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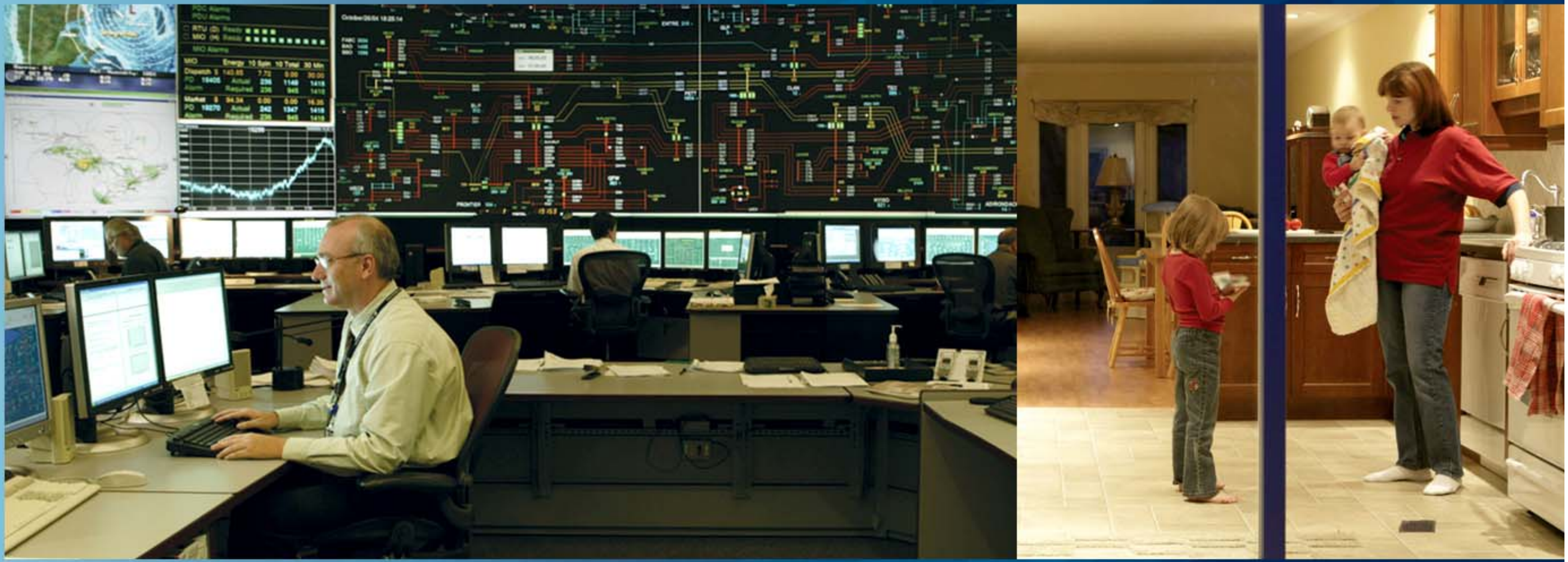
Economic Efficiencies

MPWG

December 6, 2006



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Agenda

- Discuss briefly working definitions for:
  - Productive efficiency
  - Allocative efficiency
  - Dynamic efficiency
- Work through examples for allocative and dynamic efficiencies as means to illustrate the concepts
- Discuss Going Forward

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Productive Efficiency Definition

- Productive efficiency is defined as using the least amount of resources to produce a given good or service. In other words, output is being produced at the lowest possible unit cost.
- A process that uses more of any input – labour, capital, or land – than the minimum needed to produce the given level of output suffers from productive inefficiency.

Allocative Efficiency Definition

Allocative efficiency is the market condition whereby resources are allocated in a way that maximizes the net benefit attained through their use. A market will be allocatively efficient if:

1. Output is produced by the lowest cost producers
2. Output is consumed by those most willing to pay for it and only when its value to the consumer is at least as great as the incremental cost of its production

Dynamic Efficiency Definition

- Dynamic efficiency relates to efficient technology choice and timely and efficient capacity investment decisions both on the supply side and the demand side of the industry.

