Allocation of Transmission Capacity in the Central America Electricity Market

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Proyecto SIEPAC SNC·LAVALIN MERCADOS ENERGY MARKETS GROUP

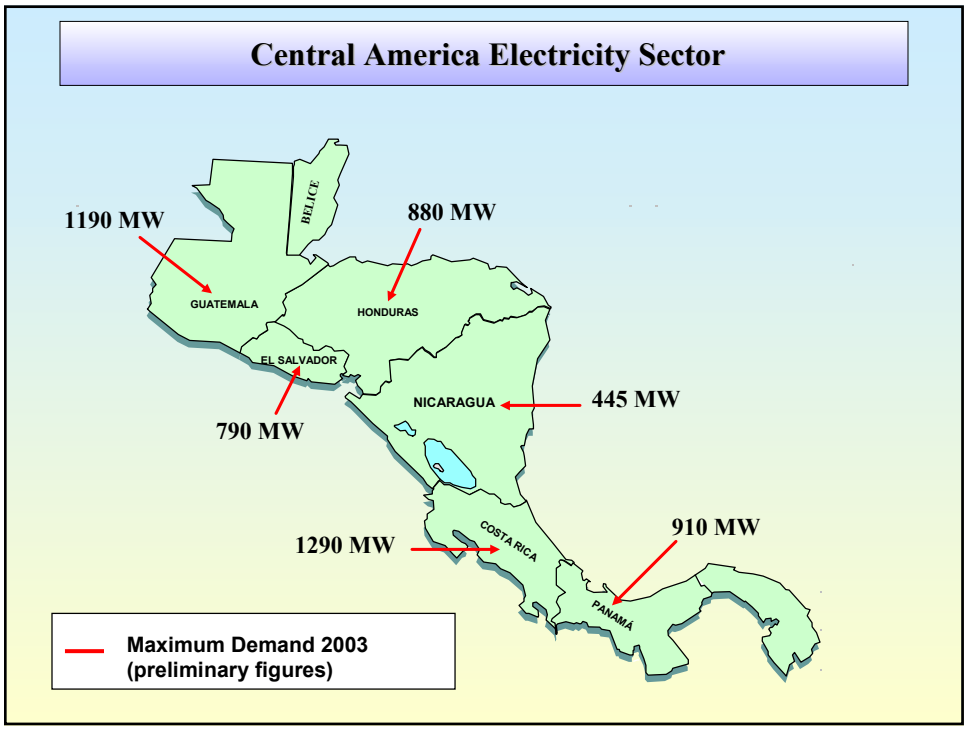
Topics

- Description of the Electricity System in Central America
- The current MER (Regional Electricity Market)
- The future MER

Proyecto SIEPAC

SISTEMA DE INTERCONEXION ELECTRICA DE LOS PAISES DE AMERICA CENTRAL (SIEPAC)

ELECTRICTY SUPPLY INDUSTRY IN CENTRAL AMERICA



EVOLUTION OF THE ELECTRICITY SECTOR REFORMS IN CENTRAL AMERICA

	Model 1 VIU	Model 2 Single buyer	Model 3 Wholesale competition	Model 4 Retail competition
Guatemala	Up to 1991	1991 PPA EEGSA-ENRON 100 MW	1996 Law	
El Salvador	Up to 1994	1994 PPA CEL-Nejapa Power 80 MW		1996 Law
Honduras	Up to1993	1993 PPA ENEE-ELCOSA 54 MW	Proposal	
Nicaragua	Up to 1996	1996 PPA ENEL-Anfells 36 MW	1998 Law	
Costa Rica	Up to 1990	1990 Law 7200 QFs		
Panamá	Up to1996	1997 PPA IRHE-Petroterminales 50 MW	1997 Law	

MAIN ASPECTS OF THE REFORMS

	Guatemala	El Salvador	Nicaragua	Panamá
Contracts	Financial	Physical	Financial	Financial
Spot market price	SRMC with no T constraints	SRMP with T constraints	SRMC with no T constraints	SRMC with no T constraints
Capacity	Yes	No	Yes	Yes
Capacity price	Regulated	Not applicable	Regulated	Market based

MAIN ASPECTS OF THE REFORMS

	Guatemala	El Salvador	Nicaragua	Panamá
Transmission Co	ETCEE	ETESAL	ENTRESA (OS&M)	ETESA (OS&M)
Centralised T expansion		ETESAL	ENTRESA	ETESA
T expansion - triggered by agents	Agreement among parties / consultation	Agreement among parties	Agreement among parties / consultation	
Existing T costs	Replacement (adapted system)	*O&M*	Replacement	Replacement
Existing T charges	Postage stamp (G&I) MW installed	Postage stamp (G) MW declared	Postage stamp kWh (G & D)	Sensitivities MW-km (G/D)

