Real-Time Co-Optimization + Batteries: Real-Time Simulation Examples Training

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RTC+B Task Force Meeting
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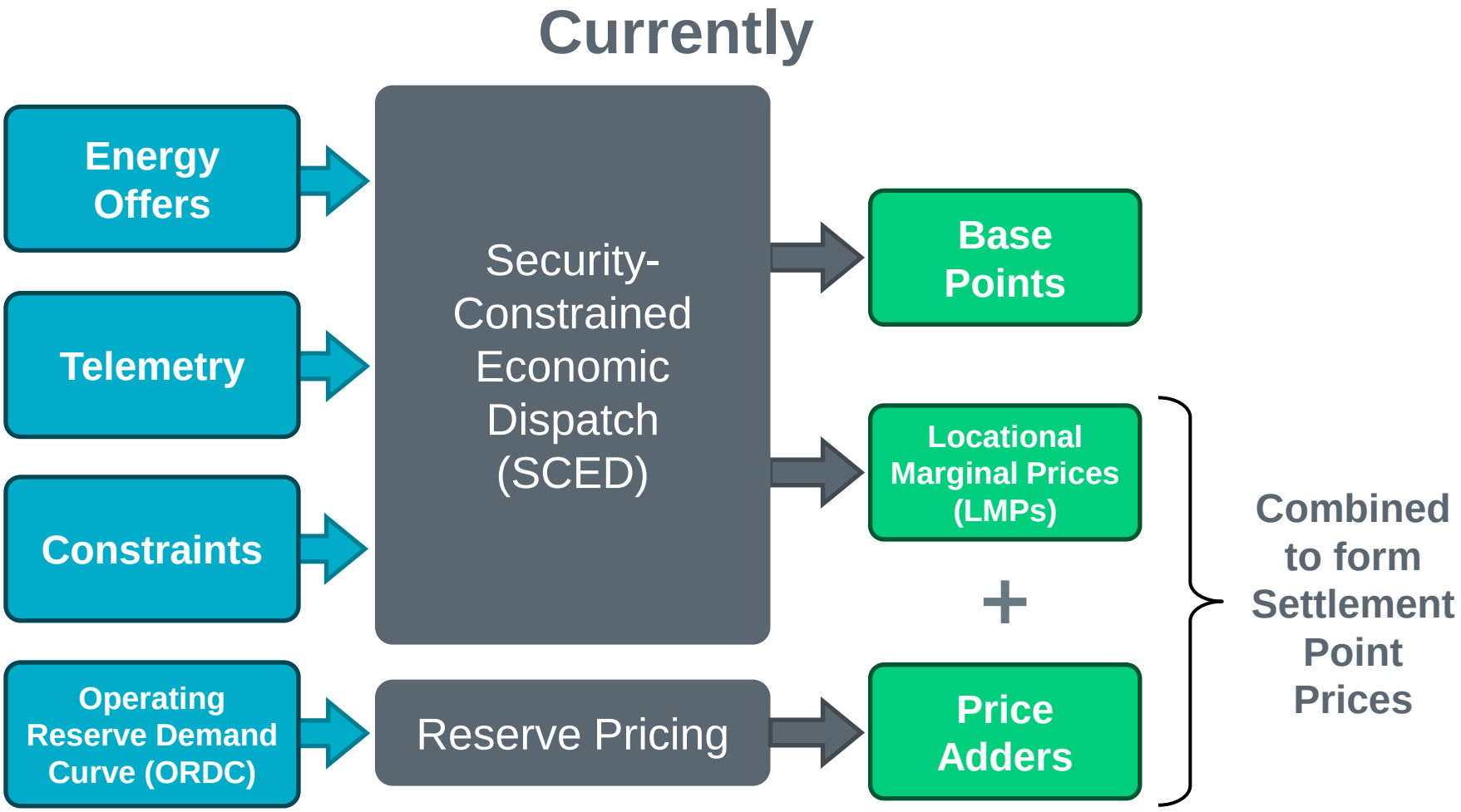
ERCOT Public

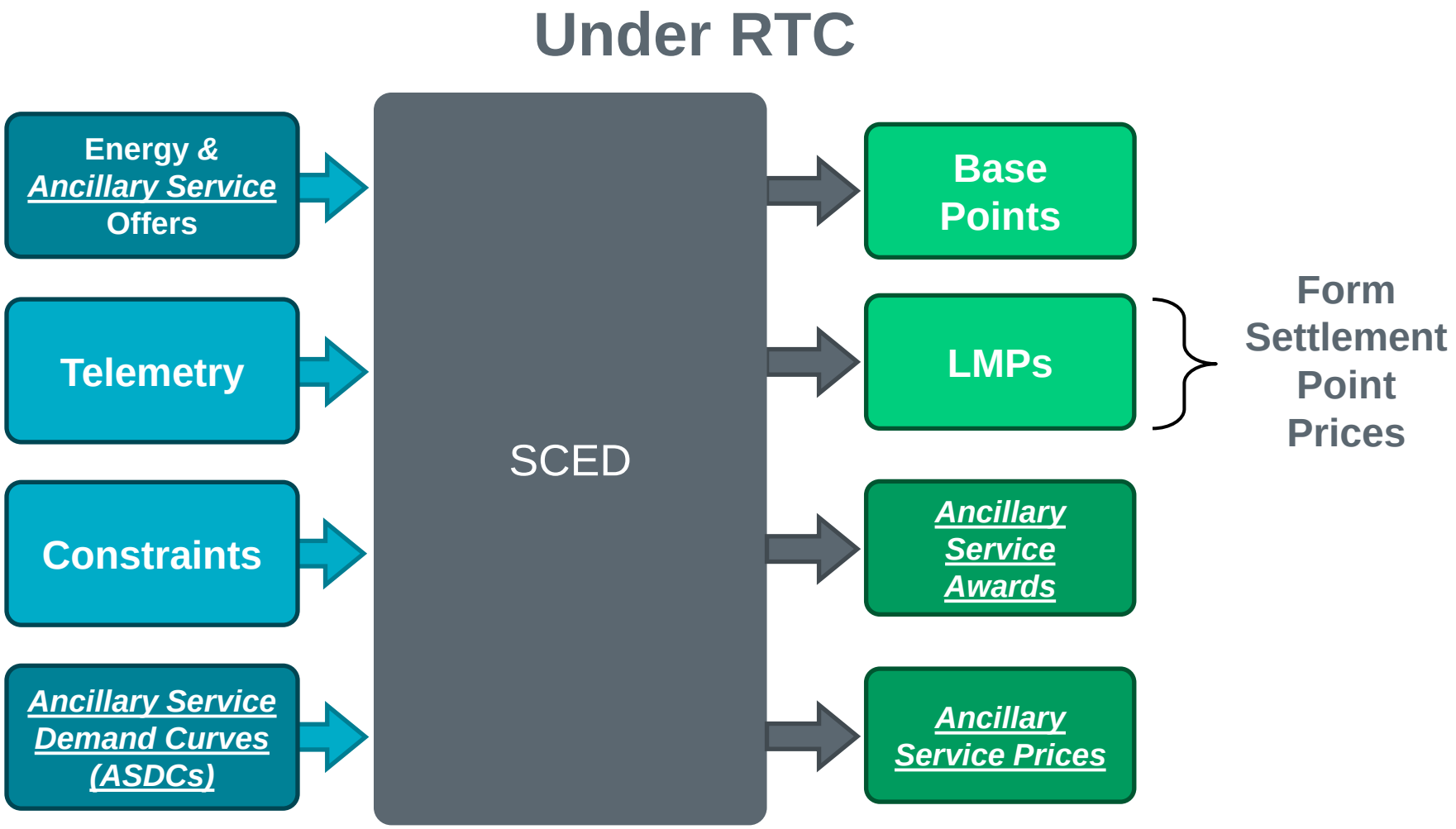
Agenda

- Focus of this presentation is to illustrate how market clearing prices, basepoints and awards will be determined under RTC using different scenarios
- ERCOT will use an internal RTC simulation tool for these scenarios which uses a simple model of a 5 generator and 6 transmission line system

