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USAID's Regional Energy Security, Efficiency & Trade Program (RESET)

Workshop on Market Models and Information Systems to Support Competitive Electricity Markets

Practical Aspects of Operating Electricity Markets of PJM and New England

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Key Topics

- Organization of operation of competitive electricity markets
  - Operators of competitive wholesale markets
  - Jurisdictions of Independent System Operators
- Asset Ownership structure
- Market governance
- Trading products
- Market models
- Competitive market and reliability
- Planning of power system expansion
- Retail markets
- History of development of the regional market in Central Asia and possibilities to use elements of advanced electricity markets in Central Asia conditions

Organization of Operation of Competitive Electricity Markets

Operators of Competitive Wholesale Markets

- Wholesale electricity markets of PJM and New England are among the most successful in the USA
- These markets and their operators were formed in 1997 on the basis of existing power pools
- Markets cover territories of many states and, therefore are regional
- Strategic high voltage grids are owned by different transmission grid companies
- Operation of competitive wholesale markets is managed by Independent System Operators (ISO)
  (in this case - “PJM Interconnection” and ISO-NE)

Jurisdictions of Independent System Operators

- Jurisdiction of an Independent System Operators (ISO) are areas of their dispatch control:
  - In PJM initially there was 3 states, now there're 14;
  - In New England – power systems of 6 states
- Neighboring ISOs interact with each other both to ensure reliability and to resolve market issues
- High voltage transmission grids are transferred by their owners to the operational control by ISO
- A uniform regional transmission tariff is applied within an ISO's jurisdiction. The notion of "price for transit" within and across areas does not exist.
- ISOs are responsible for operational control of united power systems and serve as providers of transmission services

Structure of Ownership on Markets of PJM and New England

- The majority of transmission and generation assets are privately owned
- Some resources belong to municipalities

Management of Competitive Wholesale Markets

- ISOs play an executive role in the governance of market's operation
- ISOs govern market operation in close coordination with organizations of market participants
- Organizations of market participants have the right of advisory vote
- Federal Energy Regulatory Commission of USA (FERC) regulates the work of ISOs, regulates market provisions, settles disputes and is responsible for market monitoring

FERC’s Mission

- FERC’s authority is set by the Federal Power Act
- FERC's Mission is to ensure reliable, efficient and sustainable power supply for customers and assist customers in obtaining reliable, efficient and sustainable power supply services at a reasonable cost through appropriate regulatory and market means.
- To fulfil this mission, several responsibilities are imposed. One of such responsibilities is to regulate the transmission and wholesale sales of electricity in interstate commerce

FERC's Activity in Organization of Competitive Electric Power Markets Management

- Unlike in other countries, in the USA there are no laws regulating electric power sector restructuring and organization of electric power markets at the national level.
- To work in this area FERC relies on limited authorities provided under the Federal Power Act.

Specific Challenges in Sector Restructuring and Organizing Competitive Markets in the USA

- Unlike many other countries, US transmission networks are privately owned. It is quite complicated to force an owner to agree with actions which may. to some extent, infringe on its ownership rights.
- It was also difficult to persuade vertically integrated private electricity companies to sell a portion of their assets.
- In the U.S. the efforts to restructure the sector and organize competitive power markets were first took place in the states, where power pools had operated (northeastern US - PJM, New York, New England) and in states where the state governments insisted on restructuring, namely, California.
- In exchange for their consent to drop specific rights derived from asset ownerships the owners of enterprises were given substantial rights in the market management governance process.
- FERC is a regulatory body, rather than a management body. It was necessary to determine an organization that could be responsible for governance of competitive markets. **Welcome Independent System Operators - "ISO"!**

Justification for Creation of the ISO

- Electricity system consisting of physical assets belonging to various owners needs a coordinator
- ISO's critical function is to provide open and non-discriminatory access to the transmission network for all market participants
- The operation of an ISO must pursue the following objectives:
  - Reliability: ensure reliable operation of power systems in the process of supporting market activity of participants
  - Non-discrimination: equal access to services for all participants
  - Services sharing: services must be offered on a shared basis, if possible
  - Efficiency: market rules and pricing must support the efficient operation of the market. No cross-subsidizing should exist. Total costs should be equally allocated with no damage to economic incentives.

ISO Organizational Process

- FERC Order 888 did not require vertically integrated electricity companies to organize competitive electricity markets. It simply required from the grid owners to provide access to grids balancing services and provision of operating reserves. That is, grids operators were allowed to retain ownership of generation capacities as well.
- However, in three energy pools of the North-East (PJM, New Your and New England operated, and in the states of California and Texas, and several states of the Mid West) state authorities proceeded further in power sector restructuring and introduced competitive retail markets and established Independent System Operators – ISOs
- These organizations became the core of competitive electric power markets management

Organizations of Market Participants

- However, Independent System Operators, as such, could not satisfy all principles stated by the FERC. Market participants should also be involved in the market governance. The issue at hand was their role and authorities.
- In the power pools of the North-East market participants (vertically integrated utilities) have long term relationships with regional dispatch centers that operated power systems. These centers were accountable to the organization of participants, and their managers were assigned by the energy pools members. Requirements for the independence of System Operators meant that this practice should be changed.
- In PJM the power pool was dismantled and an independent system operator was formed instead, as well as a new organization of market participants. Subsequently, the same arrangement was implemented in New York State.
- In New England, the power pool “NEPOOL” was preserved, but a dispatch center was separated and became a system operator called “ISO-NE”. The power pool then contracted the ISO to perform functions stipulated by FERC’s Order 888. Later on, FERC was not satisfied with this situation, and the PJM model was introduced in New England as well, but the power pool was maintained.
- In the State of California, everything had to be started from scratch, and a lot of mistakes were made. (This is a whole separate story in itself).

Who Governs Independent System Operators

- Independent System Operators are normally not-for-profit organizations and governed by Board of Directors. In-between meetings of the Board of Directors the Executive Director manages the work of System Operator.
- The number of directors may vary. For example, there are 10 directors at ISO-NE , including the Executive Director who does not the right to vote. There are 8 directors at PJM.
- Directors should not be affiliated with any market participants and should have senior level work experience in the energy related sectors, such as, economy, finance, information technologies, legal practice.
- Directors are recruited by specialized personnel recruiting organizations and candidates are presented to the nomination committee. The Market Participants' Committee review the candidacies and presents its opinion to the Board of Directors.
- System Operators are funded from the tariff approved by the FERC. The tariff is calculated on the basis of the budget that has been coordinated with the market participants organization.

Rights to submit proposals to FERC

- Under the Federal Power Act all proposals regarding tariffs submitted for approval to FERC shall be classified into two groups. Those aimed at changing tariffs with the purpose of their improvement (Section 205 of the Act) and those aimed to change existing tariffs that allegedly are not consistent with the principle of being “fair and reasonable” (Section 206 of the Act). Proposals under Section 206 can be submitted by any party. But the right to amend tariffs under Section 205 are not granted to everyone.
- Market rules as well as changes and additions to them must be submitted in compliance with Section 205. These rights are granted to System Operators. But this does not mean that these rights are unlimited.
- For example, grid owners can have a right under Section 205 with respect to tariffs for network services cost recovery.
- Before using this right the System Operator must submit draft new rules or amendments to existing rules to market participants for their approval. The following slides will demonstrate how a decision is made.

Coordination Procedure Between the Market Participants' Organization and ISO

- On the first stages of market formation only parties that were a wholesale market participants – generators, transmission companies, distribution companies, suppliers – had a right to become a member market participants' organization. Subsequently this right was given to retail consumers as well.
- All members of the participants' organization were divided into relevant sectors depending on a participant's profile. For example, market participants in New England are divided into 6 sectors: generators, grid companies, suppliers, municipal power companies, alternative power sources and retail consumers.
- Voting on proposals is implemented by sectors, with each sector having 16.7% of total votes. The result of the vote is determined by number of votes received during the voting process in each sector.
- The proposal was considered as having passed, if it received 67% of positive votes.

Operation Procedure of Market Participants' Organization

- As mentioned above, all participants are divided into relevant sectors for the decision making voting
- Technical work is performed in committees. There is a Committee of Participants having authority to submit recommendations to ISO and the following Technical Committees accountable to the Committee of Participants:
  - On market operations
  - On transmission networks operation issues
  - On reliability issues
  - On financial issues
- Recommendations adopted by Technical Committees shall be submitted for approval to the Committee of Participants
- Subcommittees and working groups can be organized under Technical Committees, if necessary. Formal voting is implemented only in committees.
- All Technical Committees are chaired by ISO employees.

