



Clustering Electric Load Curves: The Brazilian Experience Workshop Franco-Brasileiro sobre Mineração de Dados Workshop Franco-Brésilien sur la Fouille des Données

José Francisco Moreira Pessanha (CEPEL / UERJ) francisc@cepel.br Luiz da Costa Laurencel (UERJ / UFF) getlecl@vm.uff.br

Introduction



- The Brazilian electric power sector adopts tariffs based on marginal cost pricing since 1980.
- The electricity tariffs are calculated by a methodology, whose origin is the Electricité de France (EDF) and the French 'marginaliste' economists like Allais and Boiteux.
- In this methodology, an important step is the identification of a few typical daily load profiles from a set of electric load curves measurements on a sample of customers.
- These profiles represent patterns of energy use of different class of customers e.g. residential, commercial, industrial, rural, public lighting, public administration etc.
- The standard way to identify the typical load profile from a sample of load curves is to perform a clustering of the representative workday load curves. The centroid of each cluster defines a typical load profile.
- This work presents a brief history about the softwares for identifying of typical daily load profiles developed in the Brazilian electric power sector.
- In order to tell this history we present the features of three softwares that have been used by the Brazilian electric distribution utilities.
 WFB2009

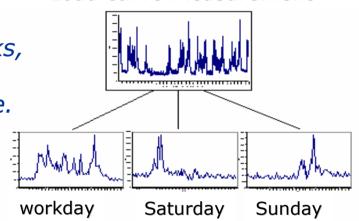
Procedure to identify typical load profiles



- 1) Select a sample of customers (or power transformers)
- 2) Get a load curve measurement from each customer

The load curves measures cover a period of two weeks, where the demand is recorded every 15 minutes by recording meters installed at each point in the sample.

3) Examine the load curve measurement (kW) of each customer in order to identify its three representative load curves (workday, Saturday and Sunday)



Load curve measurement

4) Apply a clustering technique to group customers with similar workday load curves (each daily curve has 96 points). After that, take the typical load profiles from each cluster

Sample of workday representative load curves $\begin{bmatrix} 1 & 1 & 1 & 1 \\ 0 & 1 & 1 &$

5) Derive typical load profiles for the entire population



We select a representative sample of three softwares for identifying of typical load profiles used in the Brazilian electric power sector.

• SNACC (1991) Sistema Nacional de Avaliação do Comportamento da Carga National system of evaluation of the load behavior

• TARDIST (1998)

Programa para cálculo dos custos marginais de fornecimento e tarifas de uso da distribuição *Computational program for computing the supply marginal costs and distribution tariffs*

• ANATIPO (2005)

Sistema computacional para construção de tipologias de curvas de carga Software for building typical load curves

SNACC Program (1991)



It was the first software for clustering load curves developed in the Brazilian power sector.

It was developed by the National Department of Waters and Electric Power (DNAEE).

DNAEE was officially closed upon the establishment of the Brazilian Electricity Regulatory Agency (ANEEL).



The SNACC employs the methods of cluster analysis programmed in two computational routines in Fortran brought from the Electricité de France (EDF): NUDYC (*nuées dynamique*) and DESCR2 (Ward method).

• Molliere, M. Um ensemble de modules de classification automatique et de modules explicatifs associes, Note EDF, Direction des etudes et Recherches nº HI 2818/02, 1978.

• BRASIL, Ministério das Minas e Energia, DNAEE, Eletrobrás, Empresas Concessionárias de Energia Elétrica, Nova Tarifa de Energia Elétrica: metodologia e aplicação, DNAEE, Brasília,1985. **WFB2009**

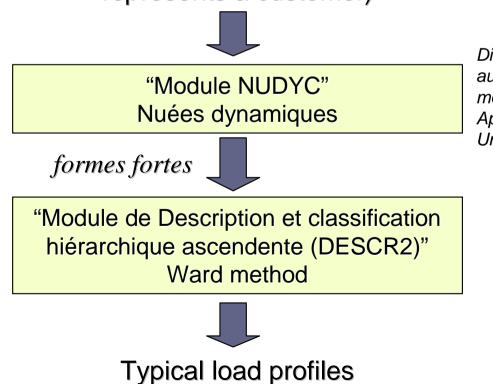
SNACC Program (1991)



The NUDYC and DESCR2 routines are executed sequentially:

first the typical workday load curves are clustered by the "*nuées dynamique*" programmed in the NUDYC routine, then the *formes fortes* are clustered by the Ward method programmed in the DESCR2 routine.

Set of workday load curves (each load curve has 96 points and represents a customer)



Diday, E. Une nouvelle méthode em classification automatique et reconnaissance des formes. La méthode des nuées dynamiques. Revue de statistique Appliquée, 1971, vol. XIV nº 2. Institut de Statistique. Université de Paris.

SNACC Program (1991)



- 8 × C:\SNACC\SNACC.EXE S N A C C Sistema Nacional de Avaliacao do Comportamento da Carga DNAEE 29/04/09 MMF 17:03Relatorios Utilitarios Finalizar Arquivos Parametros Executar Graphical outputs are very useful for the Cadastro Consumidores Backup das Medicoes load curve analysis, but the SNACC does not Movimento Consumidores show graphs of load curve measurements Todos Arquivos Acima and typical load profiles. The identification of the typical profiles requests a visual analysis of a large number of load curve measurements. It is the heaviest work stage and the main critical step in the computation of distribution tariffs. In order to overcome this deficiency, in 1998 the Brazilian Electric Power Research Center (Cepel) developed the TARDIST program

Mensagem 🕨 🛛 Para selecionar a opcao tecle <ENTER> ou <ESC> para sair



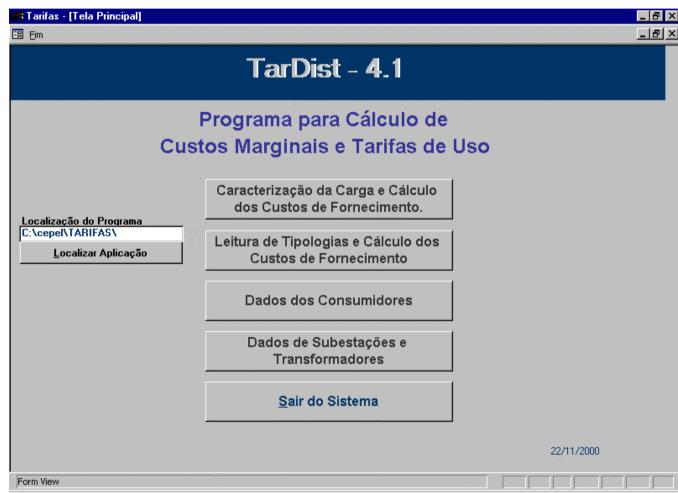
WFB2009

Software developed by the Brazilian Electric Power Research Center (Cepel) to compute the distribution tariff framework based on marginal cost.