Today's market is designed to reflect scarcity through a process that is outside of the optimization



RTC is also designed to reflect scarcity, but now it occurs within the optimization



RTC Simulator Scenarios

- Scenario 1: Optimal Allocation of Ancillary Services
- Scenario 2: Transmission Congestion
- Scenario 3: System Scarcity

Scenario 1: Optimal Allocation of Ancillary Services

- Goal: Illustrate how RTC will optimally allocate resource capacity to both ancillary services and energy in real time
- Exercise: Increase RRS plan by increments of 10MW and observe which resources receive awards

INPUTS

Resource Data

		Offers ($/MWh)					Limits (MW)		
Resource	*Bus*	*Energy*	*REGUP*	*RRS*	*ECRS*	*NSPIN*	*AS Qty*	*LSL*	*HSL*
G1	A	14	-	20	-	-	20	-	110
G2	A	15	-	20	-	-	20	-	100
G3	C	30	-	-	-	-	-	-	520
G4	D	29	-	20	-	-	20	-	200
G5	E	10	-	20	-	-	20	-	400
L1	E	10	-	-	-	-	-	-	-
								TOTAL	1,330

Load Data

Load	*Bus*	*Load*
AUS	B	300
HOU	C	300
DFW	D	500
	TOTAL	1100
	Load + AS Plan	1100

Line Data

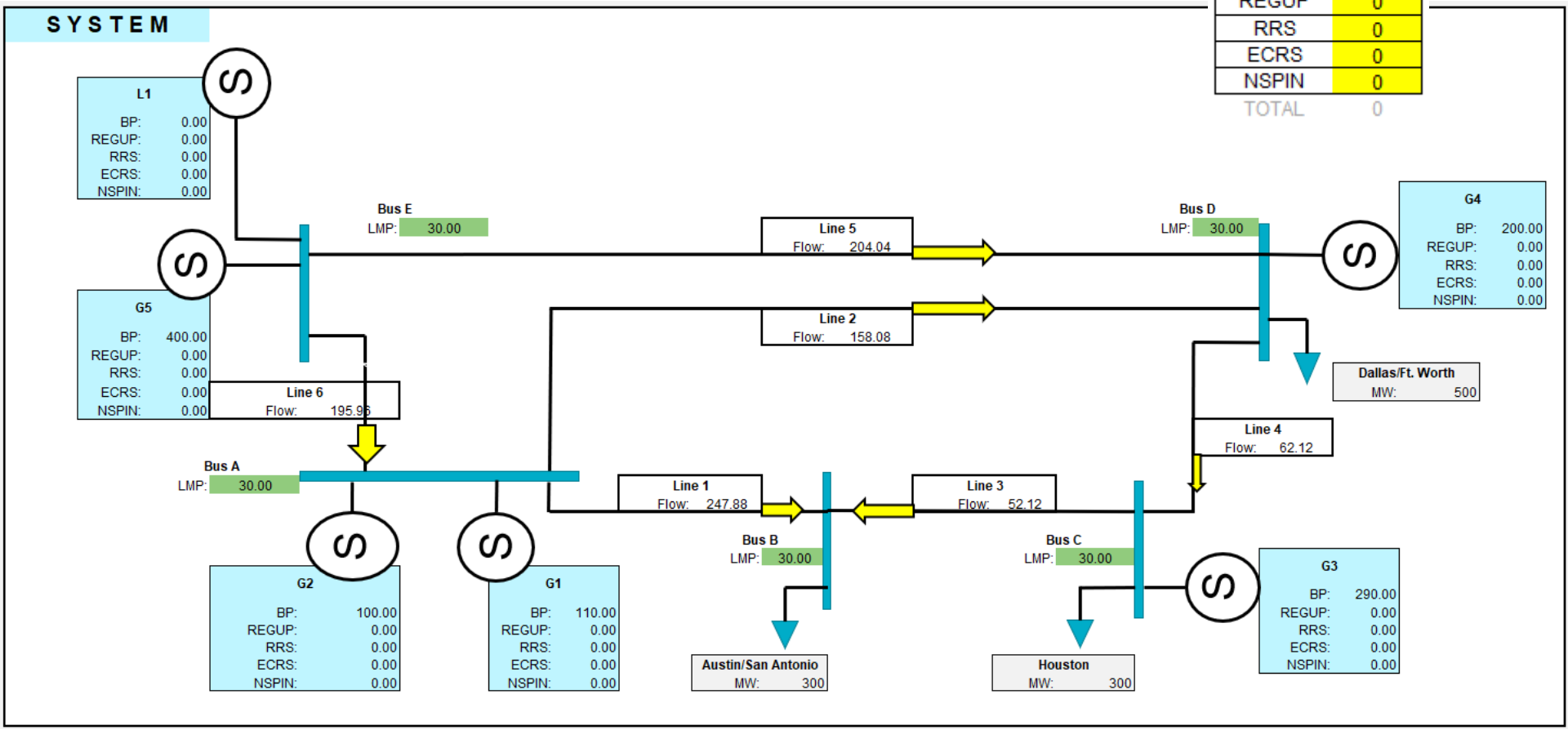
Line	*Limit**	*Max Shadow*
L1	1000	4500
L2	1000	4500
L3	1000	4500
L4	1000	4500
L5	1000	4500
L6	1000	4500

AS Plan

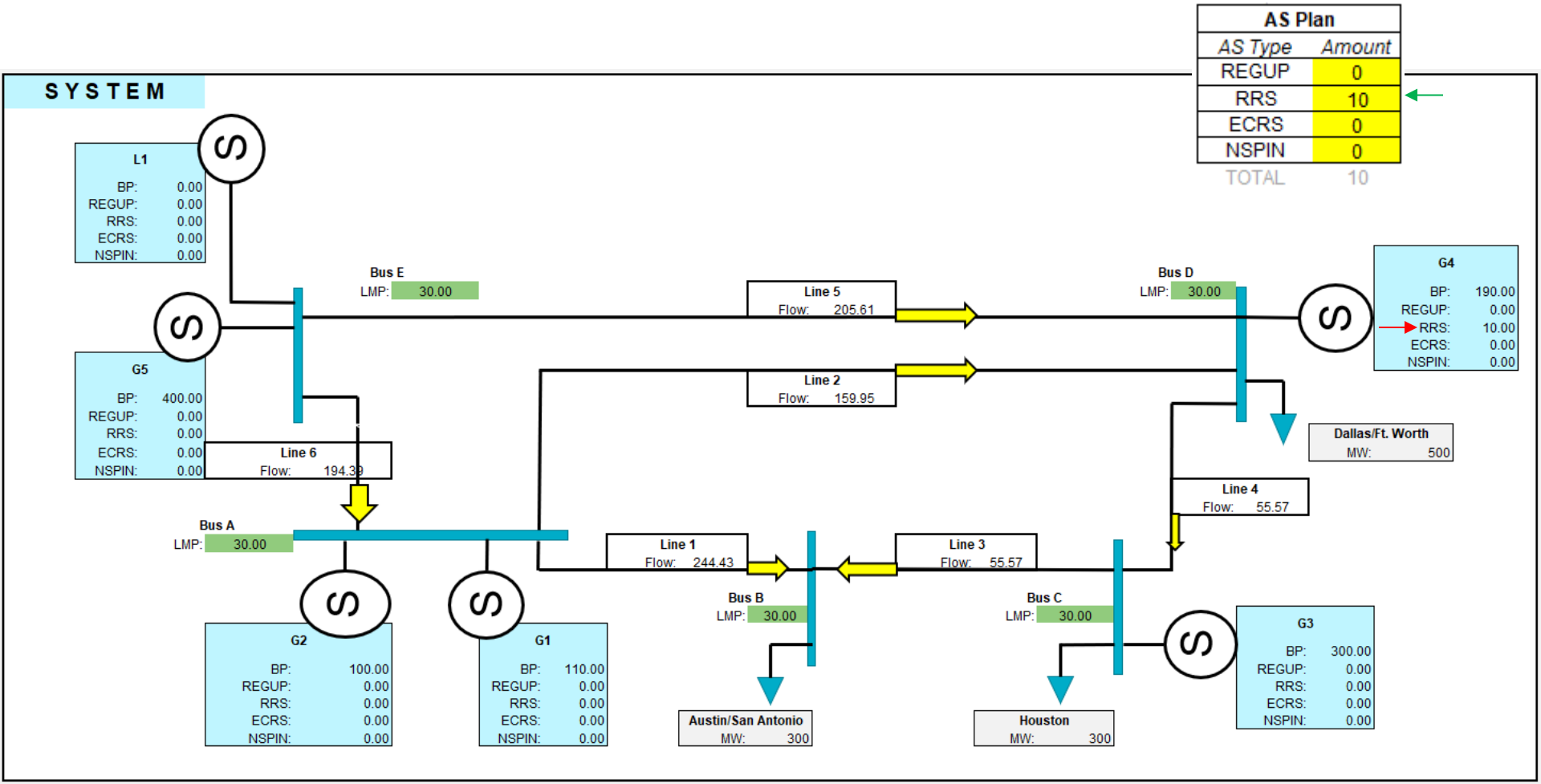
AS Type	*Amount*
REGUP	0
RRS	0
ECRS	0
NSPIN	0
TOTAL	0