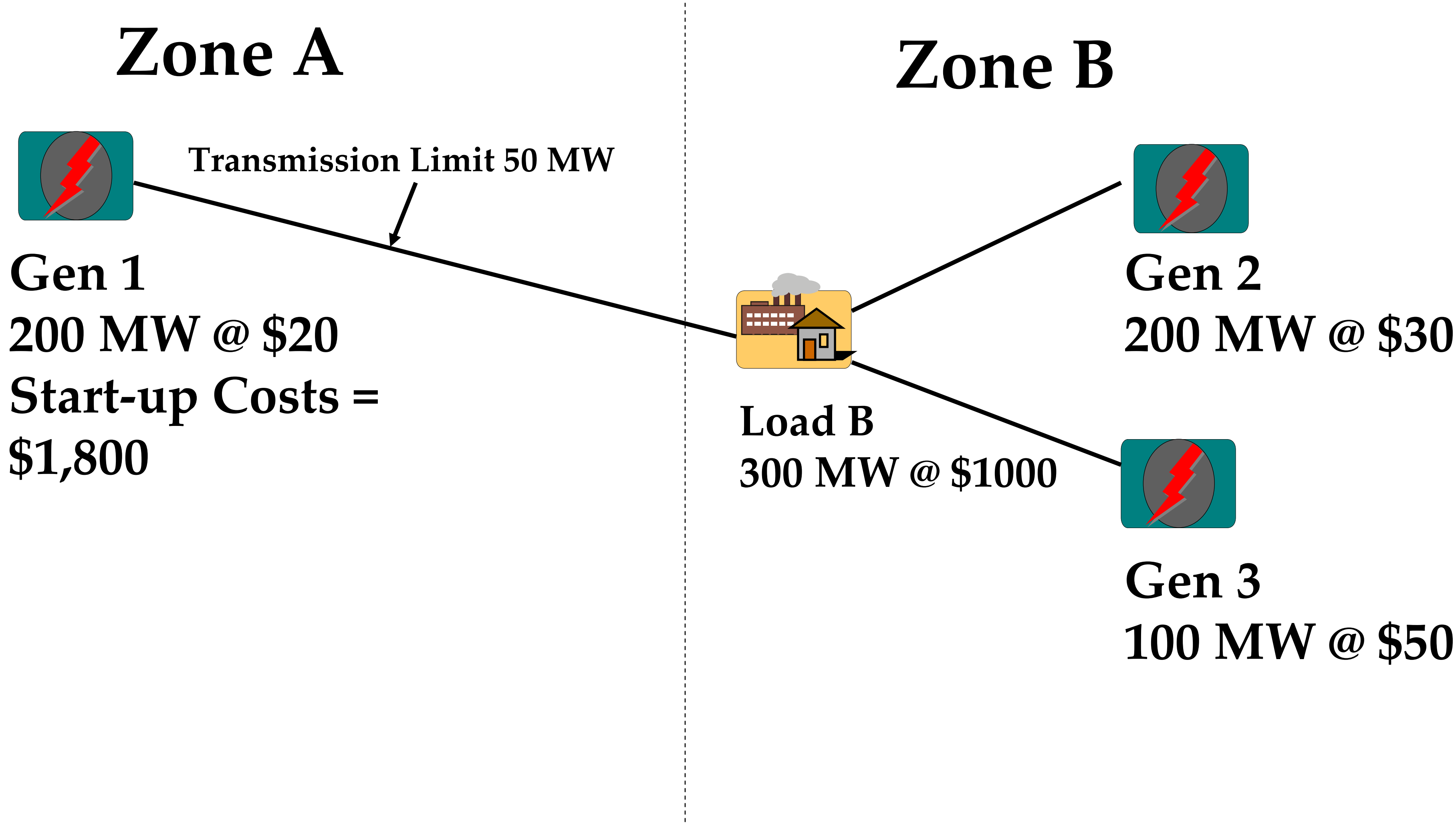
- Dynamic efficiency deals with the evolution of a more efficient mix of resources for the market over time.

Explaining Efficiency Through Examples

- Following examples will be used to illustrate allocative and dynamic efficiency concepts

- First example illustrates allocative inefficiency when electricity is not produced by lowest cost suppliers

Allocative Efficiency Example 1



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How to Calculate Welfare

- **Generator Welfare:**

  Production Benefit = Energy revenue plus uplifts less production costs

- **Load Welfare:**

  Consumption Benefit = Consumption value less total energy costs (includes positive or negative uplifts)