TARDIST also has a module to build typical load profiles, but it has a friendly user interface.

The software is used by the Brazilian Electricity Regulatory Agency (ANEEL) to set the distribution tariff.

Pessanha, J.F.M., Huang, J.L.C., Pereira, L.A.C., Passos Júnior, R., Castellani, V.L.O. Metodologia e sistema computacional para cálculo das tarifas de uso dos sistemas de distribui»cão, XXXVI SBPO, São João del Rey - MG,2004.



TARDIST program (1998)

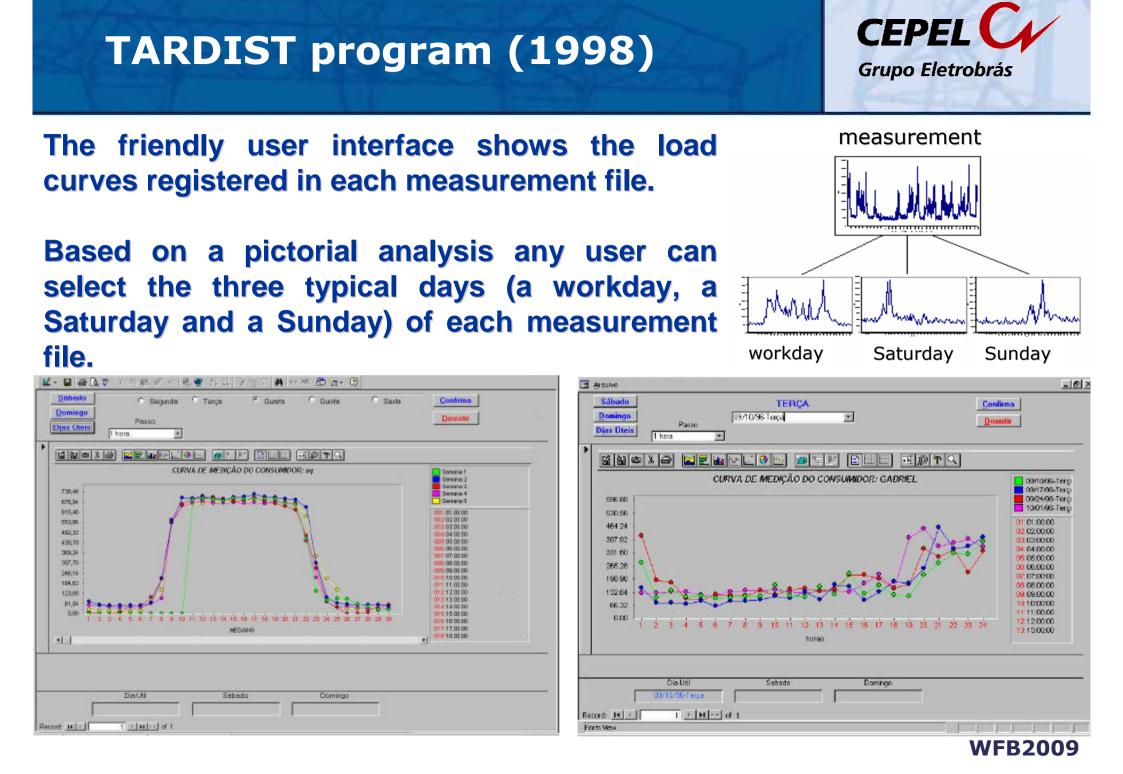


Input data:

- List of costumers and electric power transformers in the sample.
- Load curves measurements files (Excel or text format) for each sample point
- Annual energy demand (MWh) for each consumption class and energy flows (MWh) among the voltage levels.