Scenario 1: Optimal Allocation of Ancillary Services

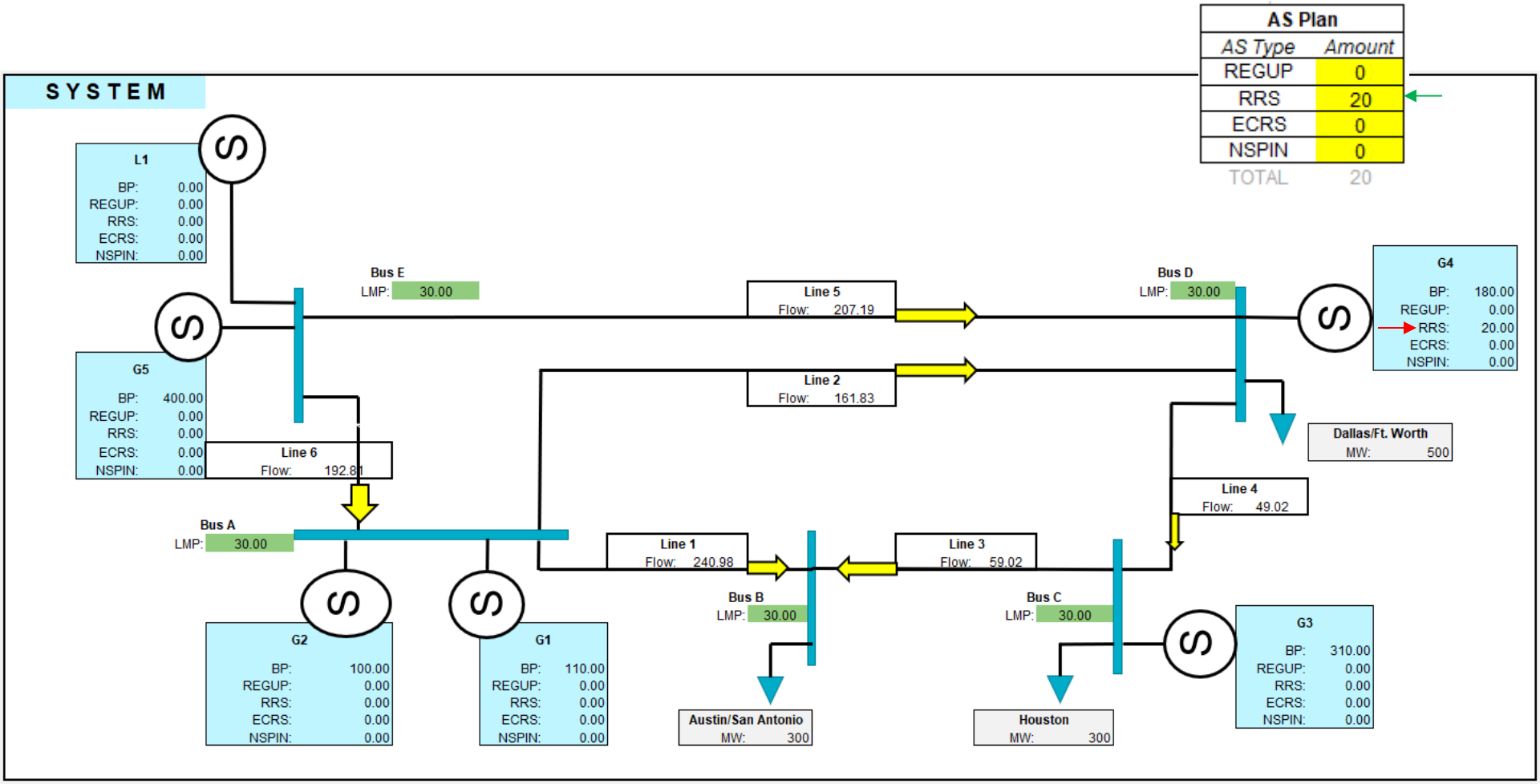
AS Plan	
AS Type	*Amount*
REGUP	0
RRS	0
ECRS	0
NSPIN	0
TOTAL	0



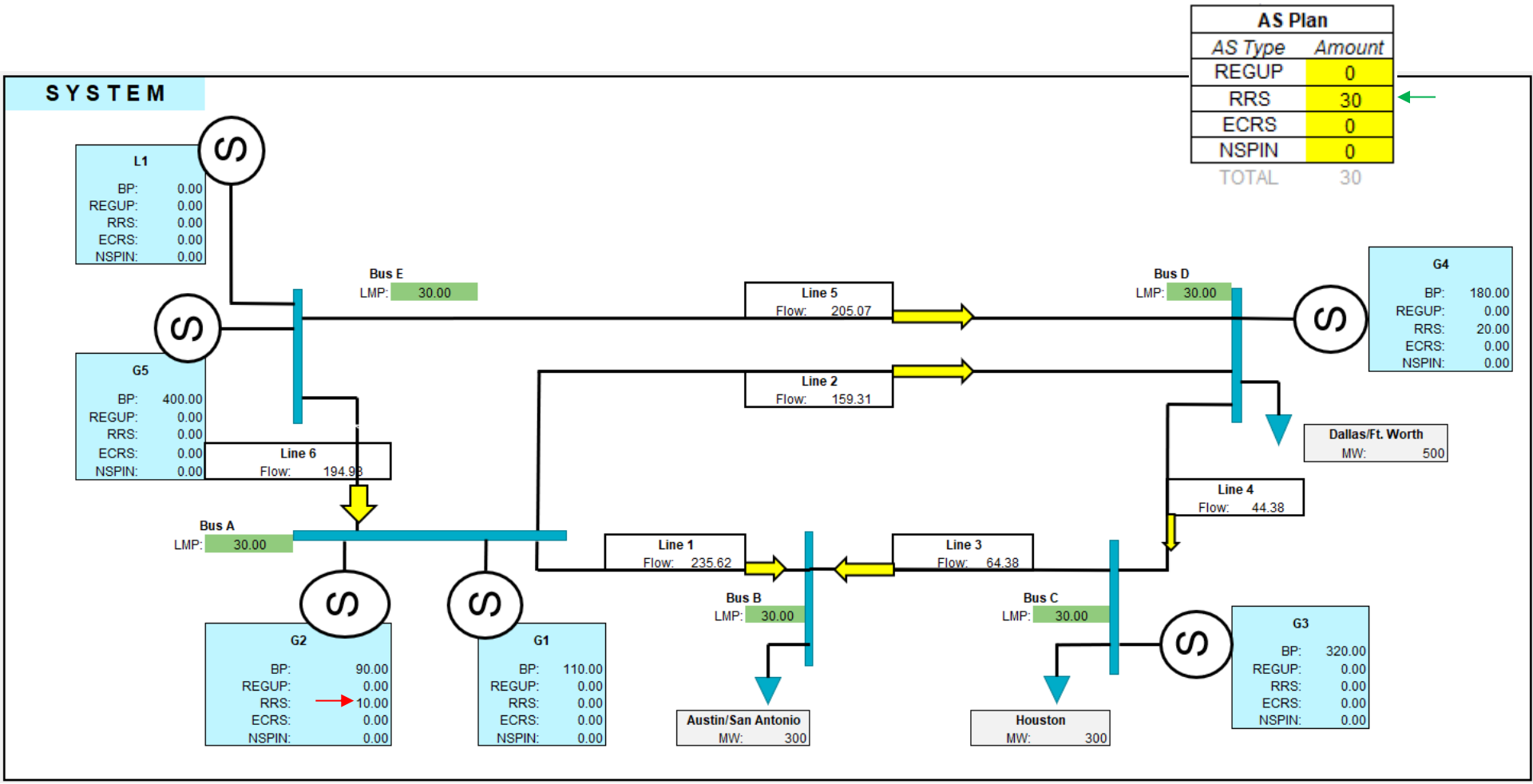
Scenario 1: Optimal Allocation of Ancillary Services