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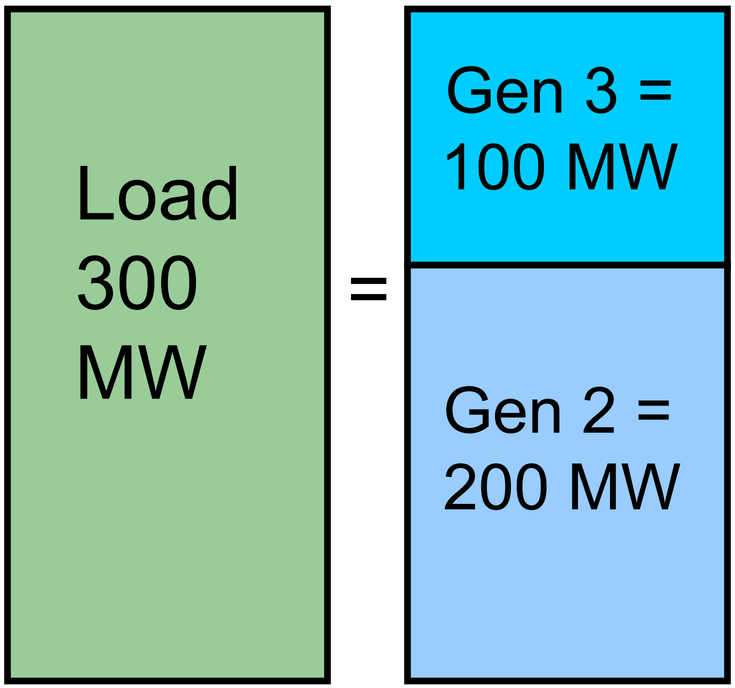
Defining Generator Marginal Cost

- Marginal cost of another unit = Marginal benefit gained from its consumption
- Gen 1 = Average incremental cost which includes any start up costs and/or transmission constraints:

  = ($1,800 + $20x50 MW) ÷ 50MW

  = **$56/MWh**
- Gen 2 = **$30/MWh**
- Gen 3 = **$50/MWh**

Allocative Efficient Outcome

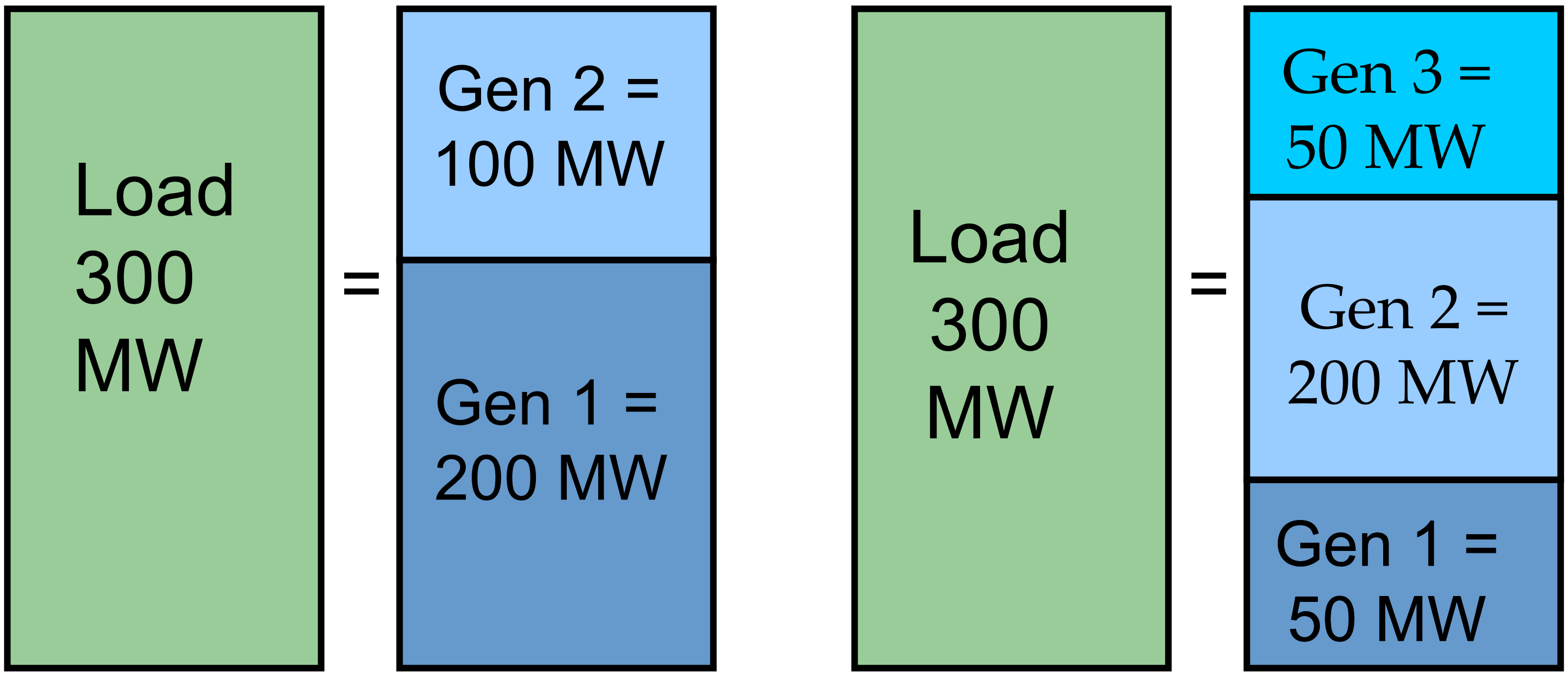


Stacking the MWs required by the generator’s costs from lowest to highest to meet the demand illustrates that Gen 1 should not run