Legal Formalization of Relationships Between ISO and Market Participants

- The legal basis that underpins relationships between market participants and ISO includes two principal agreements:
  - Agreement on Market Participation (signed by all market participants)
  - Agreement on transfer of bulk power transmission systems to the operational management of ISO (signed by ISO and transmission asset owners)
- The Agreement on Market participation outlines all aspects of relations between ISO and market participants, including rights and duties and tools of control of System Operator for market participants. These agreements are usually model agreements.
- Agreements on transfer of bulk power transmission systems to the operational management of ISO can include provisions specific to each particular grid owner. Among other things these agreements specify the conditions under which the grid owner can revoke the right of a system operator for operational management of its grids. This is the most difficult issue to be resolved in reaching agreement. A few years ago grid owners disputed PJM's proposal that a grid owners can terminate agreements on grid transfer to operational management only if the organization of market participants approves such decisions. FERC supported PJM on this issue but the court subsequently annulled FERC's decision.

ISO Responsibilities with respect to Market Monitoring

- Market monitoring to prevent or mitigate the exercise of market power is FERC's prerogative.
- Each ISO has an internal market monitor accountable to FERC on monitoring and keeping track of market operations.
- Internal monitor reports to the ISO management only on administrative issues. But in executing its official duties the internal monitor reports only to FERC.
- Internal monitor has the right to ask market participants for an explanation, if in his opinion the price offers submitted by a participant show signs of non-competitive behavior. If the monitor is not satisfied with participant's explanation then the monitor has a right to request that participant change its offer or monitor can himself change the price offers in question.
- Internal monitor does not have a right to impose punitive sanctions, which is FERC's prerogative.
- ISO Board of Directors usually has an "external" independent monitor that provides advice to the Board of Directors on the issues of market operation.
- Issues related to the suspicion of collusion are not under jurisdiction of FERC but must be submitted to the Department of Justice.

Control over ISO Activities by the Market Participants

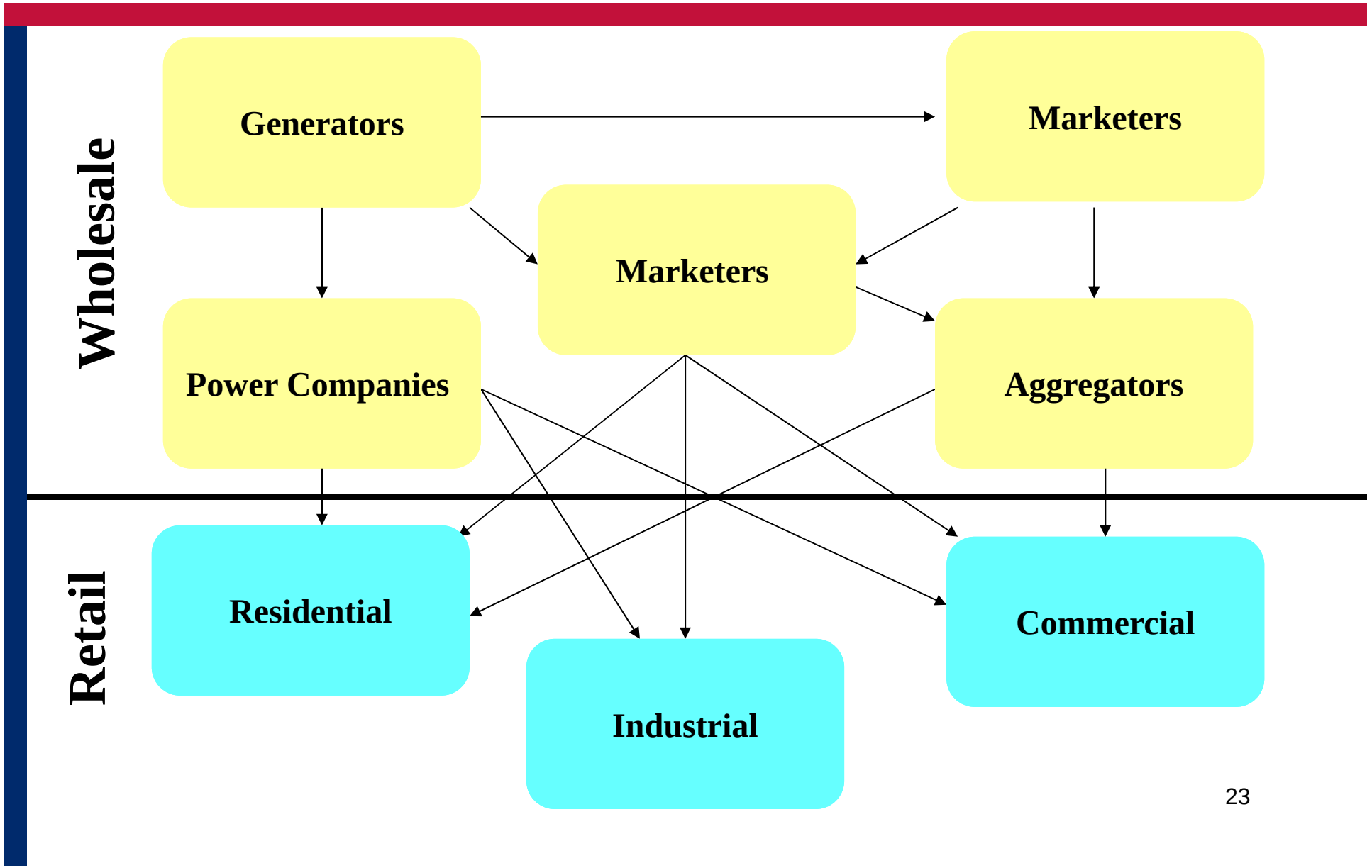
- Market participants may address the employees of the System Operator in the everyday operation and receive explanations on the issues of concern.
- No complaints against the actions of operating personnel of the System Operator in real-time mode are accepted. Market participants must strictly follow instructions of the System Operator personnel related to the mode of operation.
- The agreement on market participation envisages that the System Operator is periodically audited by independent auditors. All complaints regarding decisions made by the System Operator may be reviewed during the audit process.
- ISO Board of Directors or its representatives must have regular meetings with market participants. Meetings may be held as the General Meetings, or as meetings with the representatives of specific sectors.
- In the process of budget formulation the System Operator should have the participants review the budget, and consider the comments by the participants before submission to FERC.
- Market participants have voting right to approve the nominees to the Board of Directors. For example, in New England, if at least 70% of participants vote against the nominated candidate, the nomination committee must provide another candidature.

Market Model Use

Commercial Products

- Trading products in markets of PJM and New England:
  - Electric energy
  - Installed capacity
  - Ancillary services :
    - Operating reserves (spinning and non-spinning)
    - Ability for and Automatic Load-Frequency Control (AGC)
    - Forward market of capacities of “quick start” (In New England)
  - Financial Transmission Rights

Market Participants



Market Models: Electric Energy

- In principle the electricity market models of PJM and New England are similar
- Electric energy may be sold/bought through bilateral contracts and on a spot market
- Demand and supply on a spot market are based on competitive offers and bids of sellers and buyers
- Two-tier settlement system:
  - the Day-Ahead Market – financial;
  - Real-Time, where deviations from the DAM are traded.