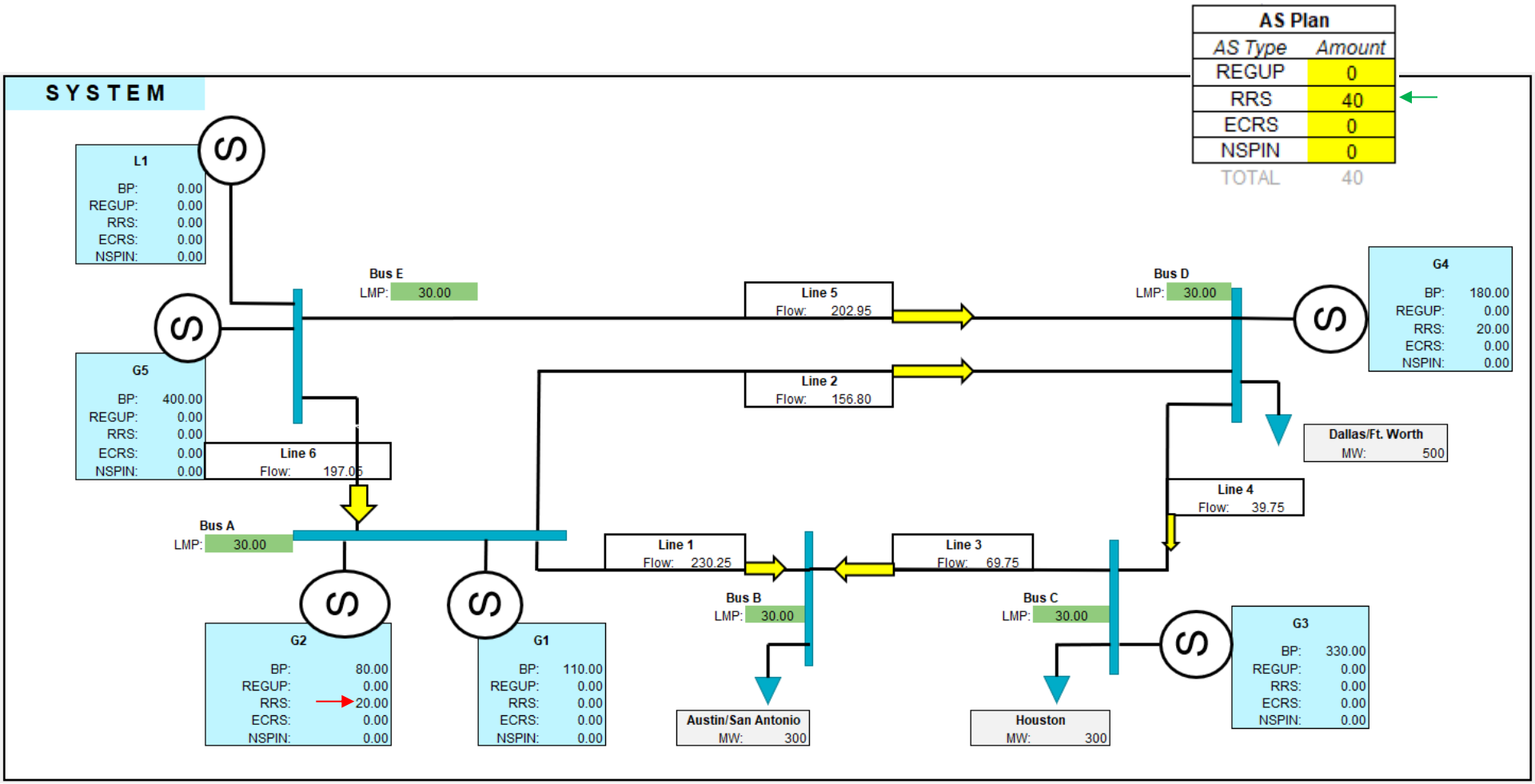
Scenario 1: Optimal Allocation of Ancillary Services



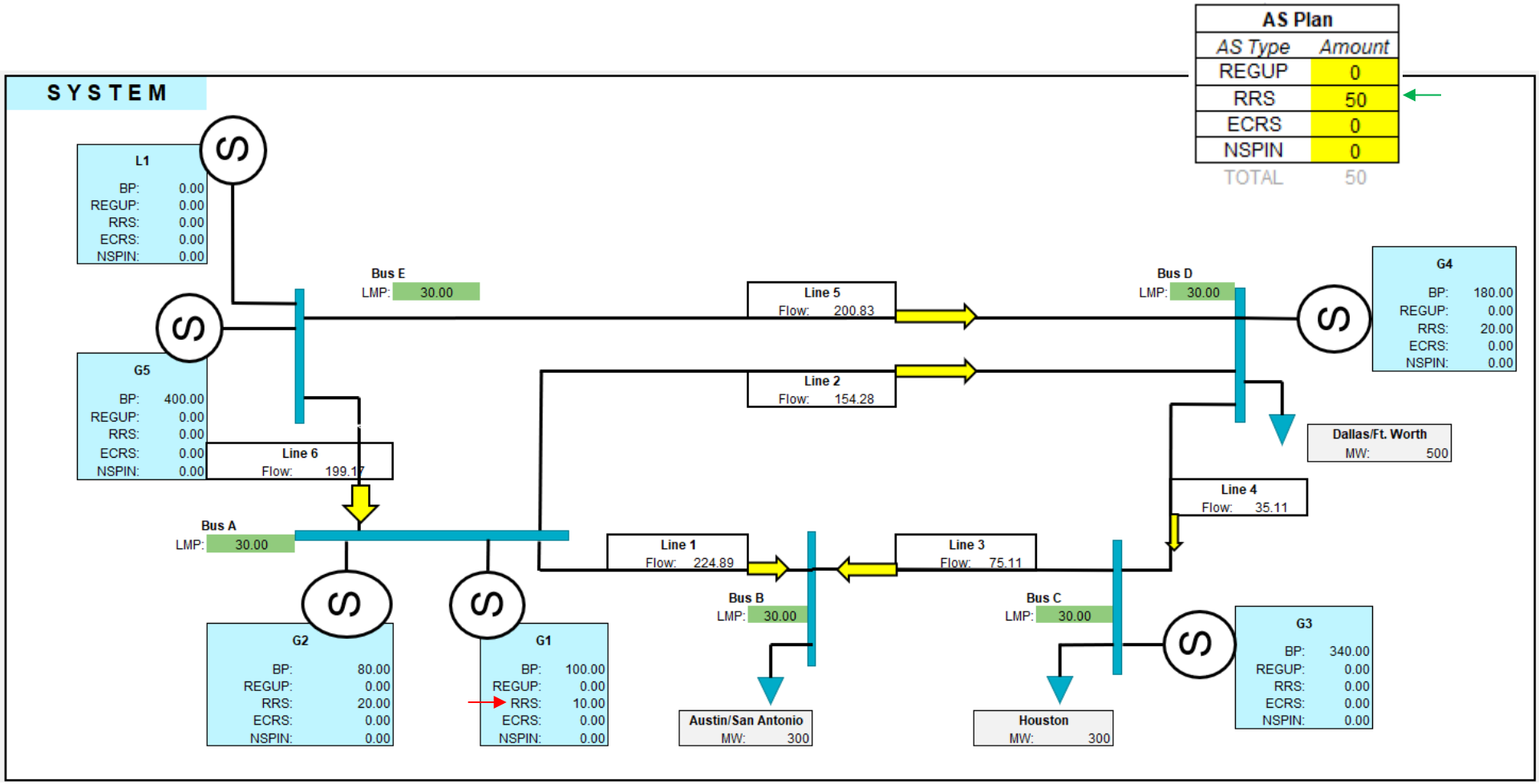
Scenario 1: Optimal Allocation of Ancillary Services