- Marginal cost of producing another unit = Marginal benefit gained from its consumption

Uniform Pricing Regime Results - Example 1

Unconstrained Schedule **Constrained Schedule**



Ignores 50 MW Transmission Limit
HOEP = $30

Recognizes 50 MW Transmission Limit
Shadow Prices: Zone A = $20
Zone B = $50

Uniform Pricing Regime Welfare - Example 1

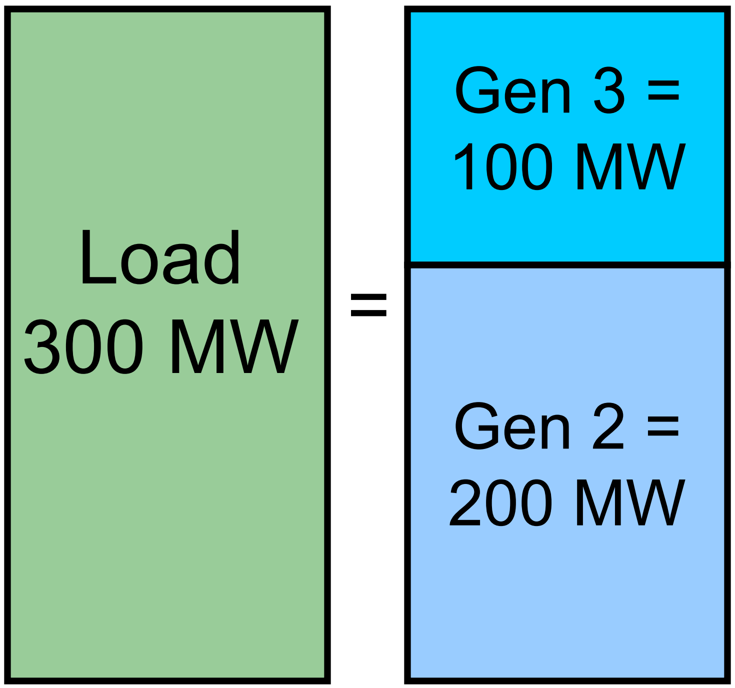
Generator Welfare						
	MS	CS	Energy Revenue	CMSC	Production Cost	Welfare
Gen 1	200	50	$1,500	$1,500	-$2,800	$200
Gen 2	100	200	$6,000	$0	-$6,000	$0
Gen 3	0	50	$1,500	$1,000	-$2,500	$0

Consumer Welfare					
	Consumption	Value of Consumption	Energy Cost	Uplift	Welfare
Load A	300	$300,000	-$9,000	-$2,500	$288,500

MS = Market Schedule
CS = Constrained Schedule

Total Welfare = $288,700

Locational Marginal Pricing Regime Results – Example 1



- LMP recognizes constraints, the most Gen 1 will be scheduled is 50 MW
- Gen 1 covers costs of production only if LMP ≥ $56 MW (assumes no production cost guarantee program)
- LMP for Zone B = $50
- Gen 1 is not scheduled

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Locational Marginal Pricing Welfare - Example 1

Generator Welfare				
	Output	Energy Revenue	Production Cost	Welfare
Gen 1		$0	$0	$0
Gen 2	200	$10,000	-$6,000	$4,000
Gen 3	100	$5,000	-$5,000	$0

Consumer Welfare				
	Consumption	Value of Consumption	Energy Cost	Welfare
Load A	300	$300,000	$15,000	$285,000

