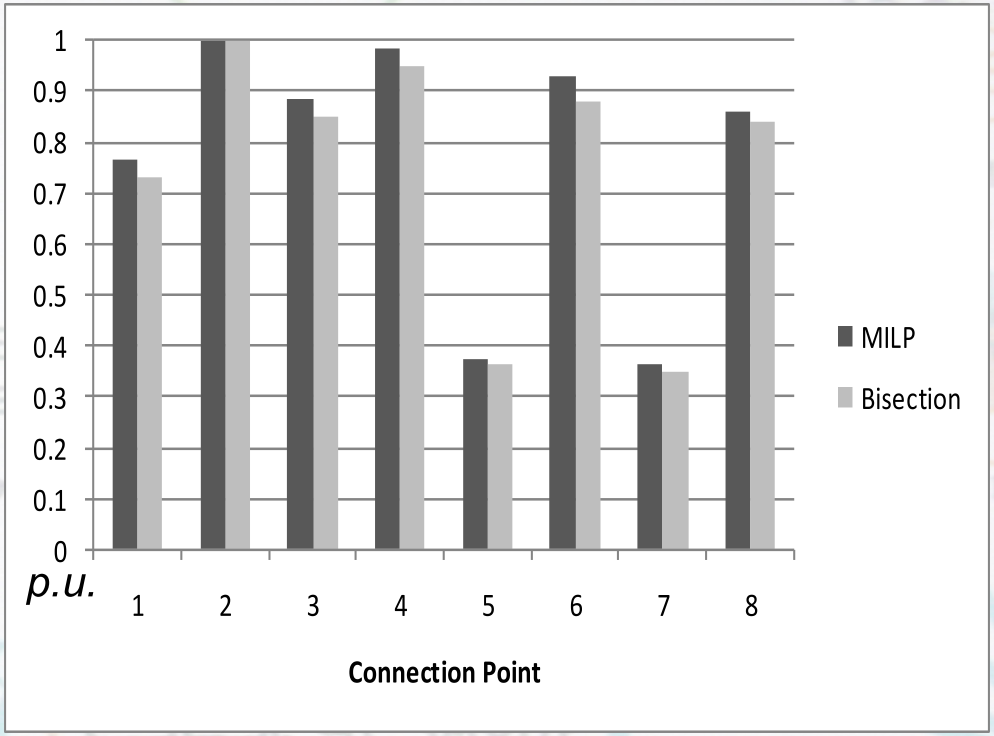
Results Obtained

Results Obtained with MILP Model

x_i [MW]		t_i [R$/kW.month]	TC_i [R$/ano]
S. Jose 138kV	1.111,17	4,765	63.536.757,78
Adriano 138kV	1,51	4,752	86.334,34
Grajau 138kV	1.491,31	4,819	86.239.185,54
Jacarepagua 138kV	658,23	4,838	38.214.142,82
C. Paulista 138kV	99,47	4,668	5.571.743,47
Sta Cruz 138kV	101,32	4,798	5.833.830,62
Nilo Peçanha 138kV	35,75	4,802	2.060.173,25
Brisamar 138kV	72,81	4,776	4.172.886,72

Results Obtained with Bisection Method

x_i [MW]		t_i [R$/kW.month]	TC_i [R$/ano]
S. Jose 138kV	1.157,51	4,765	76.433.020,88
Adriano 138kV	1,51	4,752	86.106,24
Grajau 138kV	1.553,58	4,819	100.842.107,62
Jacarepagua 138kV	684,67	4,838	46.232.508,41
C. Paulista 138kV	103,06	4,668	7.419.053,35
Sta Cruz 138kV	105,49	4,798	6.490.627,97
Nilo Peçanha 138kV	37,09	4,802	3.449.105,04
Brisamar 138kV	75,49	4,776	5.159.686,37



Summary & Conclusions

- Presented the ***Transmission System Usage*** problem
- A ***methodology was created*** and used to help the decision maker at the moment to ***settle contracts***
- The applied methodology uses:
  - ***Real Data*** from Substation Demands
  - ***Clustering Analysis*** to group the substations
  - ***Monte Carlo*** to generate demand scenarios
- Two ***problem formulations*** are proposed
- It ***can help*** the ***decision makers*** to find the ***best way to contract***

Thank you!