Scenario 1: Optimal Allocation of Ancillary Services



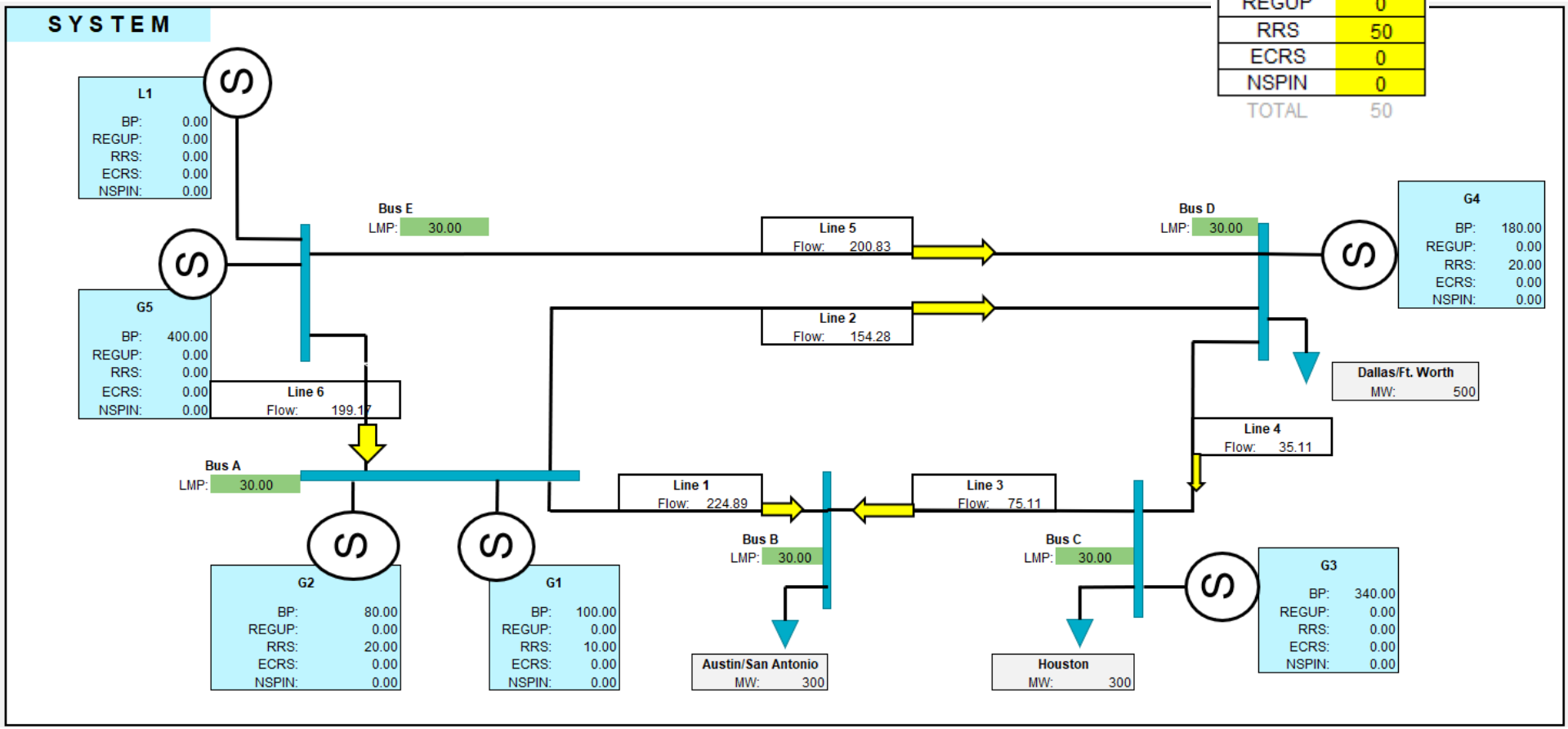
Scenario 1: Optimal Allocation of Ancillary Services



Scenario 1: Optimal Allocation of Ancillary Services

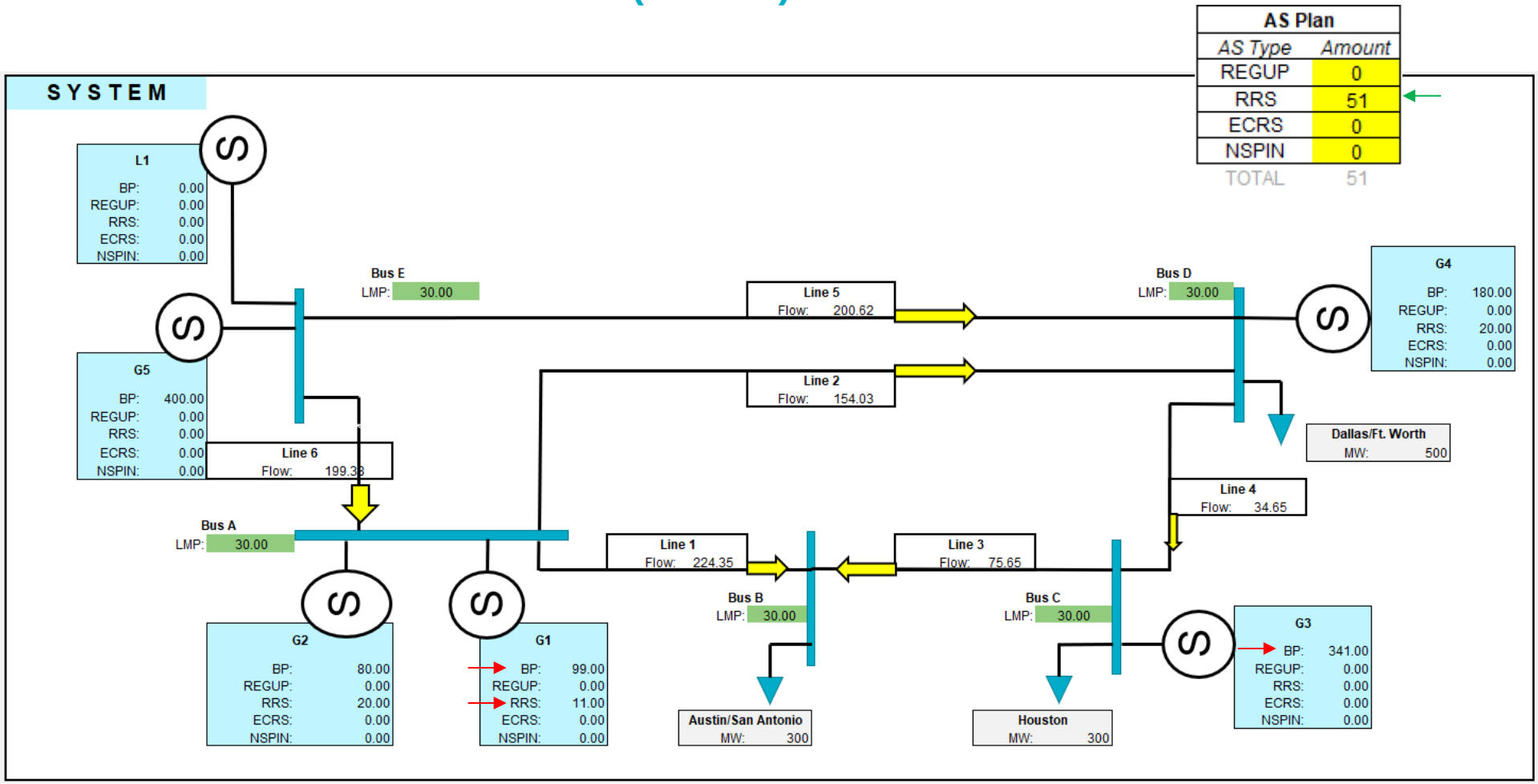
Exercise: Calculate AS Prices (MCPCs)