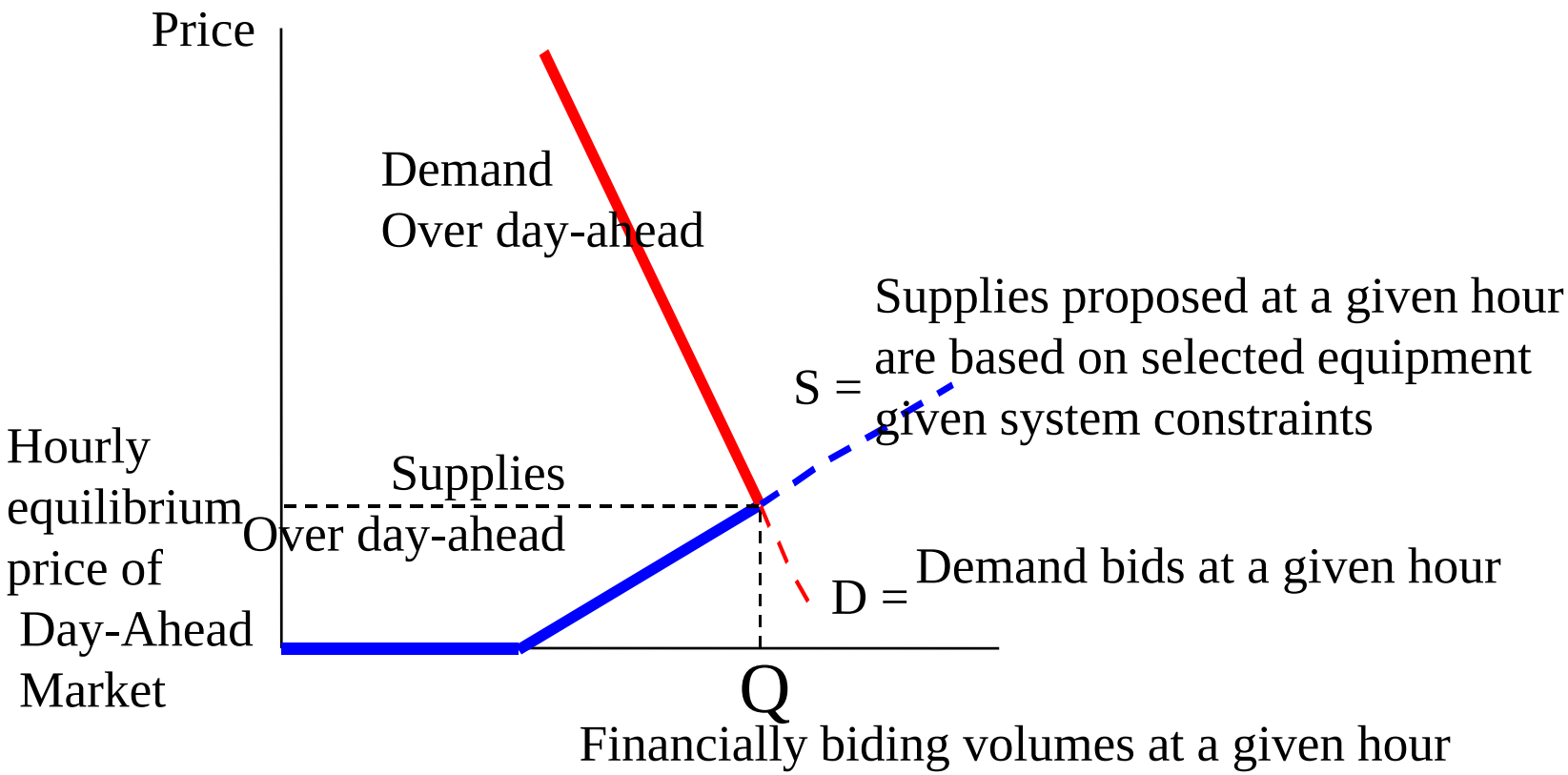
Market Models: Electric Energy, continued

- Sellers may (but are not obligated to) submit competitive price bids only in the Day-Ahead Market
- Price basis is location marginal nodal prices
- Generators get location marginal nodal prices calculated at nodes of connection
- Consumers pay prices averaged by a load area
- Nodal prices are calculated hourly, divided into 3 components – energy, congestion, load.
- The objective of this model is to have electricity prices reflect system constraints
- A specific aspect of this model is that, as a rule, the amount of payments made by loads exceeds the amount of payments to generators, thus a fund of nodal prices difference (congestion fund) is formed.

Systems of Multi-Tiered Settlement

- Initially there are two markets – Day-Ahead and Real-Time Markets
  - Current day market and Hour-ahead Market may be added later
  - Separated from bilateral contracts
- Day-Ahead Market
  - Resources and demand submit offers and bids
  - Clearing nodal prices are determined
  - Volumes of supply and demand are fixed and binding
- Real-Time Market
  - Real-time prices are calculated in the process of cost minimization by selection of additional operating equipment and dispatching
  - Difference in volumes of Day-Ahead and Real-Time Markets is calculated at real-time clearing prices

Financial Liabilities in Day-Ahead Market



Settlement

For Generators

	DA (MWh)	RT (MWh)	Difference (MWh)	DA Revenue or Payment	RT Revenue or Payment	Total
Gen. 1	50	90	**40**	50*30 = $1500	**40*45 = $1,800**	**$3,300**
Gen. 2	40	0	**–40**	40*30 = $1200	**–40*45 =–$1,800**	**($600)**
Load A	–50	–50	0	–50*30 = ($1500)	0	($1,500)
Load B	–40	–40	0	–40*30 = ($1200)	0	($1,200)
Price($/MWh)	$30	$45				

For Loads

	DA (MWh)	RT (MWh)	Difference (MWh)	DA Revenue or Payment	RT Revenue or Payment	Total
Gen. 1	50	50	0	50*30 = $1500	0	$1,500
Gen. 2	40	50	**10**	40*30 = $1200	**10*40 = $400**	**$1,600**
Load A	–50	–50	0	–50*30 = ($1500)	0	($1,500)
Load B	–40	–50	**-10**	–40*30 = ($1200)	**-10*40 -$400**	**($1,600)**
Price($/MWh)	$30	$40				

Congestion Management
Locational Marginal Nodal Prices

Congestion Management Using the System of Marginal Nodal Prices

- Different prices at each node
- Price differences may reflect marginal losses
- Price differences reflect management of transmission constraints
- Prices are, as a rule, less in exported regions and higher in imported regions
- Each participant sells/buys at its local prices
- Funds paid by purchasers are usually higher than funds paid to suppliers. The difference reflects cost of congestion and used in the hedging mechanism

Location Marginal Prices (LMP)

Load = 1,000 MW

Generation = 500 MW @ $10

500 MW @ $15

500 MW @ $20

(additional power available at @ $20/MWh)

LMP = $20/MWh

Load = 600 MW

Gen. = 100 MW @ $30

(additional power available @ $30/MWh)

LMP = $30/MWh

LMP = Location Marginal Price reflects the cost of supply of additional MW of Load at a node