Proyecto SIEPAC

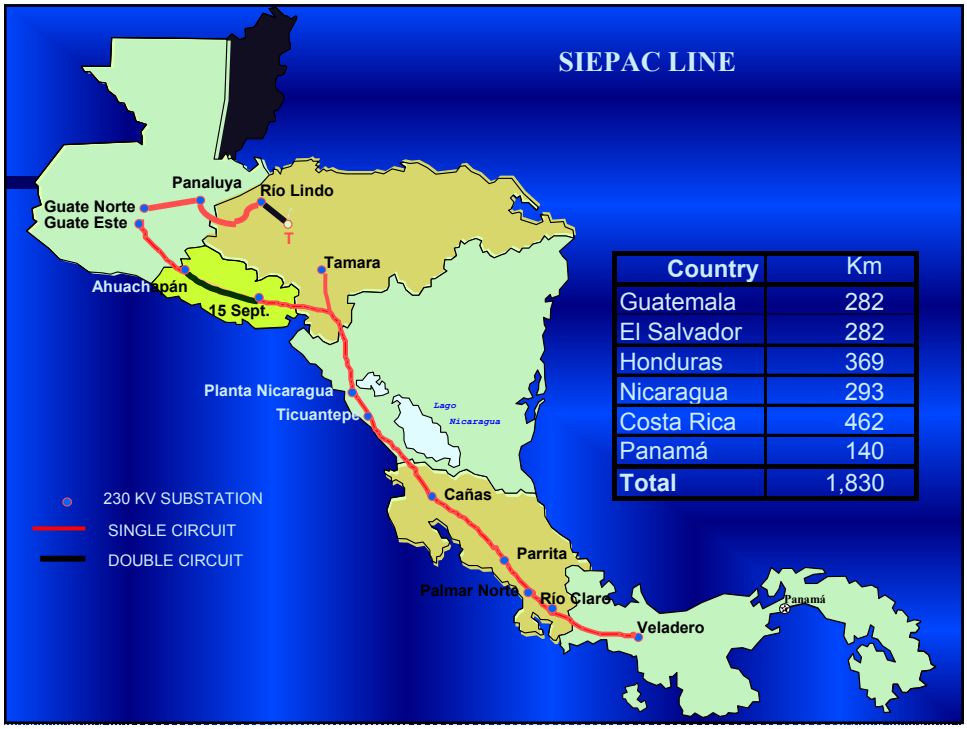
SISTEMA DE INTERCONEXION ELECTRICA DE LOS PAISES DE AMERICA CENTRAL (SIEPAC)

RELEVANT ASPECTS

SIEPAC Project

Main objectives:

- The establishment of a Regional Electricity Market (MER – a *seventh* market), a regional regulator (CRIE) & a regional operator (EOR).
- The development of a regional transmission line, the SIEPAC line.



Country	Km
Guatemala	282
El Salvador	282
Honduras	369
Nicaragua	293
Costa Rica	462
Panamá	140
Total	1,830