AS Plan	
AS Type	*Amount*
REGUP	0
RRS	50
ECRS	0
NSPIN	0
TOTAL	50



Scenario 1: Optimal Allocation of Ancillary Services

Exercise: Calculate AS Prices (MCPCs)



Scenario 1: Optimal Allocation of Ancillary Services

Exercise: Calculate AS Prices (MCPCs)

Resource Data									
		Offers ($/MWh)					Limits (MW)		
Resource	*Bus*	*Energy*	*REGUP*	*RRS*	*ECRS*	*NSPIN*	*AS Qty*	*LSL*	*HSL*
G1	A	14	-	20	-	-	20	-	110
G2	A	15	-	20	-	-	20	-	100
G3	C	30	-	-	-	-	-	-	520
G4	D	29	-	20	-	-	20	-	200
G5	E	10	-	20	-	-	20	-	400
L1	E	10	-	-	-	-	-	-	-

- Resource award changes:
  - G1's RRS award increases by 1 MW (+$20)
  - G1's RRS award decreases by 1 MW (-$14)
  - G3's Energy award increases by 1 MW (+$30)
- MCPC of RRS = $36
- MCPC = Shadow price of the AS constraint (the cost in the objective function to award an additional MW to satisfy the ASDC)

Why is G1 indifferent?

- G1 (via their offer) was willing to provide energy at $14 and the LMP was $30
- When G1 was awarded an additional MW of RRS, the opportunity cost (in the form of revenue forgone from selling energy) needs to be factored in the MCPC of RRS
- The opportunity cost of providing RRS is the lost revenue from selling energy
- This cost is factored in the MCPC so that G1 receives the same operating profit it would have received from the energy market –making it *indifferent* to the scheduling of its capacity for energy or AS
  - Optimization process ensures that Resources are not incentivized by the prices to deviate from their awards

G1 Offer	Price	Operating Profit
Energy: $14	LMP: $30	$16
RRS: $20	RRS MCPC: $36	$16

Scenario 2: Relieving Transmission Constraints

- Goal: Illustrate how RTC will adjust ancillary service awards to alleviate congestion
- Exercise: Decrease transmission limit of lines and observe rearrangement of awards to manage congestion

INPUTS

Resource Data

		Offers ($/MWh)					Limits (MW)		
Resource	*Bus*	*Energy*	*REGUP*	*RRS*	*ECRS*	*NSPIN*	*AS Qty*	*LSL*	*HSL*
G1	A	14	-	20	-	-	20	-	110
G2	A	15	-	20	-	-	20	-	100
G3	C	30	-	-	-	-	-	-	520
G4	D	29	-	20	-	-	20	-	200
G5	E	10	-	20	-	-	20	-	400
L1	E	10	-	-	-	-	-	-	-
								TOTAL	1,330

Load Data

Load	*Bus*	*Load*
AUS	B	300
HOU	C	300
DFW	D	500
	TOTAL	1100
	Load + AS Plan	1167

Line Data

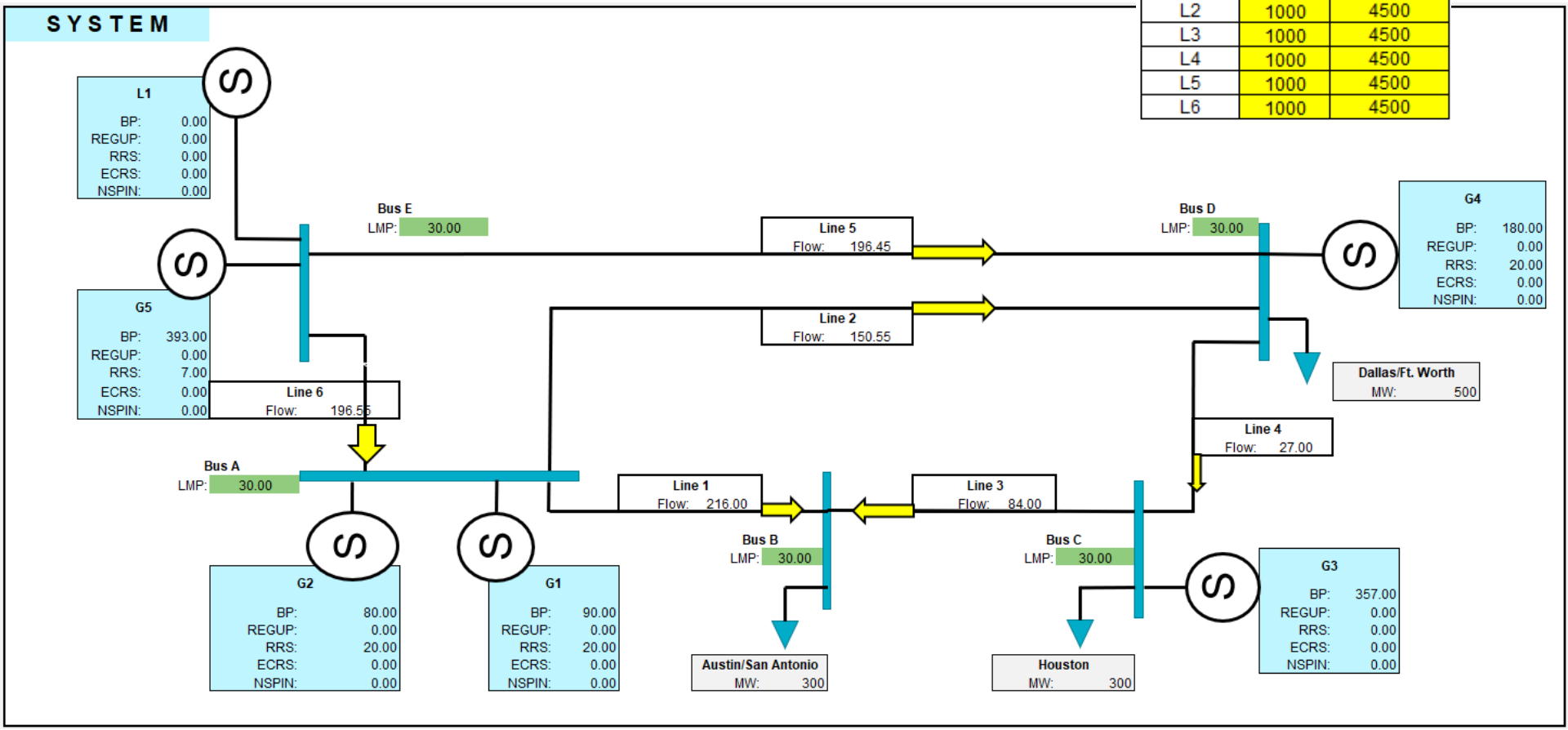
Line	*Limit**	*Max Shadow*
L1	1000	4500
L2	1000	4500
L3	1000	4500
L4	1000	4500
L5	1000	4500
L6	1000	4500