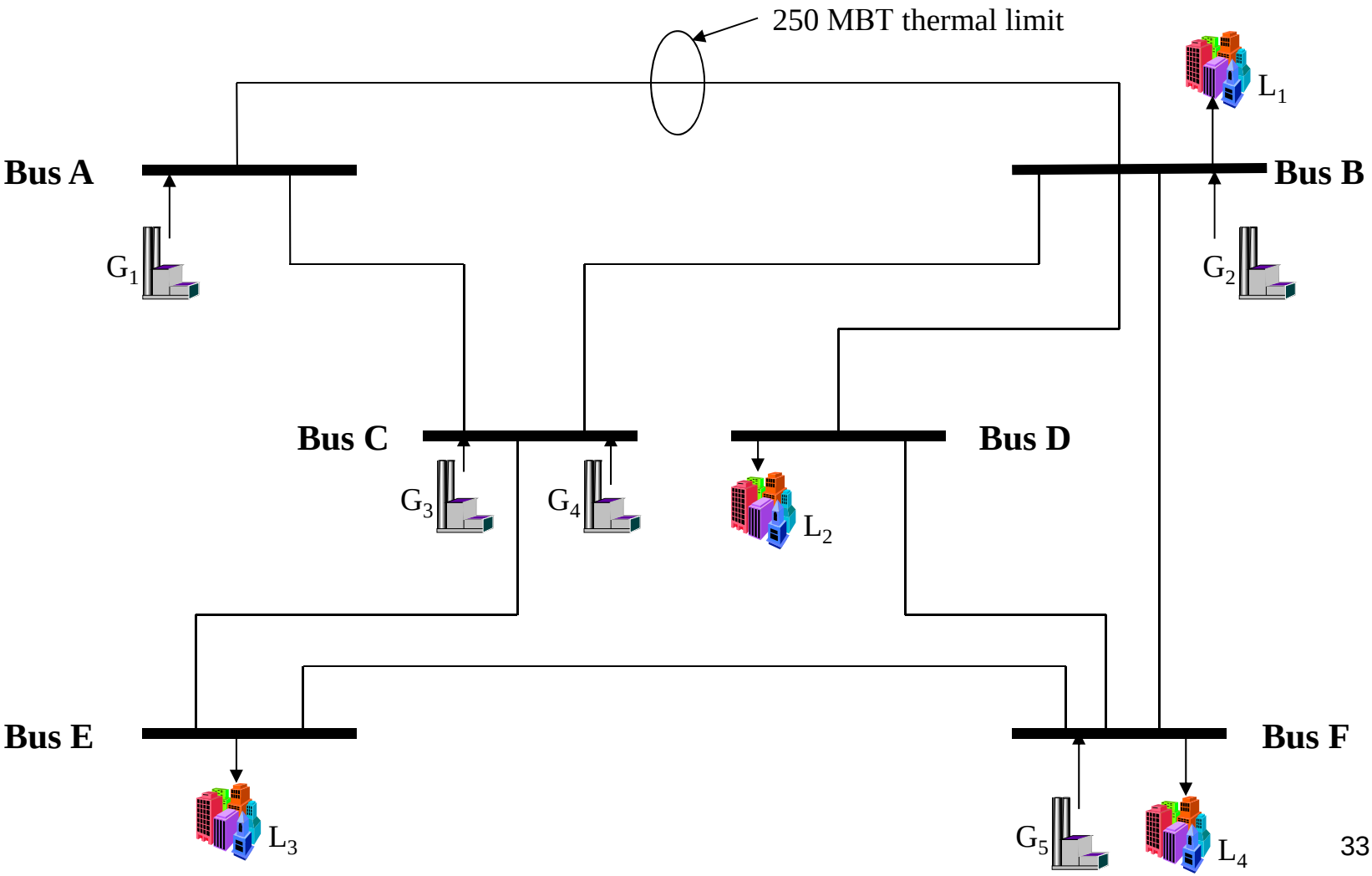
Example of Settlement

Location A: LMP = $20/MWh			Location B: LMP = $30/MWh		
Entity	**MW**	**Revenues**	**Entity**	**MW**	**Revenues**
Load	1,000	($20,000)	Load	600	($18,000)
Generation	1,500	$30,000	Generation	100	$3,000
Total		$10,000	Total		($15,000)

Market operator collected $5,000 more from Loads than paid to Generators.

$5,000 reflects a part of the process of constraints hedging

Example of Illustrative Power System



Example of Nodal Prices

- 6 buses – A - F
- 4 Loads – L_1 - L_4
- 5 Generators – G_1 - G_5
- 8 Transmission Lines
- 250 MW thermal limit under line A-B
- Discount the losses
- A company serving the Load (LSE) has:
  - Obligation to serve up to 110 MW of Load L_1 at bus bar B;
  - Contracts (RTO is aware only about the number of MW) for purchase of 100MW supply @ $15/MWh from G_1 to A and everything exceeding 100 MW from G_5 to F @ $30/MWh; and
  - 100 MW FTR from A to B, but has no FTR from F to B

  Effect of these transactions is demonstrated at the end of each example.

Key Features of the Model

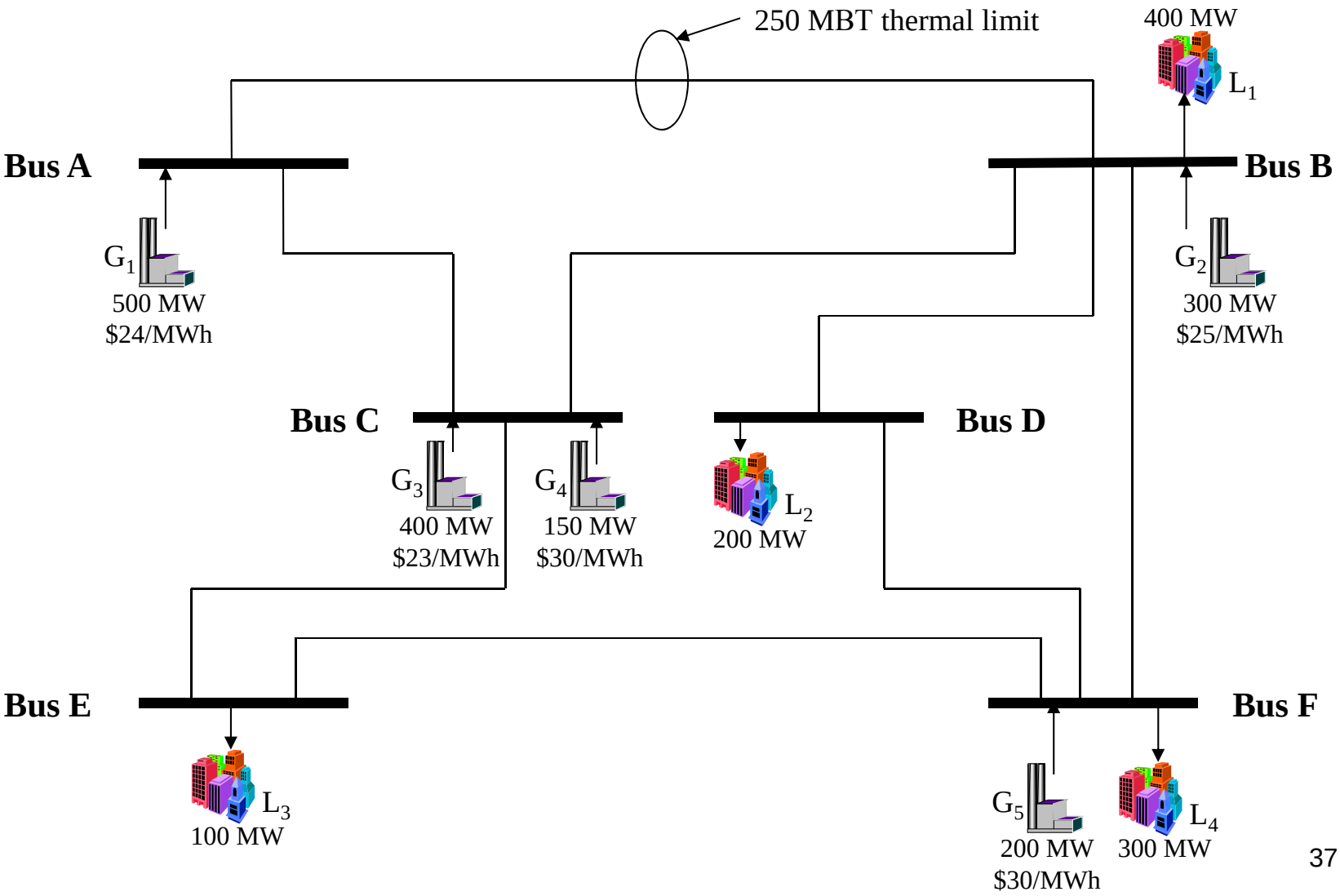
- Generators
  - Each has 5 marginal prices (see table)
  - Next chart shows only the price of the last unit
  - Each Generator may dispatch throughout the entire range
- Load Entities:
  - Uninterruptable and without price regulation
  - L_1 at B will be then increased to create constraint
- Transmission network
  - Line from A to B is close to limit