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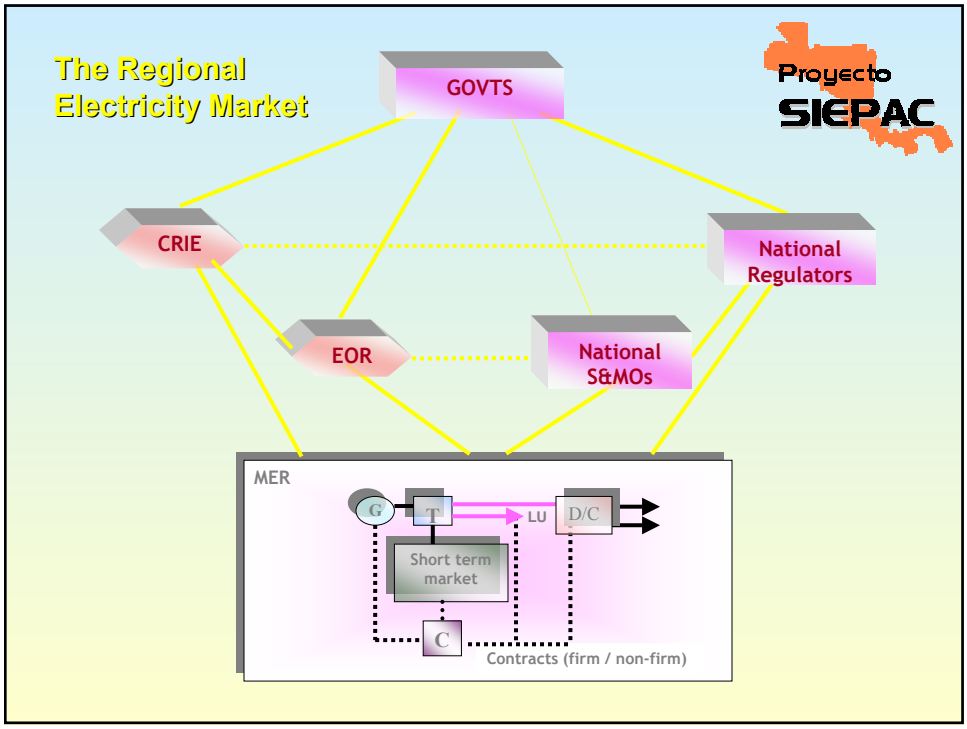
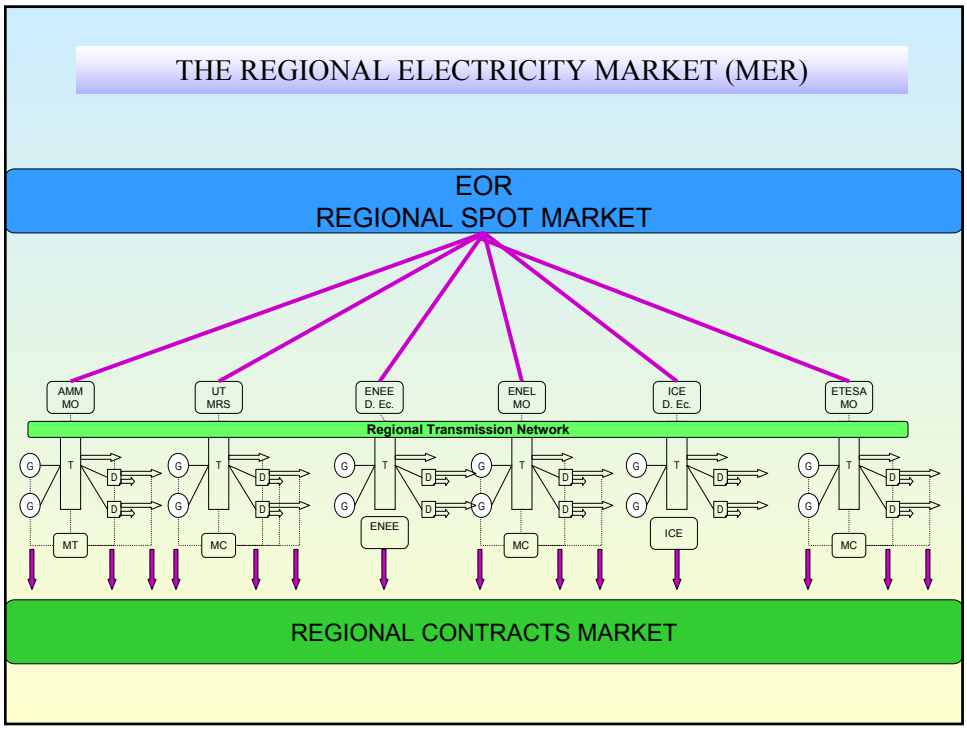

The Regional Electricity Market
GOVTS
Proyecto SIEPAC
CRIE
National Regulators
EOR
National S&MOs
MER
G
T
LU
D/C
Short term market
C
Contracts (firm / non-firm)


THE REGIONAL ELECTRICITY MARKET (MER)
EOR
REGIONAL SPOT MARKET
AMM MO
UT MRS
ENEE D. Ec.
ENEL MO
ICE D. Ec.
ETESA MO
Regional Transmission Network
MT
MC
ENEE
MC
ICE
MC
REGIONAL CONTRACTS MARKET

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Evolution of the Transmission Regulatory Framework

Future

- General Design ⇒ Detailed Design/Reglamentos (Regional Transmission Network – RTR – definition & expansion – planned and risk, remuneration, congestion rights, quality and security, etc.)