AS Plan

AS Type	*Amount*
REGUP	0
RRS	67
ECRS	0
NSPIN	0
TOTAL	67

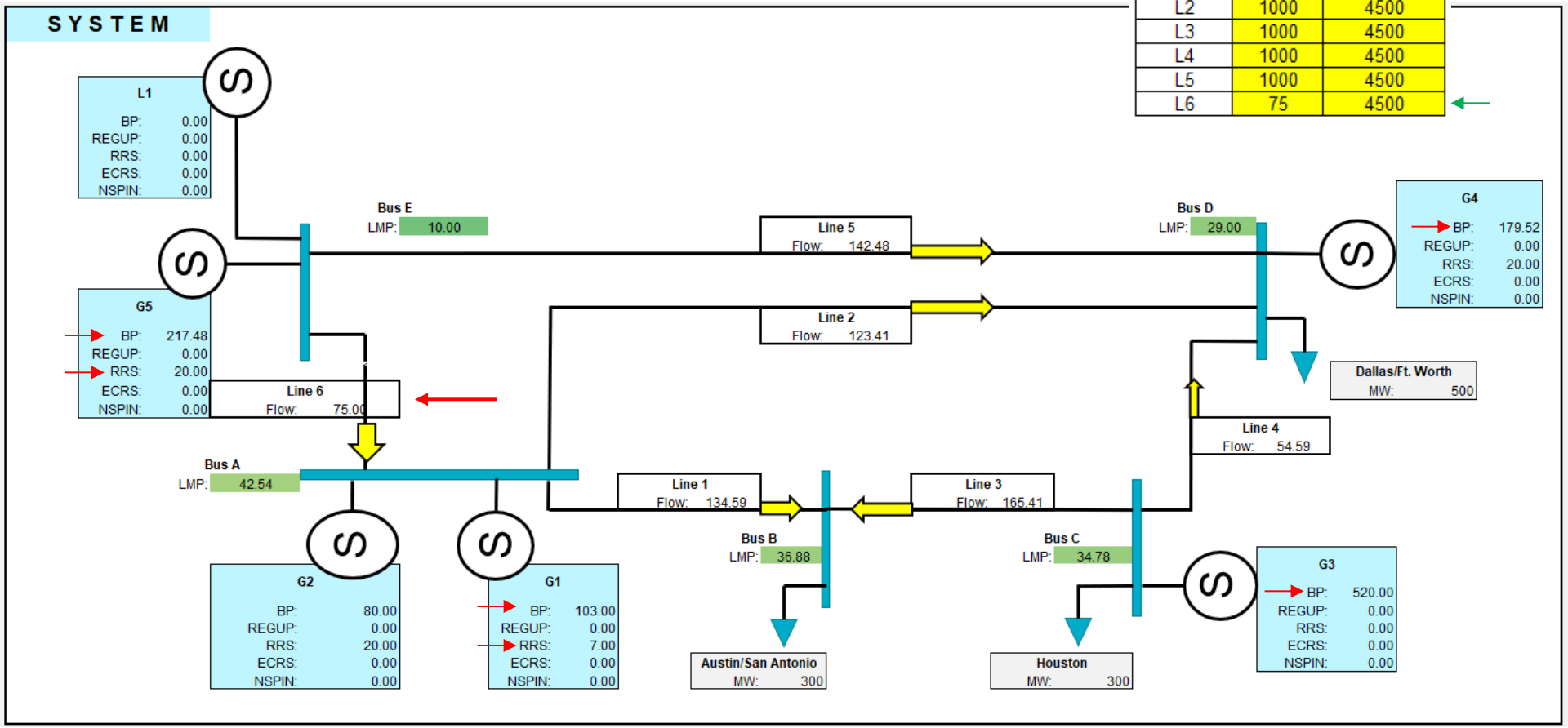
Scenario 2: Relieving Transmission Constraints

Line Data		
Line	*Limit**	*Max Shadow*
L1	1000	4500
L2	1000	4500
L3	1000	4500
L4	1000	4500
L5	1000	4500
L6	1000	4500



Scenario 2: Relieving Transmission Constraints

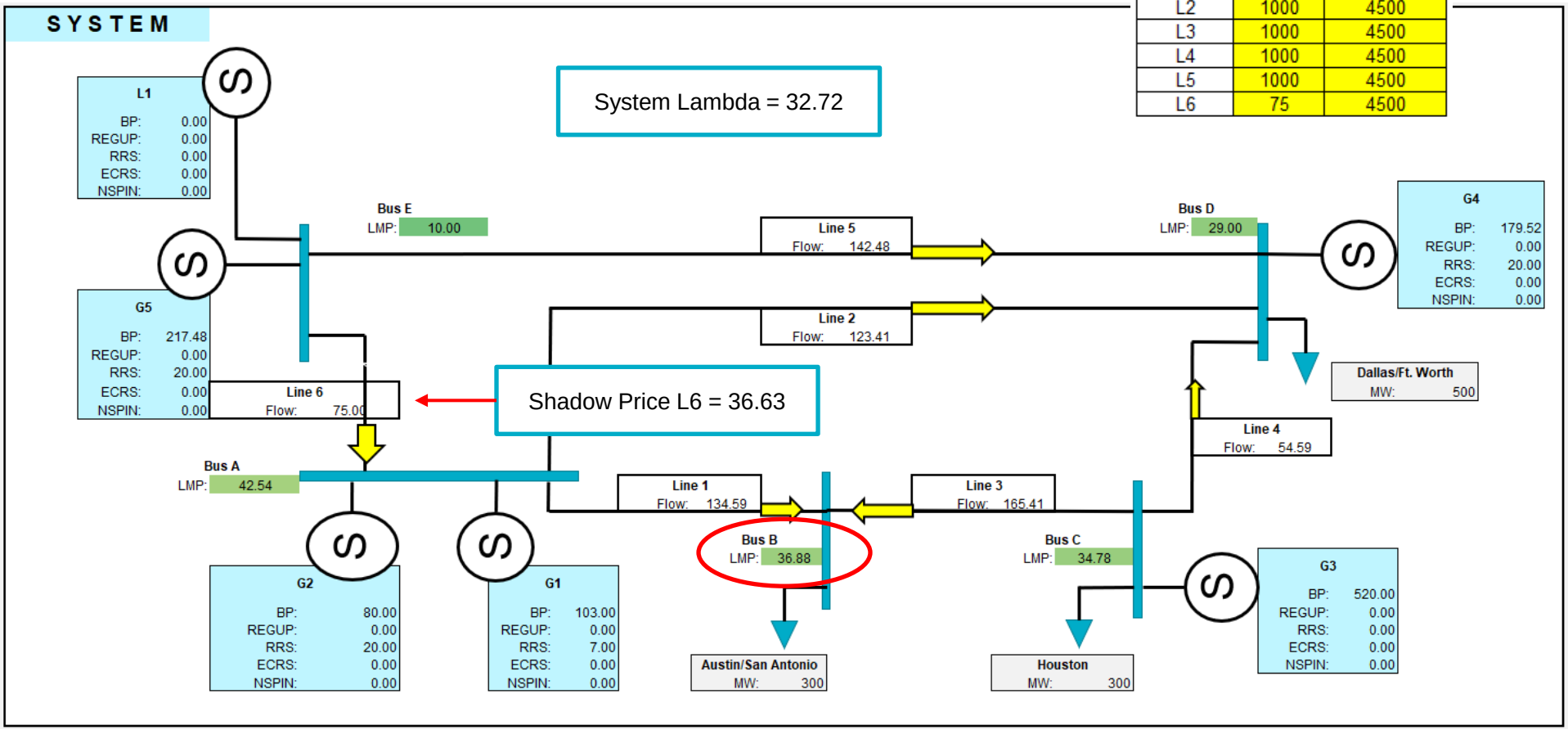
Line Data		
Line	*Limit**	*Max Shadow*
L1	1000	4500
L2	1000	4500
L3	1000	4500
L4	1000	4500
L5	1000	4500
L6	75	4500