Generators Data

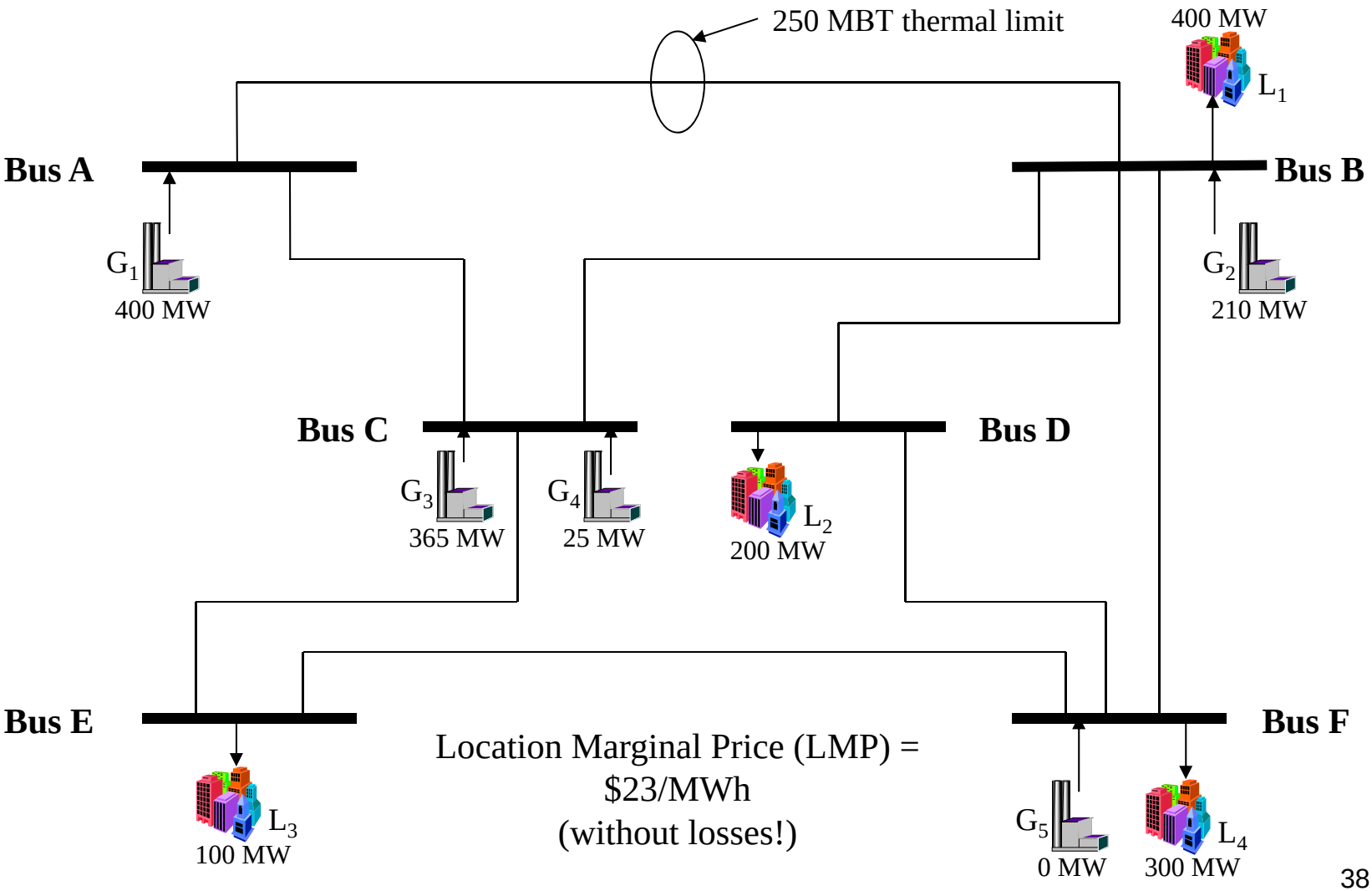
Unit-by-Unit Linear Characteristics

	G1		G2		G3		G4		G5	
	MW	$/MWh	MW	$/MWh	MW	$/MWh	MW	$/MWh	MW	$/MWh
Point 1	0	16	0	21	0	14	0	22	0	26
Point 2	101	18	76	22	101	16	26	24	51	27
Point 3	201	20	151	23	201	18	76	26	101	28
Point 4	301	22	226	24	301	20	101	28	151	29
Point 5	401	24	276	25	351	23	126	30	176	30
Max MW	500		300		400		150		200	

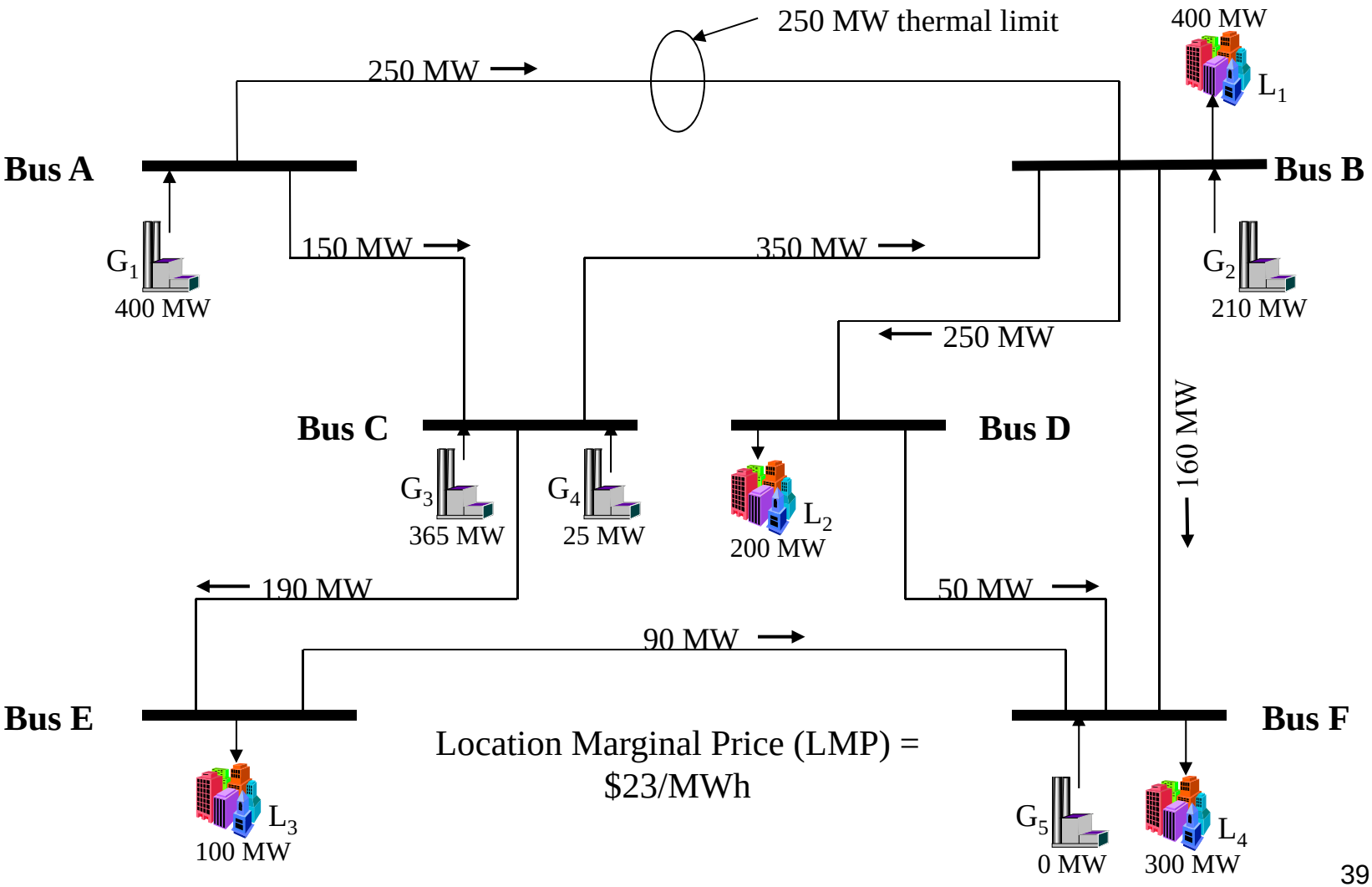
Specifics of Generators and Load Enterprises