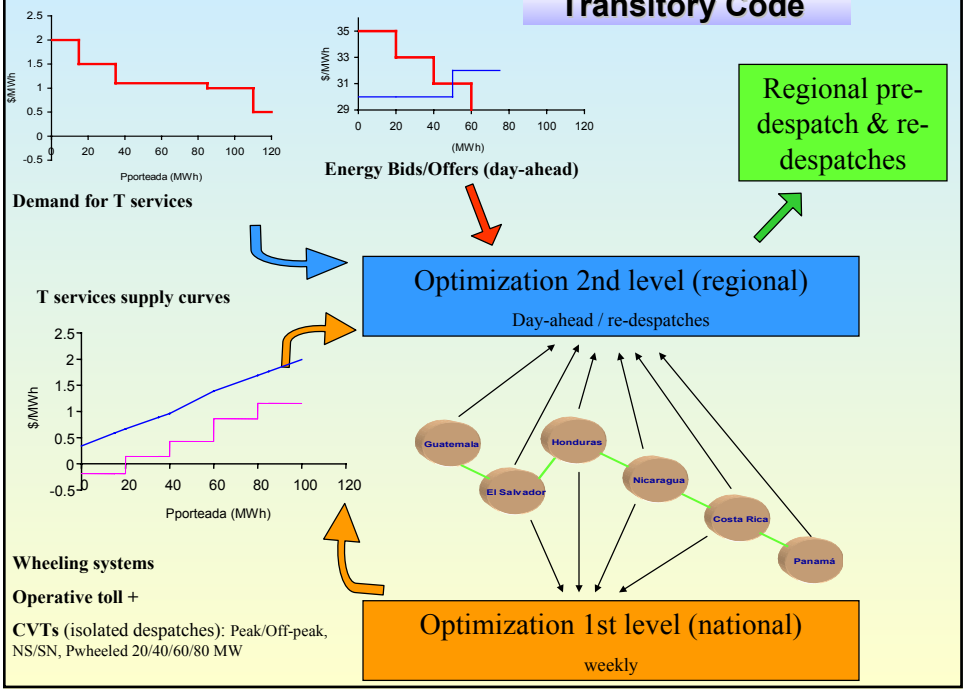
Recent past (until november 2002)

- CVTs for wheeling services (Nicaragua, Costa Rica) monthly, demand period (peak/off-peak), service direction (N-S/S-N), service level (0, 20, 40, 60, 80 MWh)

Present (in operation since november 2002)

- CVTs + operative toll for tie-lines – Transitory Code (RTMER) submitted by EOR and approved by CRIE

Transitory Code



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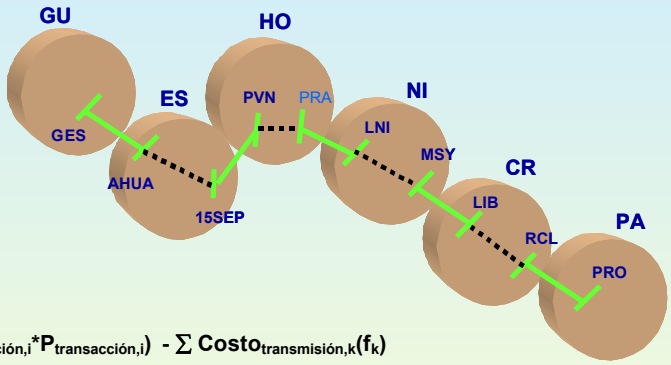
Transitory Code



Max $\sum$ (Precio$_{transacción,i}$*P$_{transacción,i}$) - $\sum$ Costo$_{transmisión,k}$(f_k)

Sujeto a

Balance nodal $[Pg - Pd] = \sum ([IT_{transacción,i}]^* P_{transacción,i})$
$[B][\theta] = [Pg - Pd]$