🖉 Microsoft Access - [Definiçã	io do Caso]		_ 8 ×	8007	73&DQ - Bloco de notas	
🖪 <u>A</u> rquivo			_ <u>= </u> = ×		Editar Eormatar Exibir Ajuda	
	Definiçã Escolha do Caso	O do Caso ⊻oltar Novo Novo SENDI_caract ■		1000000 0798151 00000001 2308002 1307982 SALV001 SALV002 SALV002	20000000000000000000000000000000000000	00000000145900091200000000000000000000000000000000
Caso 52 SE	ENDI_caract	Descrição do Caso		SALV004 SALV005	.4 000300030797000300040798000200030799000 15 000500050791000400050793000500050791000	030004 08000003 0003 07960003 0004 08000003 0003 0802 0003 0004 0802 0002 0003 07990003 0 050004 07890004 00050784 0004 0005077800050004 07770004 00050773000500060774 00060
P.U. Máximo	.9	Caso de caracterização para SENDI	7	SALV006 SALV007 SALV008 SALV010 SALV010 SALV012 SALV012	6 0006000507/0000700067/70000700067/3000000575 7 00050006075700060050756000507500057830006076200 8 000600060781000500050783000500060783000 0 0011004077200004047700120004077001 1 00080030778000700033780004100050778000 2 00150003077900040055078800400050778000 1 0003004078300020033779000500030780004	000000000000000000000000000000000000
		Inclui Todos Clientes Clientes	<u>-</u>	SALV014 SALV015 SALV016 SALV017 SALV018 SALV019 SALV020	L6 000400050795000300050794000400050794000	14 000507930004 00050794 0003000507970003 00050796000500050794 00050005079600080
1 - Receita Requerida	2 - <u>S</u> ubgrupos Tarifários			SALV021 SALV022 SALV023 SALV024	0 000500407740009004077300100040773001 2 0011000407740009004077300100040773001 2 0011004077900060005078000120040782000 3 0006003077800040030777000700020774001 4 003000407740007004077900030050777000	9000607990011.0007077101018000507740013000507780004600707713005100607720005 50000575900050060767000500500771000500060772100510006771000500060772 6000510710008006077300120005077100150006077100110005077100080060722005 6000510771000500050780000400230782000900020780001574000500050057740005000607 3000307720005000578000040033078200090002078000157400050050057540005000507750005 40004077700050005078000040033782000900020780001500507800050057540005000507550004 400047780005000507800050050782000500050782000500050780005005078000500575000500 40004778000500507800050050780005005078000500507800050050780005005078000500575000500 4000477800050050780005005078000500507800050050780005005078000500575000500 40005079300050057800050050780005005078000500507800050057800050057800050057500050057 30003074000200507800050050780005005078000500050780005005770002004478000500 3000507800050050780005005078000500507800050005
3 - <u>R</u> edes	4 - <u>P</u> eríodos Hidrológicos	*********************************	-	SALV025 SALV026 SALV027 SALV028 SALV029	5 00040005078200030005078300050050783000 6 000400040791000300050791000400050790000 7 00040005079900050050802000500050801000 8 00030083078300030078500030040785000 0 000400907890050005078500030040785000	$\label{eq:constraint} 400040789003200578700040005378100300053790005300055078900065000537880004600550789000650078500067940005078700030050785000674900050078900780000004004078900080005007870003004004078700030050005078900550055078400500050789005400040787000300507890055005507840050005078900040004178800040004078700030050005078900050005078500050005078400500050789000500050787000000507850005000507850005000$
5 - <u>P</u> ostos Tarifários	6 - Custos Marginais de <u>C</u> apacidade	Record: 14 1 1 1 14 14	.	SALV030 SALV031 SALV032 SALV033 SALV033 SALV034	0 000500060762001200060759002300060760001 1 00050006076400060060765000500060762000 0005000607700008006076500050007761001 3 001600040762001700040758001100030762002	.6006667600228005576902200667720012000807720070006077100660006077100060 3000607620050007076500050006076500060006075700050007076600050005
7 - Custos Marginais de <u>E</u> nergia	8 - <u>F</u> ator de Perda	Inclui Todas as Redes Redes		SALV034 SALV035 SALV036 SALV037 SALV038	4 000500030/1000400030/700010020/70000 5 001000307750005000307760030030771001 6 001100030769002000040778002900040779001 7 000900050779001300070781001300040783000 8 0015005079100130005079300140050795001	4000307730050003077400200030775002000307730093003077300200030773002000307750020000000000
9 - <u>M</u> ercado Período Hidrológico	10 - <u>C</u> lasse dos Consumidores	>> *SE A3 /A411 - A3 A4 >> *SE A3 /A412 - IA3 A4		SALV039 SALV040 SALV041 SALV042 SALV043		.20040778300800657786001100577830011004078000880057758001400577800090 400507850040057880015005078760050004078700404000578900404040147870044 300050785004005788001400607750040004078600040057750025005077500300407870004 40066750004004005675200400606775004400057610040060773004500867750044
11 - Relação Entre Postos Tarifários	12 - <u>C</u> lientes-Tipo	>> *SE A3 /A413 A4		SALV043	10040030771003000077100400030783000	10040/400040020/500040000/910040020/210040060/920040000/32004
13 - Redes-Tipo	14 - <u>C</u> MF e TUSD	>> *SE A3 /A414 _A3 A4 >> *SE A3 /A415 _A3 A4				
15 -Tarifa de Uso	16 -Arquivo de Resultados	→ *SE A3 /A4 16 Record: 1 1 1 1 1 1 1 1 1 1 1 1 1				

load curve measurement file





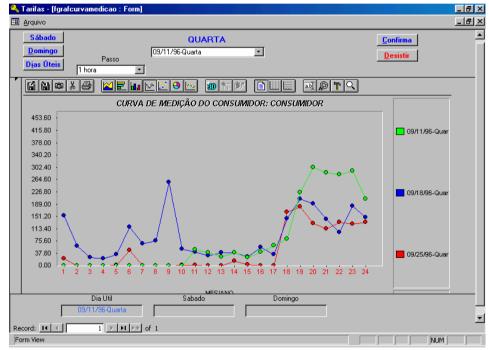
TARDIST employs only the Ward method to cluster the workdays load curves.

The user can change the clusters' composition, in order to correct any misclassification made during the clustering process.

TARDIST shows the following results useful to set the number of cluster (typical load profiles):

- Load profiles plots for each cluster
- Share (%) of each cluster in the energy consumption

 Within Sum Squares (WSS) and Between Sum Square (BSS).



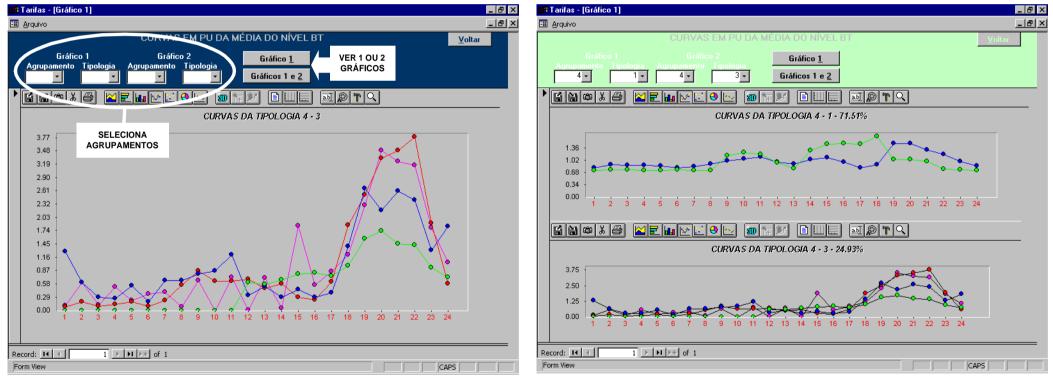
TARDIST program (1998)



The software shows the load curves classified in each cluster.

One cluster

Two clusters





Software developed by Cepel to Cosern (Companhia Energética do Rio Grande do Norte) in its R&D Program.

Purpose: To identify typical load profiles from a sample of load curves measurements.