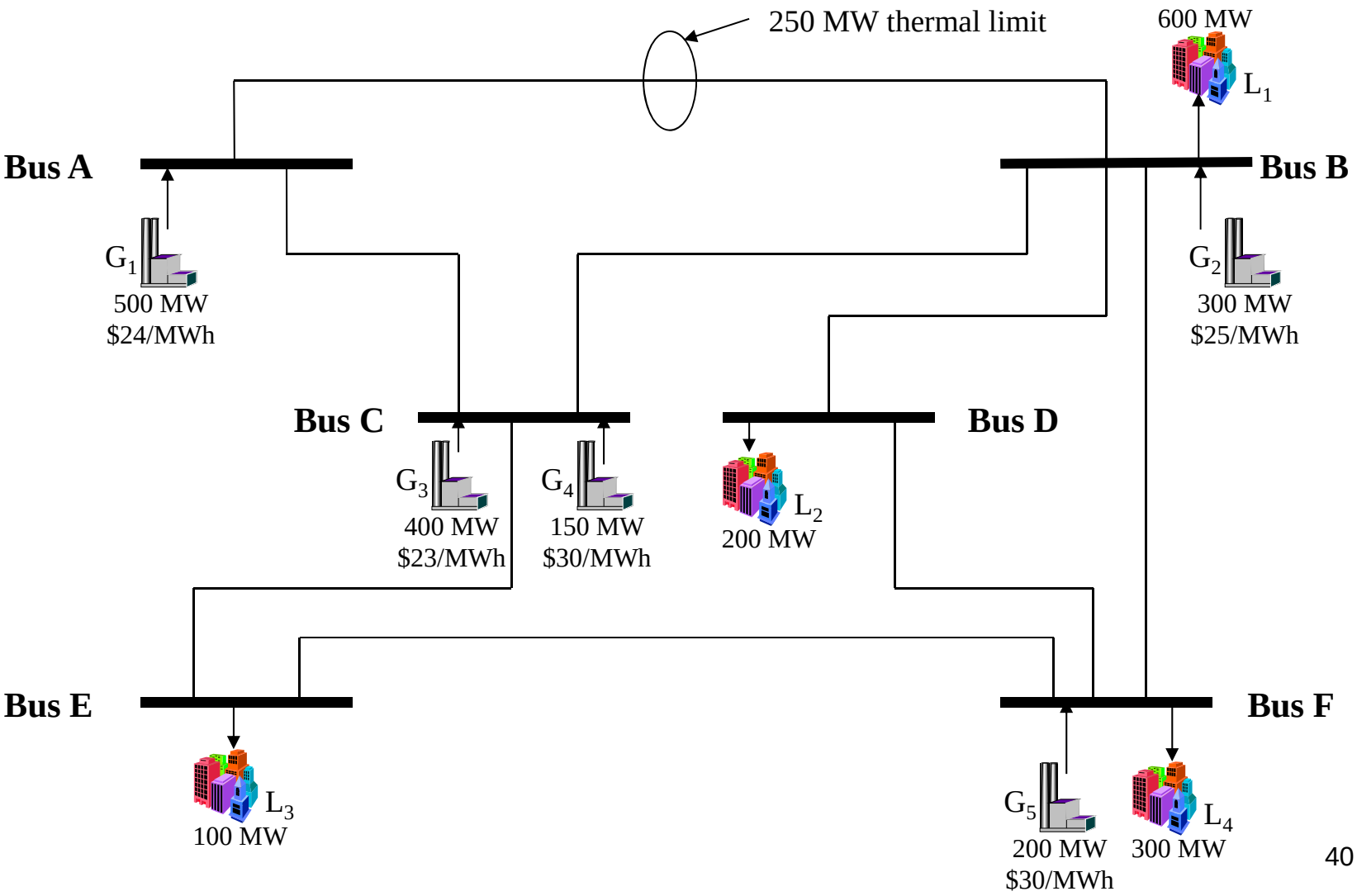
Economic Dispatch



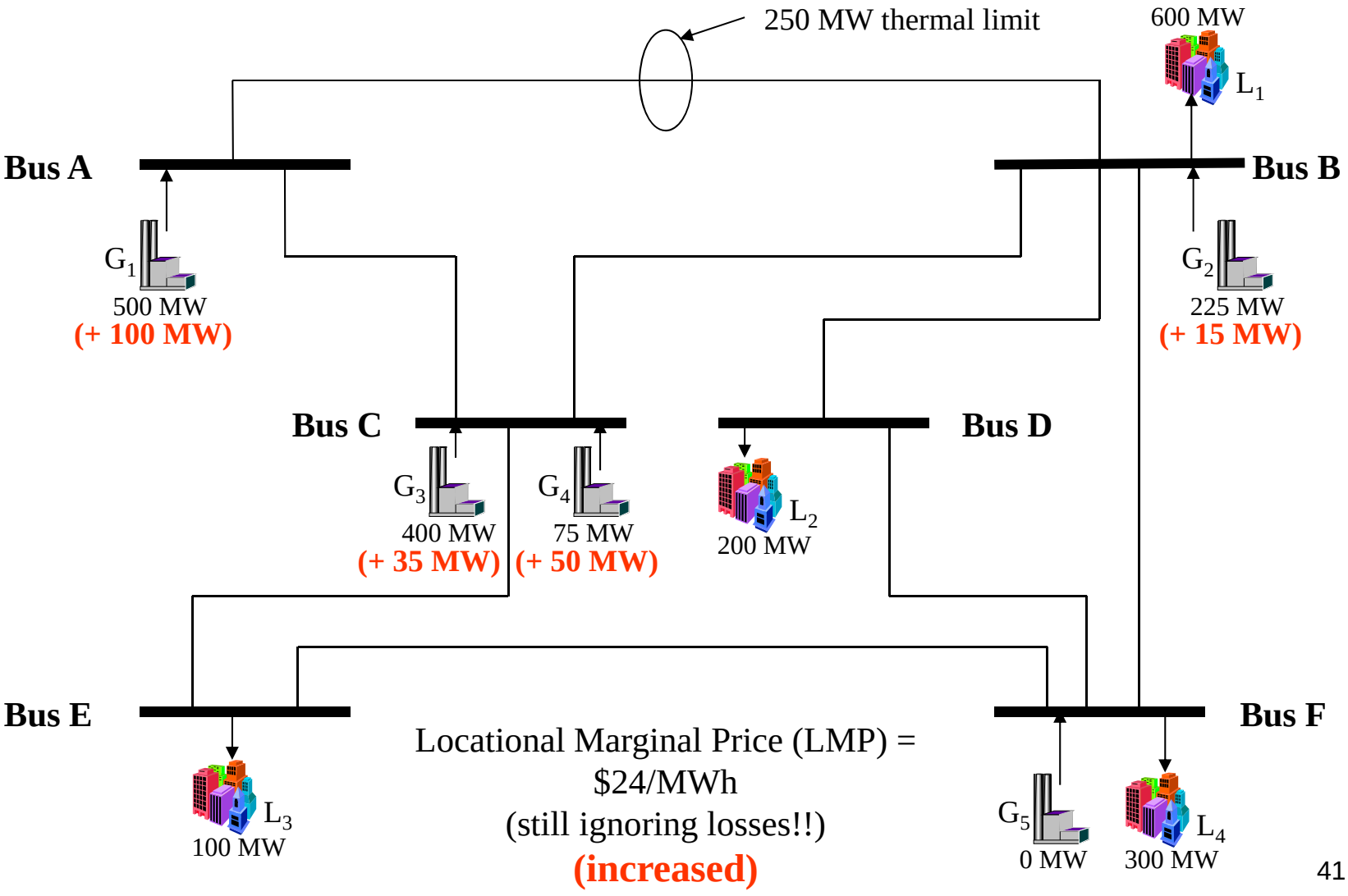
Resulting Flows



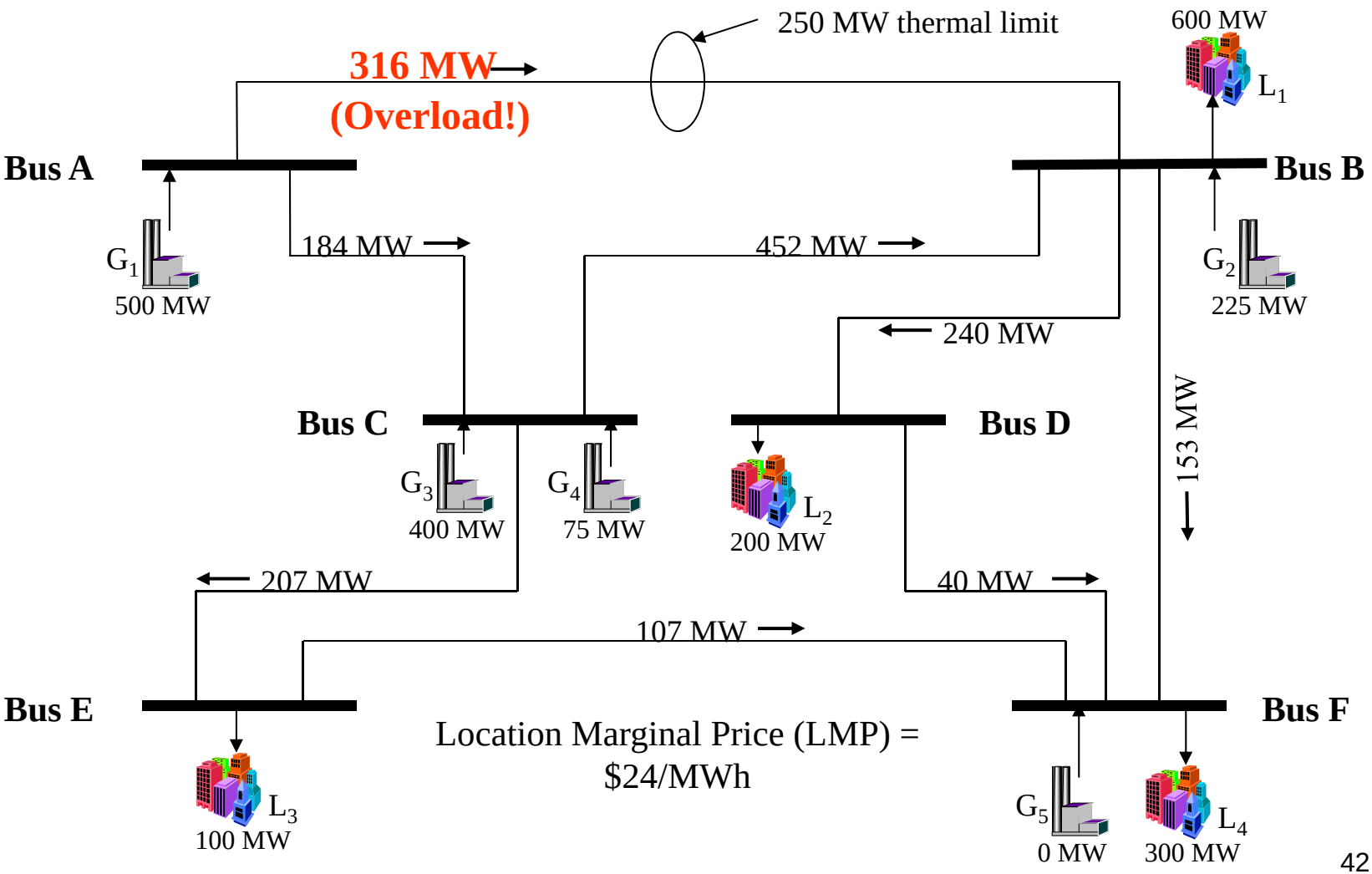
New 200 MW load connected to B