Lim ofertas $P_{transacción,i} \leq (P_{transacción,i})^{max}$

Lim transmisión $(-f_k)^{max} \leq f_k \leq (f_k)^{max}$

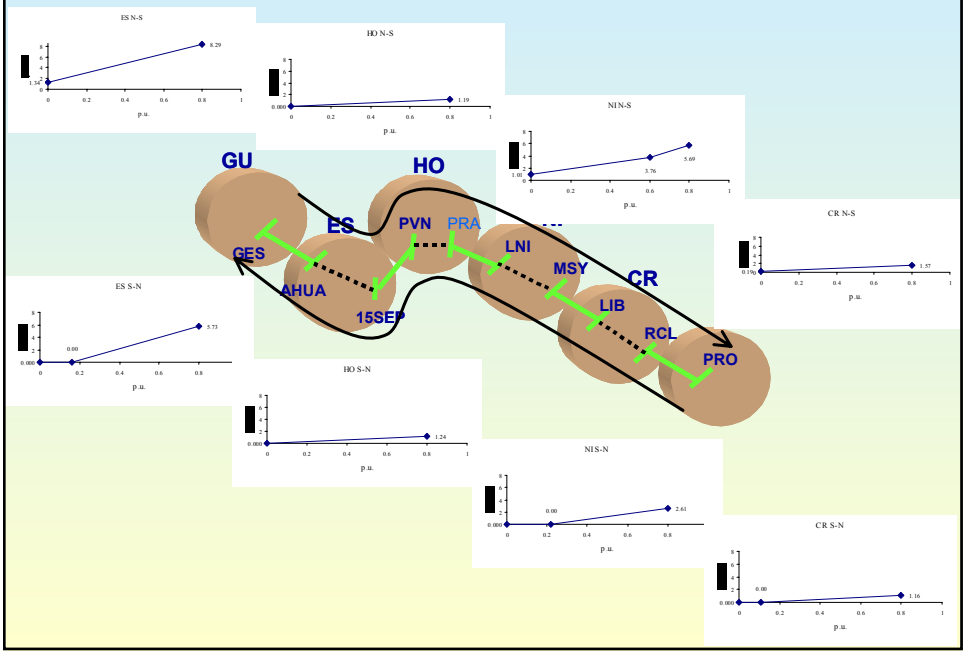
Main characteristics of the scheme

- Operative toll: only tie-lines
  - Very simple evaluation (no methodology required)
  - Sends the MER agents (importers / exporters / transmission companies/) a signal of partial recovery (the "used" portion) of transmission investment costs, and it respects the MER General Design
  - Causes a dead weight loss that should be evaluated
- CVTs are "anchored" to the wheeling systems prices (estimated from expected average conditions - inaccuracies) - CVTs are not "pulled" by the MER opportunity price
- IF CVTs $\leq$ 0.0 the CVTs = 0.0
- Offers to buy / bids to sell energy - at the border substations (MER nodal prices)

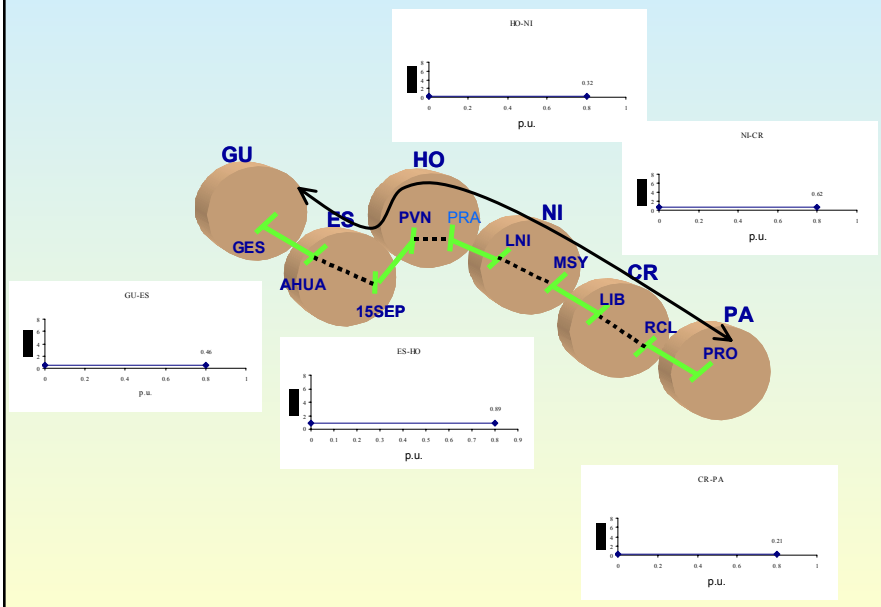
Main characteristics of the scheme

- Co-ordinated despatch of energy (bids & offers) and contracts (wheeling services)
  - facilitates (promotes?) contracts - it is possible to specify a maximum amount an agent is willing to pay for transmission services, to handle transmission charges uncertainty (without developing DCs)
  - optimal allocation of transmission services (available T is sold to those who value it the most)
  - produces opportunity prices for energy and transmission services
  - assures non-discrimination between contracts and opportunity market
  - reduces workload to EOR (pre-despatch and re-despatches)

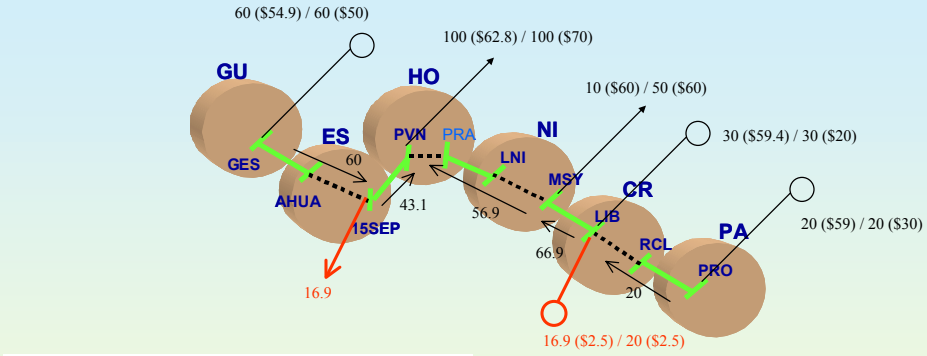
Co-ordinated despatch of contracts & energy: CVTs