Main characteristics:

- Import load curve measurements (kW) from files in text format or Excel worksheet
- Routine for automatic identification of the typical workday, Saturday and Sunday curves of each measurement file
- Allows data analysis through graphics and reports
- Three clustering techniques: Ward, k-Means and Fuzzy Clustering Method (FCM)
 Pessanha, J.F.M., Castellani, V.L.O., Araújo,
- User friendly graphical interface
- Output reports (text format and Excel)

Pessanha, J.F.M., Castellani, V.L.O., Araújo, A.L.A. Uma nova ferramenta computacional para construção de tipologias de curva de carga, X SEPOPE, Florianópolis - SC,2006.



Sample of customers or electric power transformers

	🕎 Dados do Est	udo de Clientes			inual
	às 🔽 😓	☆ 🌈 🕾 📭			
					nsumption
	⊢ Dados do Estudo			(Iv	IWh)
	Códig	o.: 005 ESTUDO SOBRE CLIENTE	S COMPLETO	Mercado (MWh).:	1000000
	Nível de Tensã	io.: 7 BT	•	Classe de Consumo.: 1 Reside	ncial
	Faixa de Consum	o.: 2 0 à 500 KW	•		
	Clientes				
	Códi	jo Nome	Ativo	Arquivo	▲
Data	005-00001-0	01 Consumidor Número 005-00001-001	Sim	C:\CEPEL\AnaTipo\INPUT\Formato_P	ublico\52733&hb.jod
		02 Consumidor Número 005-00001-002	Sim	C:\CEPEL\AnaTipo\INPUT\Formato_P	
	005-00001-0		Sim	C:\CEPEL\AnaTipo\INPUT\Formato_P	
input >	005-00001-0		Sim	C:\CEPEL\AnaTipo\INPUT\Formato_P	
	005-00001-0		Sim	C:\CEPEL\AnaTipo\INPUT\Formato_P	
	005-00001-0		Sim	C:\CEPEL\AnaTipo\INPUT\Formato_P	
form	005-00001-0		Sim	C:\CEPEL\AnaTipo\INPUT\Formato_P	
form	005-00001-0		Sim	C:\CEPEL\AnaTipo\INPUT\Formato_P	
	005-00001-0		Sim	C:\CEPEL\AnaTipo\INPUT\Formato_P	
		O Consumidor Número 005-00001-010	Sim	C:\CEPEL\AnaTipo\INPUT\Formato_P	
	005-00001-0		Sim	C:\CEPEL\AnaTipo\INPUT\Formato_Pi	
		2 Consumidor Número 005-00001-012	Sim	C:\CEPEL\AnaTipo\INPUT\Formato_P	
V V		3 Consumidor Número 005-00001-013	Sim	C:\CEPEL\AnaTipo\INPUT\Formato_E	
	005-00001-0		Sim	C:\CEPEL\AnaTipo\INPUT\Formato_E	
		5 Consumidor Número 005-00001-015	Sim Sim	C:\CEPEL\AnaTipo\INPUT\Formato_E	
		6 Consumidor Número 005-00001-016 7 Consumidor Número 005-00001-017	Sim	C:\CEPEL\AnaTipo\INPUT\Formato_E C:\CEPEL\AnaTipo\INPUT\Formato_E	
		8 Consumidor Núm p 005-00001-017	Sim	C:\CEPEL\AnaTipo\INPUT\Formato_E	
		18 Consumidor Num p 005-00001-018	5111		
Curt		Customer		File with load curve	
Custo	omer code	Customer name		measurement	WFB200



Reading load curve measurements

load curve measurement file (text format)

🖡 80073&DQ - Bloco de notas

Arquivo Editar Eormatar Exibir Ajuda

			ERRO	ALER	NIMP	DIGI	2925112516593404069
	1307982025	112514112420079830251:	1251413292707	98202511251415	0027079820251125143	31280308982025112	50847021008982025112509021218089
	SALV001	0003000207760000000	0001900000000	000000000000000000000000000000000000000	000000000000000000000000000000000000000	000000000000000000000000000000000000000	000000000000000000000000000000000000000
	SALV002	0004000507910003000	5079200040006	07940004000507	9600040005079300040	00050792000400060	78900060006079000060007079300040
	SAL V003						79300060006079300040005079600040
	SALV004						80200030004080200020003079900030
	SALV005						77700040005077300050006077400060
	SALV005						77600060006077800050006077700050
	SALV000						76700220006077100180006077000060
	SALV007						77400060006078000050005078000060
	SALV009						77900080004077700120005077700120
	SALV010						77800130005077900100004078000080
▼	SALV011						78200100004078700060003078900090
_	SALV012						78100110005078000270004077900040
	SALV013						78400020003078100030003078000020
	SALV014						79700030003079500030004079800020
	SALV015						78200030004078400030003078500020
	SALV016						79600050005079400050005079600080
	SALV017	0005000607830005000	6078000050006	07830005000607	7900050006078000050	00050774000500060	77000050006077400050006077500050
	SALV018	0006000607680005000	6077000050007	07710019000607	6900110007077100180	00050774001300050	77600040007077300050006077200050
	SALV019	0005000607600005000	5076000050006	07600005000507	5900050006076700050	00050771000500060	77200050006077100050005077000050
	SALV020	0005000407760005000	5077200110005	07700016000507	7100080006077500120	00050775000500060	77300110005077500080006078200060
	SALV021	00150004077400090004	4077300100004	07700011000407	7600100003078000100	00040776000900040	77600160004077700060004077600080
	SALV022						78200050003078400050003077900130
	SALV023						78000110003078100050003078500040
	SALV024						78200040005079000050006078500040
	SALV025						79000050005078900060005078800040
iT p	SALV026						79800030005078800030005078700030
	SALV027						78900040004078900040004078700040
IK BJ	SALV028						78500030003078700020004078600030
<u>si</u>	SALV020						77900050006077700050006076900050
	SALV029						77200070006077100060006077000060
4_ \	SALV030						76700050007076600050006076800050
0_	SALV031						
9_ \ \							76300140007076600050005076800140
0_ \	SALV033						77100140004076300170003076400170
1	SALV034						77300090003077100060003077600040
4	SALV035						77600030003077500030003078000140
	SALV036						78200100005078500120004078300100
	SALV037						77800100004077700120005077800120
	SALV038						78800090005078800130004078500090
1	SALV039						78000080005078800140005078900090
	SALV040						78700040005078900040004078700040
	SALV041						78600030005077500030004076900040
	SALV042	0006000507730025000	6077100100006	07720020000407	6900140006077100080	00080775000400060	77300050005077200040006077300040
	SALV043	0004000507710005000	6077100040005	07650004000607	6000040005076200040	00060764000400050	76100040006076300040006076500040
	<			6			>