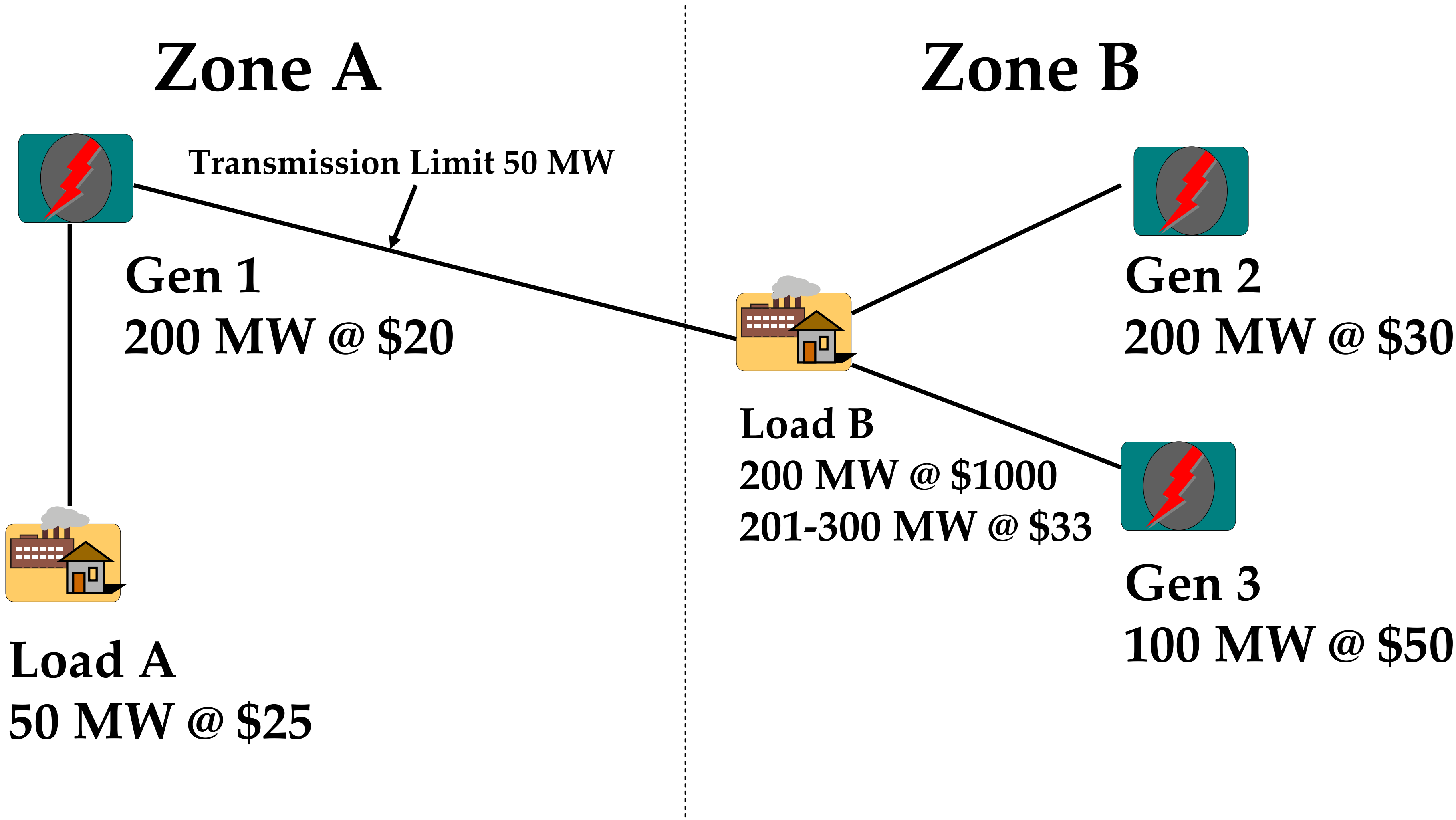
Total Welfare = $289,000
Increase of $300

Allocative Efficiency Example 2

- Second example to illustrate allocative inefficiency when consumption is inefficient

- Changed Assumptions:
  - Price Responsive Load in Zone A
  - There are no non-quick start generators