Economic Dispatch (Without Transmission Constraints)



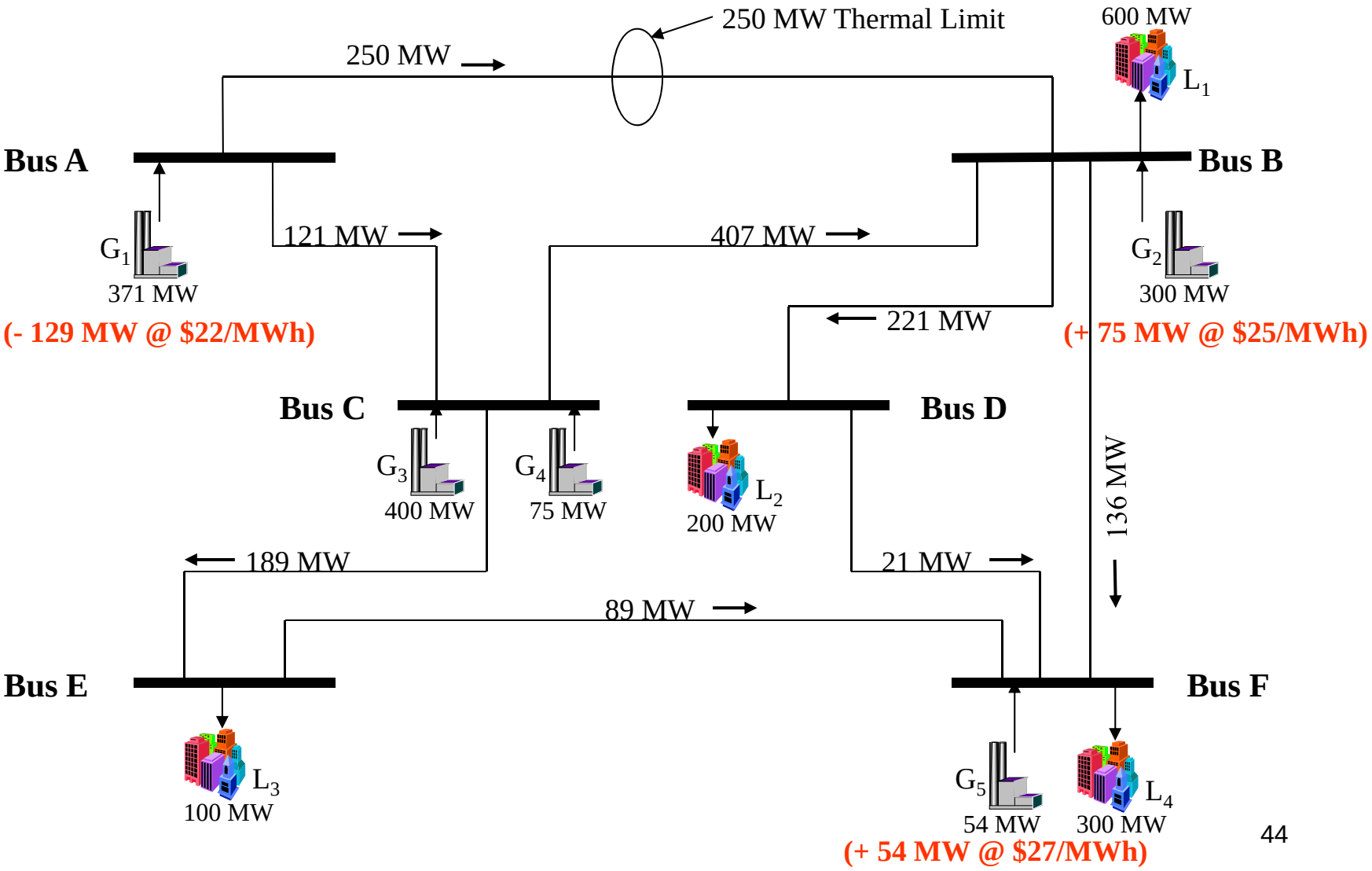
Resulting Flows



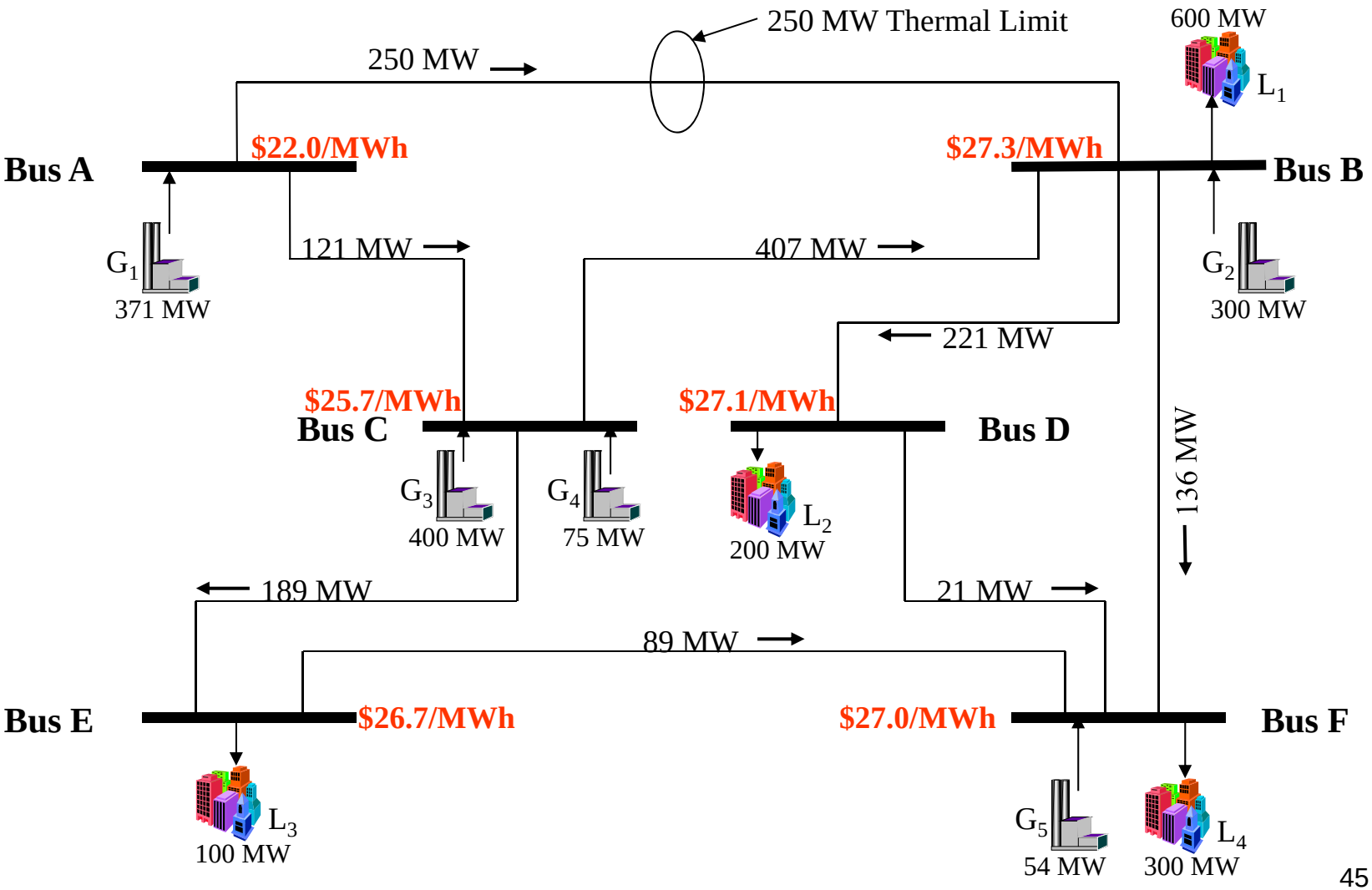
Results of Economic Dispatch without Transmission Constraints