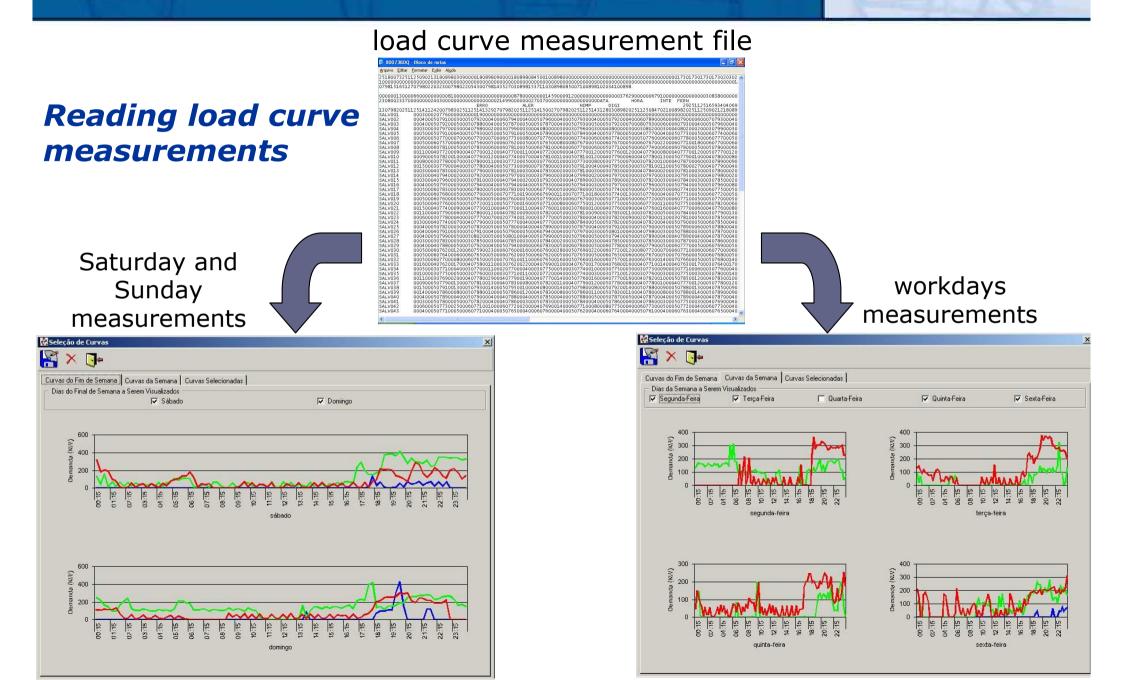
Sample points

» 😴 🚧	🖌 😭 📭		
idos do Estudo —			
Código.:	005 ESTUDO SOBRE CLIENTES CO	JMPLETO	Mercado (MWh).: 1000000
2			
vível de Tensão.:	7 BT	•	Classe de Consumo.: 1 Residencial 💌
ixa de Consumo.:	2 0 à 500 KW	-	
ixa de Consumo.:		Ľ	
entes			
Código	Nome	Ativo	Arquivo
	Consumidor Número 005-00001-001	Sim	C:\CEPEL\AnaTipo\INPUT\Formato_Publico\52733&hb.jod
005-00001-002	Consumidor Número 005-00001-002	Sim	C:\CEPEL\AnaTipo\INPUT\Formato_Publico\86150&ei.ams
005-00001-003	Consumidor Número 005-00001-003	Sim	C:\CEPEL\AnaTipo\INPUT\Formato_Publico\86178&gn.gde
005-00001-004	Consumidor Número 005-00001-004	Sim	C:\CEPEL\AnaTipo\INPUT\Formato_Publico\86193&gn.gtn
005-00001-005	Consumidor Número 005-00001-005	Sim	C:\CEPEL\AnaTipo\INPUT\Formato_Publico\86247&gn.gle
005-00001-006	Consumidor Número 005-00001-006	Sim	C:\CEPEL\AnaTipo\INPUT\Formato_Publico\86313&ei.fob
005-00001-007	Consumidor Número 005-00001-007	Sim	C:\CEPEL\AnaTipo\INPUT\Formato_Publico\86323&SCAJL
005-00001-008	Consumidor Número 005-00001-008	Sim	C:\CEPEL\AnaTipo\INPUT\Formato_Publico\86348&GS.AGT
005-00001-009	Consumidor Número 005-00001-009	Sim	C\CEPEL\AnaTipo\INPLIT\Formato_Publico\86518&MEAEP
005-00001-010	Consumidor Número 005-00001-010	Sim	C:\CEPEL\AnaTipo\INPUT\Formato_Publico\86577&PT.AAK
	Consumidor Número 005-00001-011	Sim	C:\CEPEL\AnaTipo\INPUT\Formato_Publico\86810&NH.ABJ
005-00001-011	Consumidor Número 005-00001-012	Sim	C:\CEPEL\AnaTipo\INPUT\Formato Publico\86887&IC.AKT
		Sim	C:\CEPEL\AnaTipo\INPUT\Formato_EXCEL\CG_TRB1_034
005-00001-011	Consumidor Número 005-00001-013	Sim	C:\CEPEL\AnaTipo\INPUT\Formato_EXCEL\CG_TRB1_040
005-00001-011 005-00001-012		SIM	
005-00001-011 005-00001-012 005-00001-013		Sim	C:\CEPEL\AnaTipo\INPUT\Formato_EXCEL\CG_TRB4_009
005-00001-011 005-00001-012 005-00001-013 005-00001-014	Consumidor Número 005-00001-014	Sim	C:\CEPEL\AnaTipo\INPUT\Formato_EXCEL\CG_TB84_009 C:\CEPEL\AnaTipo\INPUT\Formato_EXCEL\CG_TB84_010
005-00001-011 005-00001-012 005-00001-013 005-00001-014 005-00001-015	Consumidor Número 005-00001-014 Consumidor Número 005-00001-015		C:\CEPEL\AnaTipo\INPUT\Formato_EXCEL\CG_TRB4_009 C:\CEPEL\AnaTipo\INPUT\Formato_EXCEL\CG_TRB4_010 C:\CEPEL\AnaTipo\INPUT\Formato_EXCEL\CG_TRB4_011