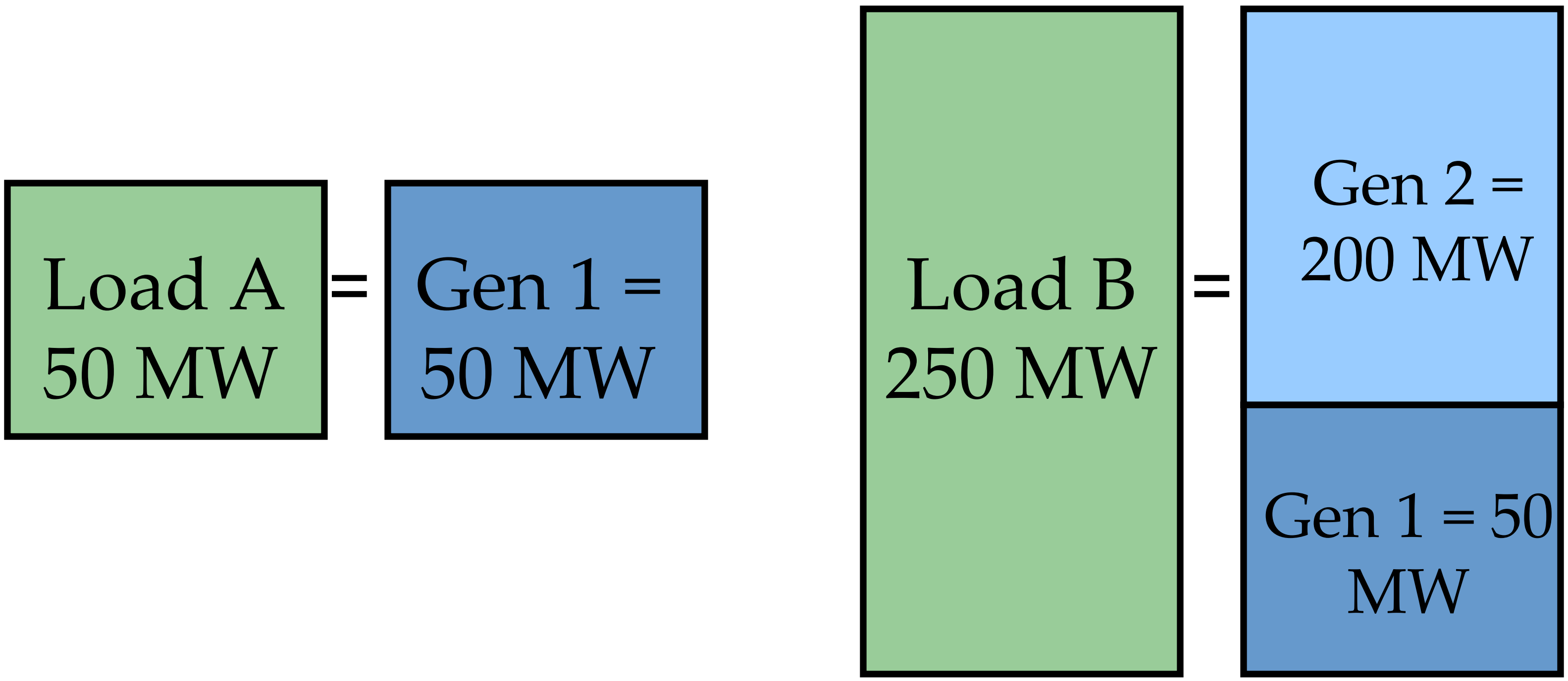
Allocative Efficiency Example 2



Allocative Efficient Outcome

- Marginal cost of another unit = Marginal benefit gained from its consumption
- Marginal benefit to Load B = **$1000** MW (≤ 200 MW)
  = **$ 33** MW (201-300MW)
- Marginal benefit to Load A = **$ 25** MW
- Marginal cost of output:
  - Gen 1 = **$20 MW**
  - Gen 2 = **$30 MW**
  - Gen 3 = **$50 MW**

Allocative Efficient Outcome



Remaining 50 MW can not be supplied at a price ≤ Load B's net benefit – no more gain from trade can be realized

Uniform Pricing Regime Results - Example 2

Unconstrained Schedule

Load B 300 MW = Gen 2 = 100 MW + Gen 1 = 200 MW

Ignores 50 MW Transmission Limit

HOEP = $30

Load A ≠ Consume

Constrained Schedule

Load B 250 MW = Gen 2 = 200 MW + Gen 1 = 50 MW

Recognizes 50 MW Transmission Limit

Shadow Prices: Zone A = $20
Zone B = $33

Uniform Pricing Regime Welfare - Example 2

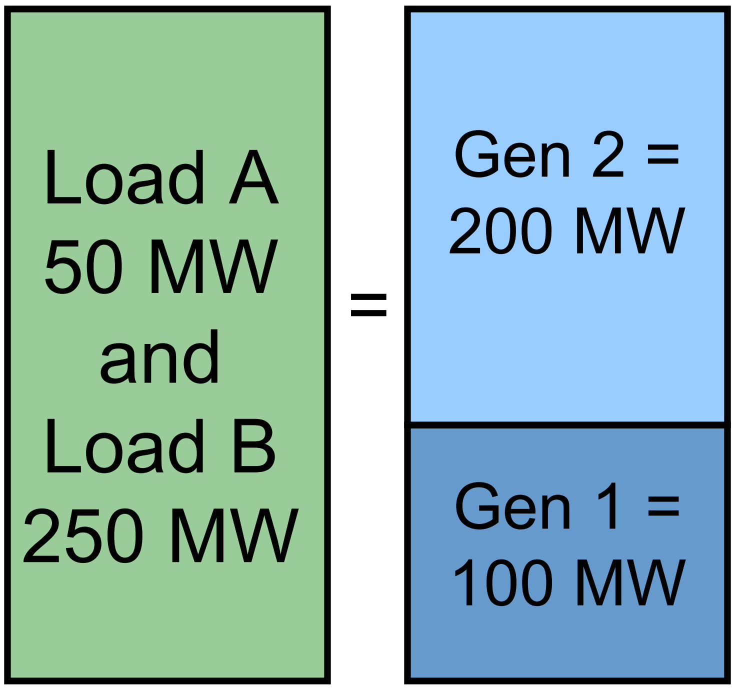
Generator Welfare						
	MS	CS	Energy Revenue	CMSC	Production Cost	Welfare
Gen 1	200	50	$1,500	$1,500	-$1,000	$2,000
Gen 2	100	200	$6,000	$0	-$6,000	$0
Gen 3	0	0	$0	$0	$0	$0