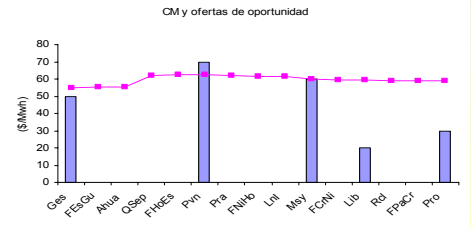


Co-ordinated despatch of contracts & energy: operative toll



Co-ordinated despatch of contracts (transmission services) & opportunity energy





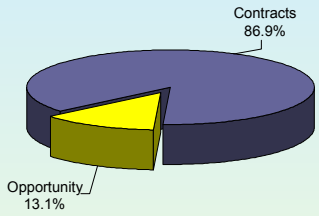
Statistics 2003

Predespatch – adjutments not included.

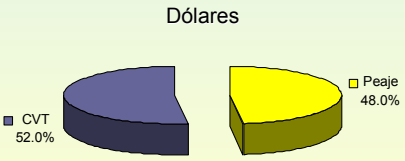
MER Transactions

País	Contrato (MWh)		Oportunidad (MWh)		Total General (MWh)		Total neto	
	iny	ret	iny	ret	iny	ret	iny	ret
Costa Rica	117,702.6	23,173.0	1,164.0	18,018.0	118,866.6	41,191.0	77,675.6	
El Salvador	77,545.8	369,759.8	22,542.8	57,956.5	100,088.6	427,716.3		327,627.7
Guatemala	407,914.0	9,868.0	13,194.1	12,992.7	421,108.1	22,860.7	398,247.4	
Honduras	0.0	300,858.6	0.0	35,909.0		336,767.6		336,767.6
Nicaragua	19,544.0	8,710.0	1,667.7	3,148.4	21,211.7	11,858.4	9,353.3	
Panamá	128,683.7	1,120.0	52,743.0	1,187.7	181,426.7	2,307.7	179,119.0	
Total	751,390.0	713,489.4	91,311.6	129,212.2	842,701.6	842,701.6	664,395.3	664,395.3