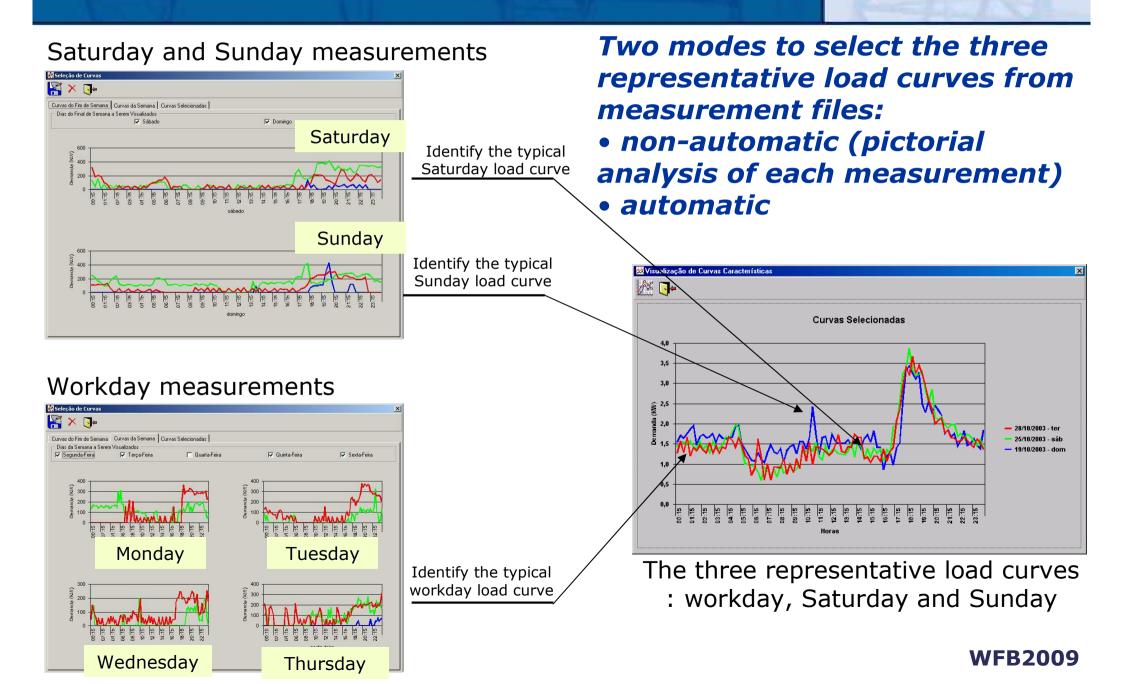
WFB2009

- IB 🛛



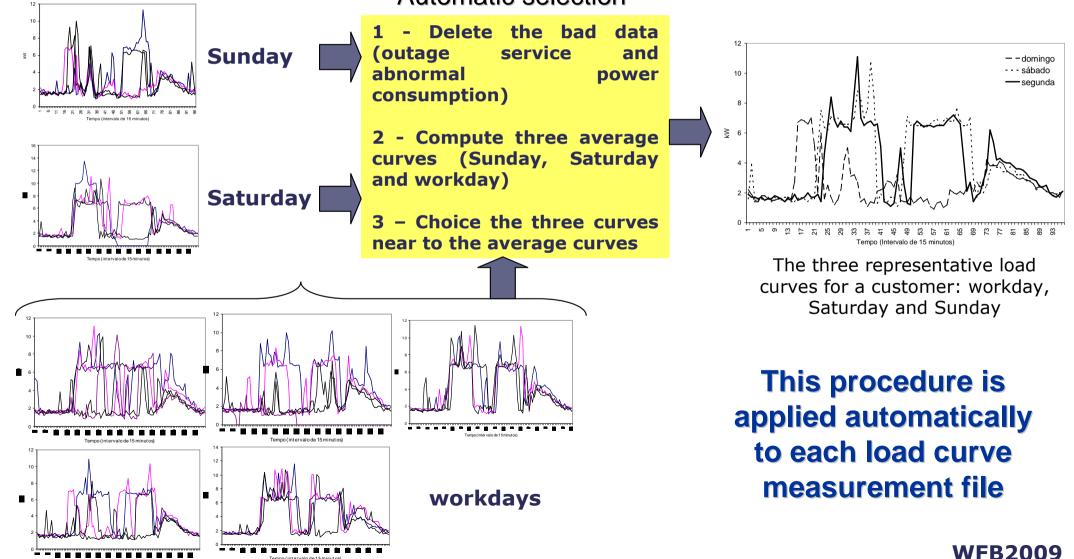






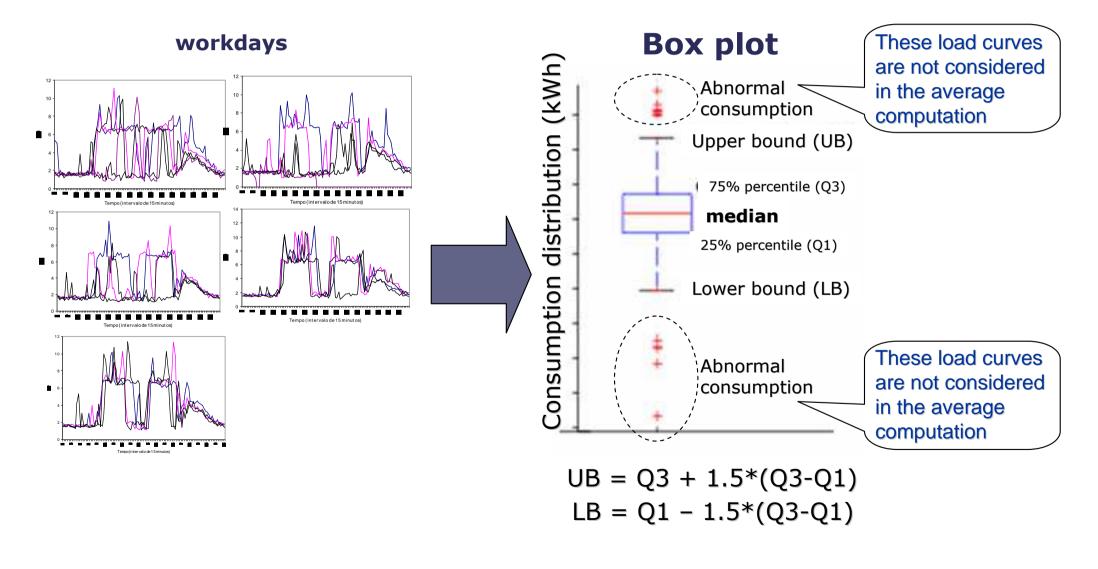


Automatic selection of the representative load curves of each measurement file Automatic selection