Consumer Welfare						
	Consumption	Value of Consumption	CMSC Revenue	Energy Cost	Uplift	Welfare
Load A	0	$0	$0	$0	$0	$0
Load B	250	$201,650	$150	-$7,500	-$1,650	$192,650

Total Welfare = $194,650

MS = Market Schedule
CS = Constrained Schedule

Locational Marginal Pricing Regime Results – Example 2



- LMP recognizes constraints but also that Load A marginal benefit is below Gen 1 marginal cost
- LMP for Zone B = $33 set by the dispatchable load
- Gen 3 is not scheduled

Locational Marginal Pricing Welfare - Example 2

Generator Welfare					
	Output	Energy Revenue	Production Cost	Congestion Rent	Welfare
Gen 1	100	$2,000	-$2,000	$650	$650
Gen 2	200	$6,600	-$6,000	$0	$600
Gen 3					$0

Consumer Welfare				
	Consumption	Value of Consumption	Energy Cost	Welfare
Load A	50	$1,250	-$1,000	$250
Load B	250	$201,650	-$8,250	$193,400

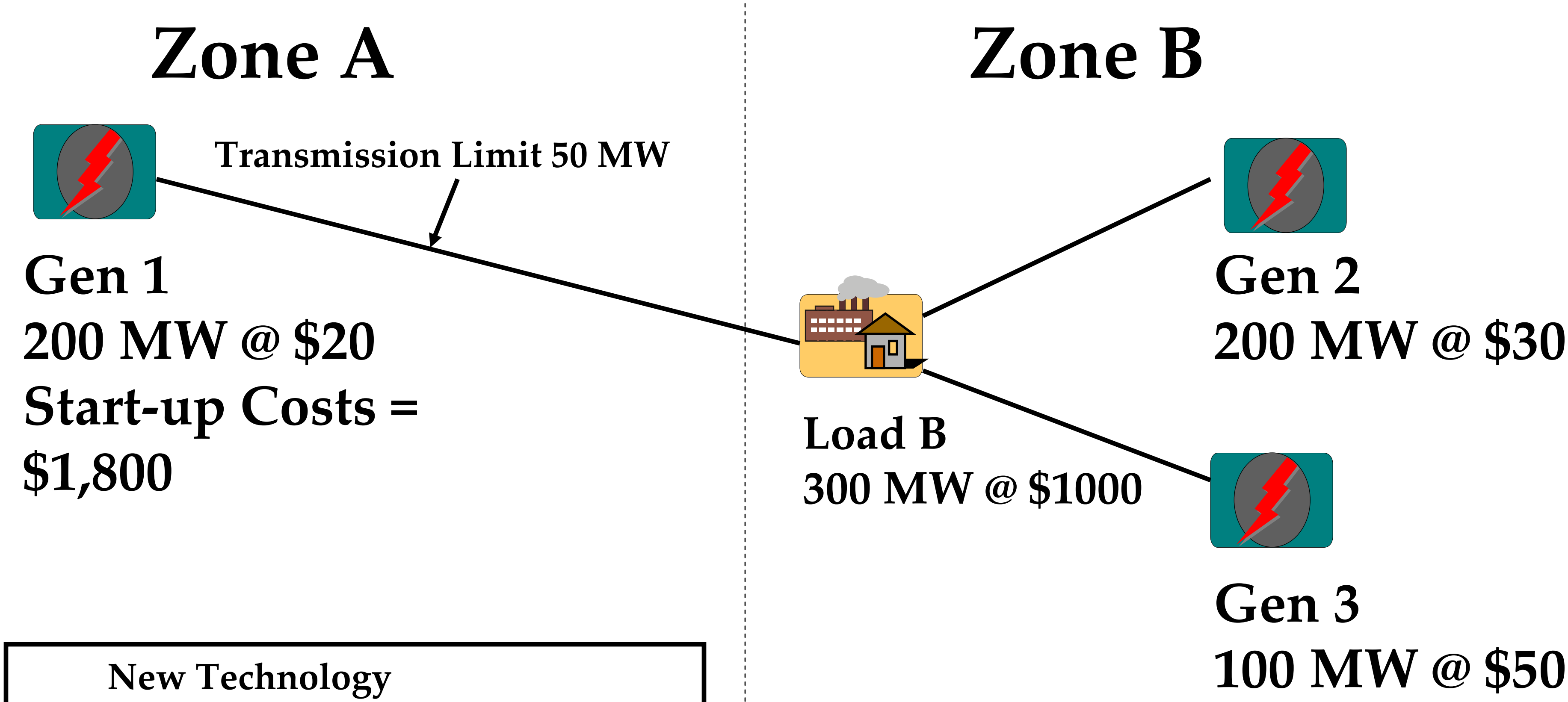
Total Welfare = $194,900
Increase $250

Dynamic Efficiency Example

- Third example to illustrate dynamic efficiency – looking at incentives for capacity investment