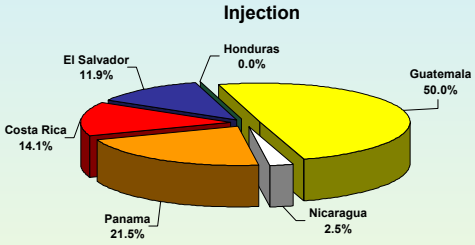
MER transactions

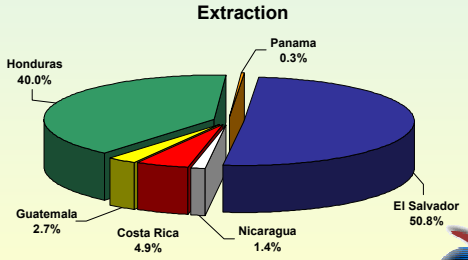


Transmmision

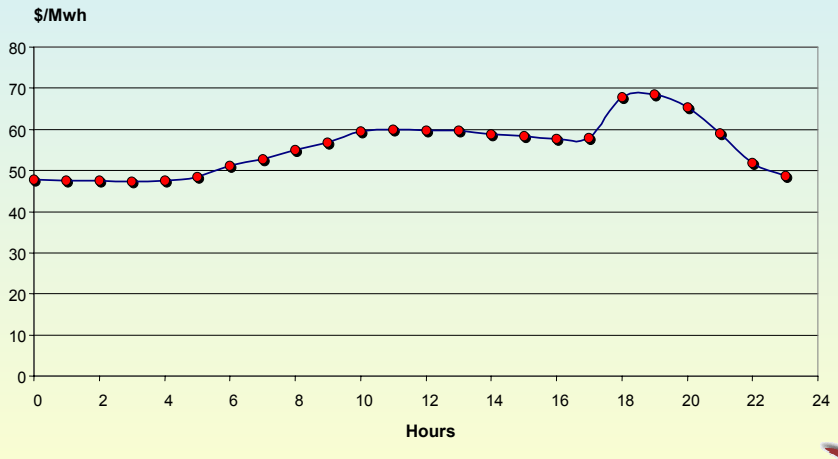


Countries participation in MER transactions

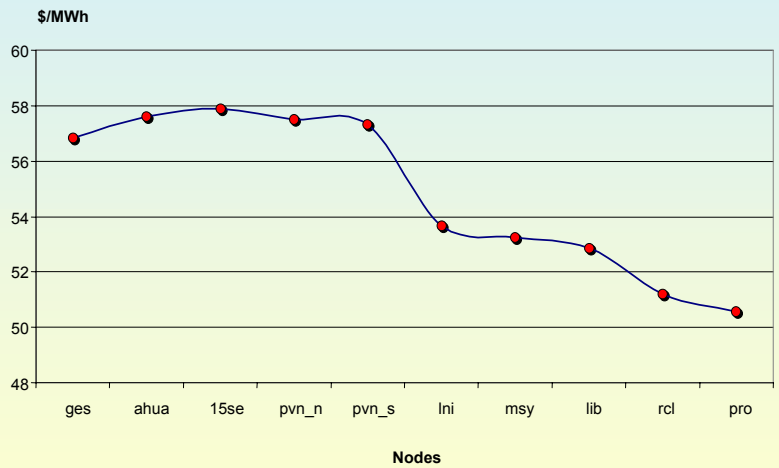




Average hourly prices



Average nodal prices



The Future MER

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The Central American Regional Electricity Market

- Rules for the final stage being developed as established in the "General Design of the Market"
- The General Design of the Market:
  - A day-ahead spot market run by the EOR, with locational marginal prices (LMP)
  - A real time balancing market
  - Financial transmission rights for "firmness" and nodal price differences hedging
  - Allow "firm contracts" between market participants in different countries
  - Transactions are performed in the Regional Transmission Network (RTN)

The Regional Transmission Network (RTN)

- The high voltage network where regional trade takes place
- Bids/Offers to the regional market in the nodes of the RTN
- Determined initially and regularly updated by means of simple topological and "usage" criteria
- As a minimum the RTN consists of: the interconnectors, the SIEPAC line and "Planned Expansions" decided by the EOR and approved by the Regional Regulator (CRIE)

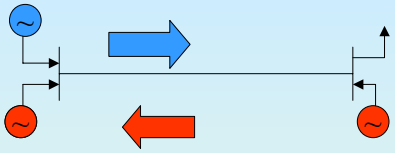
Transmission Right's Objectives

- Efficient allocation of scarce transmission capacity through market mechanisms, in a manner compatible with open access and a short term bid-based spot market.
- In MER, TRs are also linked to firm contracts:
  - Several regulations require that DisCos (suppliers of last resort) must hold contracts with generators, for their expected demand (firm contracts)
  - These regulations were designed for generators located inside each country
  - The regional market gives the opportunity to DisCos to contract in any country in CA
  - In order to ensure that there exists enough transmission capacity to consider as "firm" the supply of a generator located in another country, the parties must hold a "firm" TR

Transmission Rights in MER

- Two types of TR were proposed:
  - Point to point Financial TRs (PPFR), that entitles the holder to be paid (pay) the difference of nodal prices between an injection node and a withdrawl node. PPFR are defined as obligations.
  - Firm TR, a point to point right that entitles the holder to inject power in one node and withdraw the same power in another node at the same price
- Firm TR addresses the "firmness" requirement of the General Design

Counter flows



- Firm TRs need to be scheduled individually (each holder may ask to be scheduled with independence of other holders), therefore counter flows from other TRs cannot be considered
- But some generators may be interested in supplying counter-flows when requested, if they are paid by such service
- The EOR will carry out electrical studies to identify generators that may offer counter-flows for firm TRs
- These generators may present offers in the TR auctions, asking for a payment for being available to supply counter-flows when requested by the EOR
- If awarded generators fail to supply the requested power, they will be penalized

Simultaneous Feasibility Test

- The SFT ensures that:
  - The System Operator (EOR) will collect enough money from nodal price differences to pay to the holders of TRs
  - To ensure that "firm contracts" will have available transmission capacity every time the contract must be physically exercised
- The SFT ensures the above statements hold for the RTR in the normal state (all components in service) or in several contingency scenarios