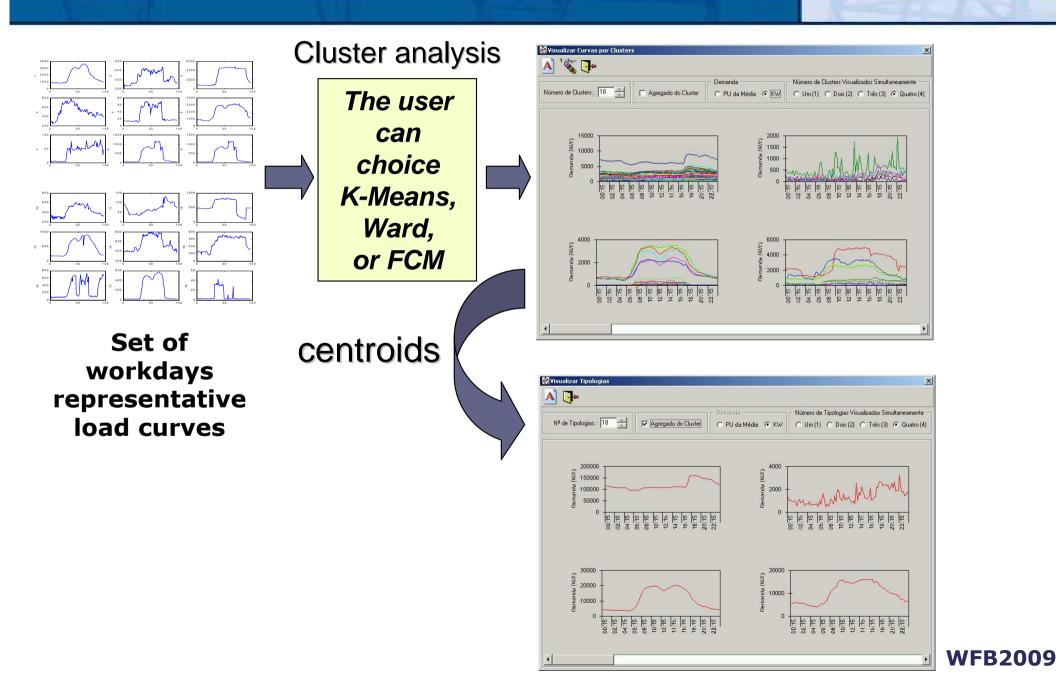




Identification of the load curves with abnormal consumptions









WFB2009

User can move a load curve from one cluster to another





Output report with statistics to set the number of clusters

	×				
	BSS	%WSS	%BSS	CS	Number of clusters
- WS	×		(> *********	<x< th=""></x<>
	0. 2010.	100.00 76.84	0.00 23.16	0.4796	
	3182.	63.35	36.65	0.4001	2
	3897.	55.12	44.88	0.7044	2
	4274.	50.77	49.23	0.7259	4
	4586.	47.18	52.82	2.2699	5 6 7 8 9
C 4.000000000	4890.	43.67	56.33	2.1014	7
·	5143.	40.77	59.23	1.9617	8
3.2 C00000000 III	5365.	38.22	61.78	1.8387	Ğ
0000000	5548.	36.10	63.90	1.7369	10
	5693.	34.43	65.57	1.6567	11
C/2000000000000000000000000000000000000	5828.	32.88	67.12	1.7017	12

BSS = Between sum squares

$$BSS = \sum_{j=1}^{k} \left\| c_j - \overline{c} \right\|^2$$

WSS = Within sum squares

$$WSS = \sum_{j=1}^{k} \sum_{i=1}^{n_j} \|x_i - c_j\|^2$$

%BSS = BSS / (WSS + BSS)

The ideal number of clusters minimizes the compacity and separation measure (CS) $CS = \sum_{i=1}^{k} \sum_{j=1}^{n} u_{ij}^{m} \|x_{i} - c_{j}\|^{2} / n \cdot \min \|c_{j1} - c_{j2}\|^{2}$

k = number of clustersx = load curvec= cluster centroidn = number of objects (load curves)u = membership functionm = degree of fuzzyfication (m=1 for crisp methods k-Means and Ward)