- Line from A to B is overloaded
  - Flow 316 MW at limit of 250 MW
- It is necessary to comply with limit at 250 MW
- What will happen:
  - G_1 should be unloaded with relevant generation increase at G_2 and G_5
  - General “cost” of production based on offers will increase
  - Nodal prices will not be the same at each node
- The objective is to minimize total “cost” of production without violating transmission constraints

Dispatch Reflecting Transmission Constraints (differences from “clean” dispatch)



Nodal Prices at dispatch reflecting constraints



Market Models: Financial Transmission Rights

- “Financial Transmission Rights” allow market participants to hedge risks related to difference of nodal prices at sale and purchase points.
- Financial Transmission Rights are sold by system operators in the process of auctions
- Owner of Financial Transmission Right from node A to node B has the right for difference between congestion components of nodal prices in these nodes.

Resource Adequacy and Installed Capacity Markets

Market Models: Installed Capacity

- A market for installed capacity is designed to ensure resource adequacy by allocating responsibility to consumers for their consumed capacity and making payments to generators
- This allows generators to cover fixed costs
- Obligations of consumers are established based on criteria of long-term reliability: this is the expectation that loss of load because of lack of installed capacities should not exceed 1 day in 10 years
- In both PJM and New England ISOs a new market of installed capacities is based on forward auctions for three years, while forms of auctions vary.

Ancillary Services

Market Models: System Services

- System services are provided by participants both on a competitive and non-competitive basis
- Cost of provision of system services by transmission entities are reflected in their tariffs
- Services for voltage regulation, restoration of the system after collapse are usually paid off based on actual expenses
- Services for provision of operating reserves, participation in work of Automatic Generation Control (AGC) are paid on a competitive basis
- In New England forward competitive auctions for purchases of “Quick start” capacities are conducted

Competitive Market and Reliability

- Within the first years of operation of electricity markets there were concerns that competition may have a negative impact on reliability
- Practice proved that such concerns are unwarranted
- Overall level of generation availability increased
- While planning operating modes the ISOs strictly follow criteria “N-1” and “N-2”, if necessary
- Centralized economic dispatch is performed taking into account system constraints
- The cost of eliminating constraints is reflected in market prices

Planning Power System Expansion in competitive market conditions

Prospective Planning of Power Systems Development

- Prospective planning of power systems development is a hard-to-implement function under competitive market conditions
- There was no clear definition of an organization responsible for this function
- The ISO organizes and implements the process of creating prospective plan of power system development
- This process is collaborative and involves all stakeholders
- Regularly, the results of this process are discussed at wider forums
- If proposed transmission grids development projects are approved their costs are reflected in the tariffs of transmission companies

Competitive Retail Markets

Retail Markets

- Within jurisdictions of PJM and New England all retail consumers have the right to choose their own electricity supplier
- Distribution grid companies ensure access for competitive suppliers to retail consumers and serve as the “last resource suppliers”
- In practice, the more transparent and the better operates a wholesale market, the greater the benefits for retail consumers

History of development of the regional market in Central Asia.

Possibilities to use elements of advanced electricity markets in Central Asia

Central Asian Power System

Background

- Under the USSR CA UPS was the last united power system which formed the Unified Power System (UES)
- It operated as control area which was mostly functioned in an isolated mode under dispatch control by the United Dispatch Center of Middle Asia located in Tashkent (now – CDC “Energiya”)
- It included the national power systems of Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan and power facilities of Southern Kazakhstan

Relatively New History

- After collapse of the USSR CA UPS was the only system out of international power systems of former USSR, which preserved parallel operation and continued to operate as united power system.
- The Regional Coordinating Council consisting of representatives of all power systems was formed
- Middle Asia United Dispatch Center became ODC “Energiya”. ODC activity was guided by the Coordinating Council

Is CA UPS ready for a regional market?

Correct answer: yes and no

Arguments for “Yes” :

- To some extent, the regional market functions:
  - History of joint operation
  - Transboundary bilateral trade
  - Parallel Operation Agreements
  - Transit and Regulating Capacity Payment Agreements
  - Cooperation of market participants from different countries
  - Quite competent professional staff
  - Relatively advanced electricity market of Kazakhstan including the centralized trading platform
  - Declared intention by Kazakhstan to promote an international power exchange
  - Coordination of water and energy interests

Is CA UPS ready for a regional market? (2)

- Arguments for “No”:
  - Policy and deficit of trust
  - Narrow understanding of the concept of energy security, which creates obstacles to the introduction of centralized economic dispatch and achievement of significant fuel saving
  - Inadequacy of operating and technological and market rules, both at regional and local levels
  - Weakened dispatching authorities of CDC “Energia”
  - Cases of discrimination in granting access to the grid
  - Unsettled disputes
  - Coordination of water and energy issues
  - The newest history

The newest History

- 2003 – Turkmenistan exits from parallel operation
- 2007 – CDC “Energia” was finally registered in Uzbekistan as an international organization:
  - For some time, it provided better financial stability for the CDC, but:
  - Dispatching authorities were lessened
- Violations of dispatching discipline became regular and resulted in the following:
  - In 2009 Uzbekistan announced its intention to exit from parallel operation
  - In 2011 Tajikistan was completely disconnected from parallel operation
  - In the past, Kazakhstan exited from parallel operation several times, and lately has threatened to of exit on a permanent basis
  - The method for settlement of payments for unplanned (unauthorized) power flows has not been developed yet
  - Funding for CDC “Energia’ had been sharply reduced, since only three power systems, which remain in the parallel operation and they have not increased their payments to CDC to compensate for funds that were formerly paid by Tajikistan
  - In the autumn-winter peak load CA UPS operates in emergency mode most of the time

Is there a hope?

- It should be noted that over the period from 1997 to 1999, with USAID sponsorship a conceptual model of CA UPS regional electricity market was developed. This model was approved by the national power systems, but could not be implemented.
- Because of the above stated reasons, it is unrealistic to expect that such a model could be reproduced.
- However, there is intensive bilateral electricity trade going on
- Since in Kazakhstan a relatively advanced electricity market operates and electric energy and capacity can be sold on the KOREM's centralized trading platform, one of the ways for further development of the regional market is expansion of electricity trade from Kyrgyzstan based on the KOREM platform
- Investment opportunities for construction of new transmission facilities and new generating capacities are being considered
- Thus, it can be ssumed that if the national power systems of the region's countries where able to restore regional coordination and ensure operational reliability, a considerable potential for cross-border trade would emerge.
- A lot will depend on whether in the near future Kazakhstan, Kyrgyzstan, and Uzbekistan will sign the new, eforceable Agreement on Parallel Operation and appropriate agreements on transit, unscheduled power flows and others.

Questions?