- Changed Assumptions:
  - Assume same market structure as example 1
  - New technology available that cost $5 per MW up to increase output of 5 MW

Allocative Efficiency Example 3



New Technology

Investment of $5 per MW up to increase output of 5 MW = $25 total investment

Allocative Efficient Outcome

- Gen 2 should invest in technology:

  Revenue – Investment cost = Investment Benefit

  ($50 -$30)x 5MW – ($5MW x $5) = $75

- Neither Gen 1 or Gen 3 should invest as both Gens have idle capacity, no benefit from capacity expansion

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Uniform Pricing Regime Results - Example 3

Unconstrained Schedule

Load 300 MW = Gen 2 = 95 MW + Gen 1 = 205 MW

Ignores 50 MW Transmission Limit

HOEP = $30

Gen 1 Invests

Constrained Schedule

Load 300 MW = Gen 3 = 50 MW + Gen 2 = 200 MW + Gen 1 = 50 MW

Recognizes 50 MW Transmission Limit

Shadow Prices: Zone A = $20
Zone B = $50

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Uniform Pricing Regime Results - Example 3

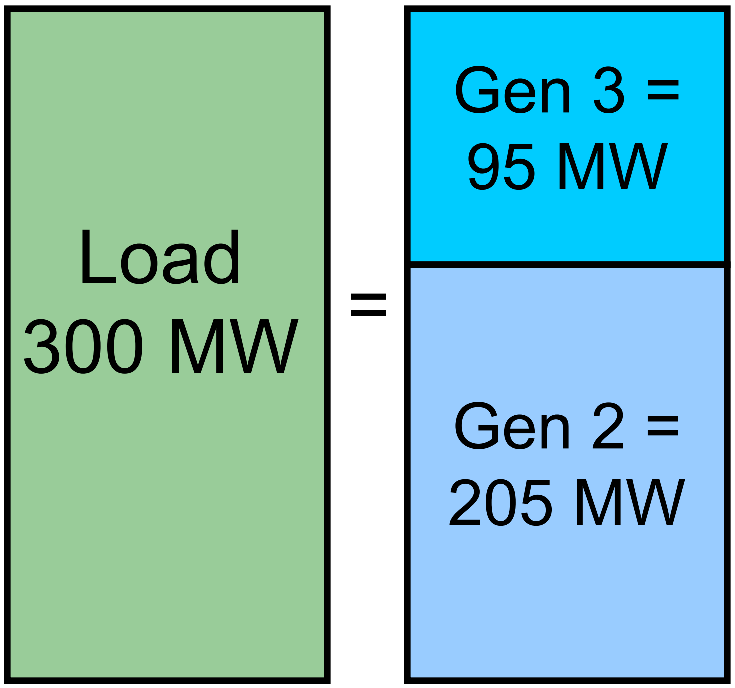
Generator Welfare						
	MS	CS	Energy Revenue	CMSC	Production Cost	Welfare
Gen 1	205	50	$1,500	$1,550	-$2,800	$225
Gen 2	95	200	$6,000	$0	-$6,000	$0
Gen 3	0	50	$1,500	$1,000	-$2,500	$0

Consumer Welfare					
	Consumption	Value of Consumption	Energy Cost	Uplift	Welfare
Load A	300	$300,000	-$9,000	-$2,550	$288,450

MS = Market Schedule
CS = Constrained Schedule

Total Welfare = $288,675

Location Marginal Pricing Regime Results – Example 3



- Gen 1 and Gen 3 have idle capacity and do not have an investment incentive

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Locational Marginal Pricing Welfare - Example 3

Generator Welfare				
	Output	Energy Revenue	Production Cost	Welfare
Gen 1		$0	$0	$0
Gen 2	205	$10,250	-$6,150	$4,075
Gen 3	95	$4,750	-$4,750	$0

Consumer Welfare				
	Consumption	Value of Consumption	Energy Cost	Welfare
Load A	300	$300,000	$15,000	$285,000

Total Welfare = $289,075
Increase of $400

Going Forward

- Group members provide IESO with comments on working definitions
- IESO incorporate comments in new draft
- Meet in New Year to finalize working definitions based on comments received