Initial TR Allocation

- Basic principle: Allocation to the parties who pay transmission charges of the facilities
  - Existent transmission facilities: TRs allocated to parties that pay transmission charges (Initial Owners)
  - SIEPAC facilities: TRs allocated to parties that pay transmission charges for the SIEPAC lines
  - Planned Expansions: TRs allocated to parties that pay transmission charges for these expansions
  - Risk (merchant) expansions: players that develop and pay for the expansion
- An owner of a merchant expansion may request CRIE to perceive "usage charges". If approved the owner must grant TRs to the agents who pay the charges

TR Auctions

- The EOR will hold every month auctions for selling yearly and monthly TRs (time horizon can be extended if needed)
- Owners of TRs will be able to sell or reconfigure their TRs
- The money collected in the auctions will be used to reduce the transmission charges of the Initial Owners, and to pay the sellers of TRs
- Until the market is liquid, a price floor for TRs will be set, based on LMPs forecasted by the EOR

Allocation Algorithm

- Bidders present offers identifying:
  - Nodes where power will be injected/withdrawn
  - Power injected/withdrawn in each node. Offers must be balanced
  - Offered price for buying (selling) the TR
  - Accepts fractions of TRs or not

$$T = \begin{vmatrix} t1 \\ 0 \\ 0 \\ -t4 \\ 0 \\ -t5 \end{vmatrix}$$

$$t1 - t4 - t5 = 0$$

Allocation Algorithm

Financial PtP

Firm TR

Counter flows

$$\text{Max } \Sigma_j C_j \alpha_j TO_j + \Sigma_k C_k \alpha_k T_k - \Sigma_h C_h \alpha_h TCF_h \quad (1)$$

(maximization of collection)

Subjet to the SFT:

$$\Sigma_k \max (0, [H_e \alpha_k T_k]_{ei}) + [H_e \Sigma_h \alpha_{ek} TCF_h \leq b_{ei} \ \forall i, \forall e \quad (2)$$

(firm TR feasibility)

$$[H_e \Sigma_j \alpha_j TO_j]_i + [H_e \Sigma_k \alpha_k T_k]_i) + [H_e \Sigma_h \alpha_{eh} TCF_h] \leq b_{ei} \ \forall i, \forall e \quad (3)$$

(Financial adequacy)

Counter flows of other TRs not allowed for firm TR

$$\alpha_k \leq 1 \text{ ó } \alpha_k \varepsilon \{0,1\} \quad (4)$$

(awarded capacity must be ≤ than maximum offered capacity)

$$\alpha_j \leq 1 \text{ ó } \alpha_j \varepsilon \{0,1\} \quad (5)$$

(awarded capacity must be ≤ than maximum offered capacity)

$$\alpha_{eh} \leq \alpha_h \leq 1 \quad (6)$$

(awarded capacity of a counterflow must be ≤ than maximum capacit offered ,and used capacity must be ≤ than awarded)

Allocation Algorithm

- The awarding process can be solved as a mixed linear programming problem. If bidders accept to be awarded with fractions of the power, it can be solved as a linear programming problem
- Some alternative equations were developed for consideration of losses

The Power Transfer Factors Matrix (H)

Impedance Matrix

$$H_0 = Z_0 (A\ Z_0)^{-1}$$

$$H_e = Z_e (A_e\ Z_e)^{-1}$$

Incidence Matrix

e: 0,...N
0: base case
e_i: contingency "i"

$$HM_e = \begin{vmatrix} H_e \\ \cdots\cdots \\ -H_e \\ \cdots\cdots \\ D \end{vmatrix} \qquad \mathbf{b_e} = \begin{vmatrix} bu_e \\ \cdots\cdots \\ bl_e \\ \cdots\cdots \\ bd \end{vmatrix} \qquad H = \begin{vmatrix} HM_0 \\ \cdots\cdots \\ HM_1 \\ \cdots\cdots \\ HM_e \\ \cdots\cdots \\ HM_{NN} \end{vmatrix}$$

Allocation of TRs to Expansions

F= H * T ≤ b (before the expansion set of TR is feasible)

F' = F + ΔF = H' * (T + ΔT) ≤ b' [maintain feasibility after the expansion]

Allocation

Max Z= $a*DF_{ij}$ = ΔT (New TR between end nodes of expansion)

Subject to:

H' * (T + $a*DF_{ij}$) ≤ b' [old (T) + new (ΔT) TRs must be feasible]

H * T ≤ b (T feasible before the expansion)

T: set of existing TRs

Conclusions

- Definition of the rules describing the method for setting transmission tariffs and allocation of transmission rights has special difficulties
- The need of the coexistence of firm and financial transmission rights required of tailored rules in order to achieve efficiency and appropriate incentives for expansions
- The main concern is still the liquidity of the TR auctions => initially maybe only a small number of regional transactions will be scheduled