The main result is a worksheet with the typical load profiles

3)	<u>Arquivo E</u> ditar E <u>x</u> ibir <u>I</u> nser	rir <u>F</u> ormata	ar Ferra <u>m</u> e	entas <u>D</u> a	dos <u>J</u> ani	ela Aj <u>u</u> da	T <u>r</u> adução						_ 8	×
=	Α	в	С	D	E	F	G	Н		J	к	L	M	官
1	CEPEL - Centro de	Pesqu	lisas de	e Ener	gia Ele	etrica								1
2	Sistema ANATIPO				-									
3	Tipologias em MW													
ł														
	INTERVALO	HORA			TIPO 1			TIPO 2		A	GREGAD	10		
				útil	sábado	domingo	útil	sábado	domingo	útil	sábado	domingo		
	00:00-01:00	1		15.253	18.113	15.600	0.953	0.867	0.780	16.207	18.980	16.38		
	01:00-02:00	2		14.907	18.113	16.120	0.867	0.953	0.693	15.773	19.067	16.813		
	02:00-03:00	3		15.167	17.940	15.947	0.780	0.780	0.780	15.947	18.720	16.727		
	03:00-04:00	4		15.167	17.680	16.033	0.867	0.867	0.693	16.033	18.547	16.727		
	04:00-05:00	5		15.253	17.767	15.600	0.693	0.953	0.780	15.947	18.720	16.38		
	05:00-06:00	6		18.287	19.674	16.033	0.867	0.867	0.693	19.154	20.540	16.727		
	06:00-07:00	7		32.760	35.707	16.380	1.040	1.127	0.953	33.800	36.834	17.333		
	07:00-08:00	8		44.460	63.787	16.293	1.300	1.733	0.953	45.760	65.521	17.247		_
	08:00-09:00	9		142.568	123.588	16.207	1.820	1.387	0.693	144.388	124.974	16.9	Evec	
	09:00-10:00	10		306.976	227.935	15.773	6.067	1.387	1.127	313.043	229.322	16.9	Exce	Л
	10:00-11:00	11		317.896	244.055	16.293	6.413	1.213	0.693	324.309	245.269	16.987		
	11:00-12:00	12		287.042	234.522	18.200	1.560	1.127	0.780	288.603	235.649	18.98	road	\
	12:00-13:00	13		296.749	225.855	17.680	4.680	1.040	0.607	301.429	226.895	18.287	read	У
	13:00-14:00	14		219.962	184.428	17.073	0.780	2.253	0.347	220.742	186.682	17.42		
	14:00-15:00	15		245.442	204.275	16.293	6.153	1.560	0.867	251.596	205.835	17.16	in the	
:	15:00-16:00	16		250.989	202.455	17.247	5.893	1.040	0.520	256.882	203.495	17.767	III UIV	0
	16:00-17:00	17		232.875	209.475	16.467	5.807	0.693	0.520	238.682	210.169	16.987	tariff	
1	17:00-18:00	18		228.109	215.282	16.900	0.780	1.560	1.300	228.889	216.842	18.2	taritt	(
	18:00-19:00	19		178.622	131.474	16.380	1.127	0.867	0.780	179.748	132.341	17.16	Carini	
	19:00-20:00	20		117.868	94,901	17.247	1.907	0.953	0.867	119.774	95.854	18.113		
	20:00-21:00	21		111.974	47.927	17.593	1.387	1.647	0.953	113.361	49.574	18.547		1
	21:00-22:00	22		79.041	32.414	17.333	1.127	1.387	0.347	80.167	33.800	17.68		1
	22:00-23:00	23		44.114	25.827	16.900	0.780	1.213	0.433	44.894	27.040	17.333		1
	23:00-24:00	24		23.054	17.680	16.033	1.473	1.040	0.173	24.527	18.720	16.207		1
	% mercado			98.347			1.653			100				1
	mercado M¥h			983472.4			16527.56			1000000				1
1	demanda média MV			135.606			2.297			137.902				1
	poderação sabado			0.808			0.517			0.804				1
	poderação domingo			0.122			0.314			0.125				1
	fator de carga %			42.657			35.811			42.522				1
,	demanda má z MV Ponta			178.622			1.907			179.748				1
:	demanda más MV Fora_Pon	ita		317.896			6.413			324.309				
í				0.1.000			0.110			021.000		1		

Excel worksheet ready to be used in the distribution tariff computation





The softwares for identifying typical load profiles developed in the Brazilian electric power sector are based on the French tradition, specially from the EDF's experience.

Most of the studies carried out in the Brazilian electricity distribution utilities have been used statistics techniques (Ward method, k-Means or the "*Nuées dynamiques*") to obtain the typical load profiles. For example, the statistics techniques have been used in the tariff revision process.

However it is possible to find few studies that use Self-Organizing Map (SOM) in order to get the typical load profiles. Most of these studies have been used the Matlab Neural Network Toolbox. The challenge remains to develop a software based on SOM like "*Courboscope*" (Debregeas & Hebrail, 1998) developed by the EDF's R&D Division.

Debrégeas, A., Hébrail G. (1998). Interactive Interpretation of Kohonen Maps Applied To Curves, In KDD'98, Proceedings of the 4th International Conference on Knowledge Discovery and Data Mining, New-York, pp.179-183, AAAI Press.





- 1) BRASIL, Ministério das Minas e Energia, DNAEE, Eletrobrás, Empresas Concessionárias de Energia Elétrica, Nova Tarifa de Energia Elétrica: metodologia e aplicação, DNAEE, Brasília, 1985.
- 2) Boiteux, M. La tarification dês demandes en pointe: application de la théorie de la vente au coût marginal, Revue générale d l'electricité, 1949.
- 3) Bouroche, J.M, Saporta, G., L'analyse dês données, PUF, 9e édition, Paris, 2005.
- 4) Debrégeas, A., Hébrail G. (1998). Interactive Interpretation of Kohonen Maps Applied To Curves, In KDD'98, Proceedings of the 4th International Conference on Knowledge Discovery and Data Mining, New-York, pp.179-183, AAAI Press.
- 5) Diday, E. Une nouvelle méthode em classification automatique et reconnaissance des formes. La méthode des nuées dynamiques. Revue de statistique Appliquée, 1971, vol. XIV nº 2. Institut de Statistique. Université de Paris.
- 6) Hébrail, G. Practical data mining in a large utility company, Revue Questiio (Quaderns d'Estadistica i Investigacio Operativa), Vol.25, N.3, pp.509-520, 2001.
- 7) Lebart, L.; Piron, M.; Morineau, A. Statistique exploratoire multidimensionnelle, 3e édition, DUNOD, Paris, 2000.
- 8) Jain, J.S.R., Sun C.T., Mizutani, E. Neuro-Fuzzy and Soft Computing: a computational approach to learning and machine intelligence, Prentice Hall Inc, 1997.
- 9) Molliere, M. Um ensemble de modules de classification automatique et de modules explicatifs associes, Note EDF, Direction des etudes et Recherches nº HI 2818/02, 1978.
- 10) Pessanha, J.F.M., Huang, J.L.C., Pereira, L.A.C., Passos Júnior, R., Castellani, V.L.O. Metodologia e sistema computacional para cálculo das tarifas de uso dos sistemas de distribui»cão, XXXVI SBPO, São João del Rey MG,2004.
- 11) Pessanha, J.F.M., Castellani, V.L.O., Araújo, A.L.A. Uma nova ferramenta computacional para construção de tipologias de curva de carga, X SEPOPE, Florianópolis SC,2006.
- 12) Pessanha, J.F.M., Laurencel, L.C., Souza, R.C. Kohonen Map to build load curve types, XXXVI SBPO, São João Del Rey, Brasil, 2004.

José Francisco Moreira Pessanha (francisc@cepel.br)

Luiz da Costa Laurencel (getlcl@vm.uff.br)