Scenario 2: Relieving Transmission Constraints

Exercise: Calculate LMP at Bus B

Line Data		
Line	*Limit**	*Max Shadow*
L1	1000	4500
L2	1000	4500
L3	1000	4500
L4	1000	4500
L5	1000	4500
L6	75	4500



Scenario 2: Relieving Transmission Constraints
Exercise: Calculate LMP at Bus B

- $LMP_b = \lambda - \sum_c SF_{b,c} * SP_c$
  - Where LMP_b is the LMP at bus b
  - λ is System Lambda, the Shadow Price of the Power Balance Constraint
  - $SF_{b,c}$ is the shift factor impact of the bus b on constraint c
  - SP_c is the shadow price on constraint c
- $LMP_b = \$32.72 - (-0.113 * \$36.63) = \$36.88$

Scenario 3: Prioritization of Energy During Tight Conditions

- Goal: Demonstrate trade off between energy and ancillary service penalty costs during scarcity
- Exercise: Increase load and observe relationship between supply and demand as well as price changes

INPUTS

Resource Data

		Offers ($/MWh)					Limits (MW)		
Resource	*Bus*	*Energy*	*REGUP*	*RRS*	*ECRS*	*NSPIN*	*AS Qty*	*LSL*	*HSL*
G1	A	14	-	20	-	-	20	-	110
G2	A	15	-	20	-	-	20	-	100
G3	C	30	-	-	-	-	-	-	520
G4	D	29	-	20	-	-	20	-	200
G5	E	10	-	20	-	-	20	-	400
L1	E	9	-	-	-	-	-	-	-
							TOTAL		1,330

Load Data

Load	*Bus*	*Load*
AUS	B	419
HOU	C	400
DFW	D	500
	TOTAL	1319
	Load + AS Plan	1329

Line Data

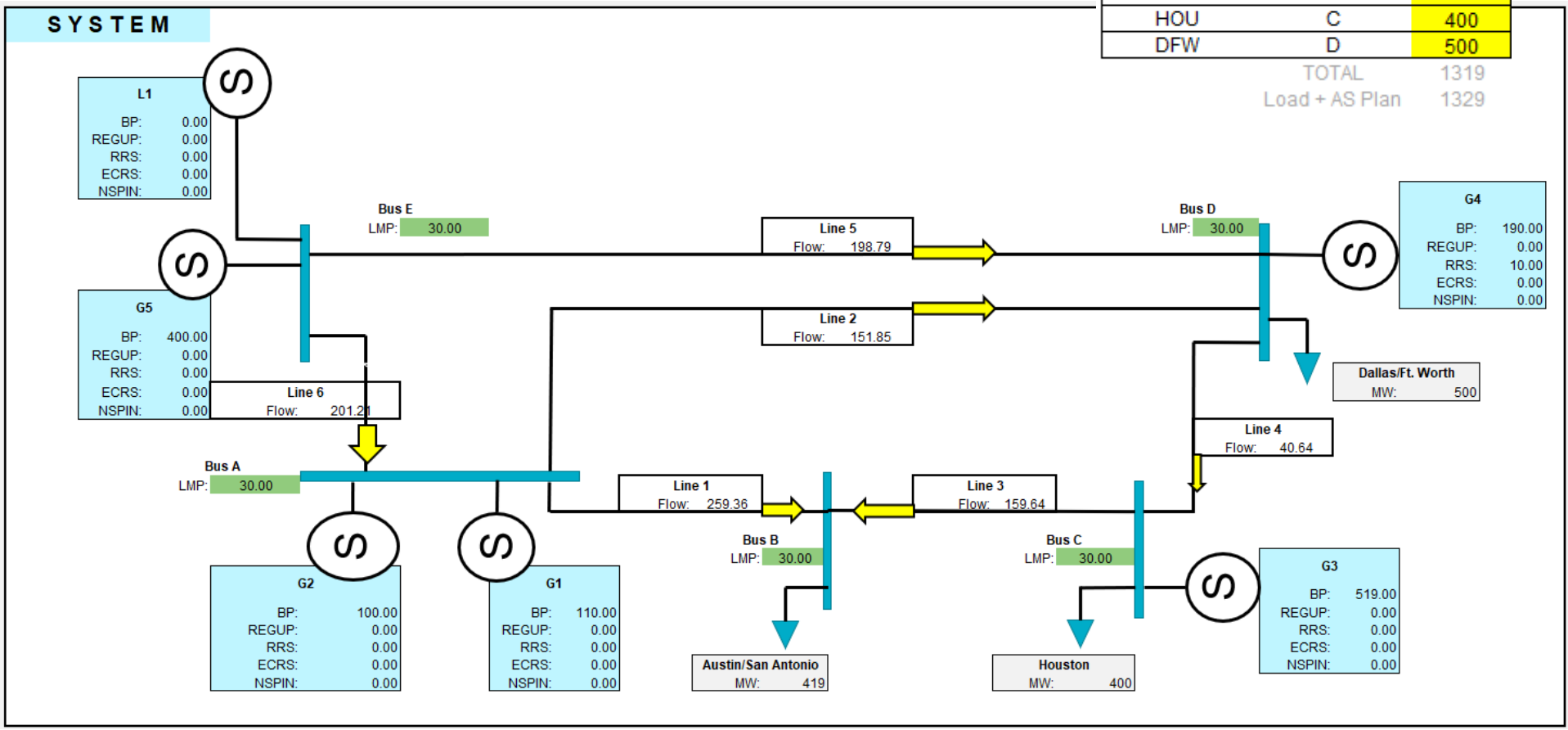
Line	*Limit**	*Max Shadow*
L1	1000	4500
L2	1000	4500
L3	1000	4500
L4	1000	4500
L5	1000	4500
L6	1000	4500

AS Plan

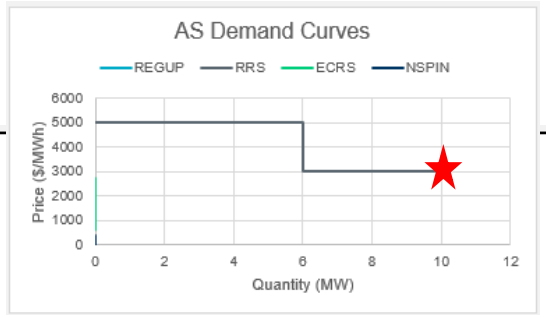
AS Type	*Amount*
REGUP	0
RRS	10
ECRS	0
NSPIN	0
TOTAL	10

Scenario 3: Prioritization of Energy During Tight Conditions

Load Data		
Load	*Bus*	*Load*
AUS	B	419
HOU	C	400
DFW	D	500
	TOTAL	1319
	Load + AS Plan	1329

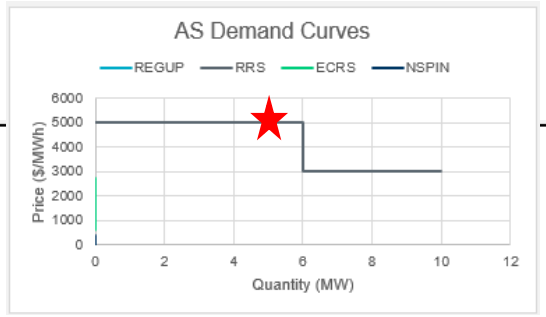


Scenario 3: Prioritization of Energy During Tight Conditions



Load Data		
Load	*Bus*	*Load*
AUS	B	420
HOU	C	400
DFW	D	500
	TOTAL	1320
	Load + AS Plan	1330

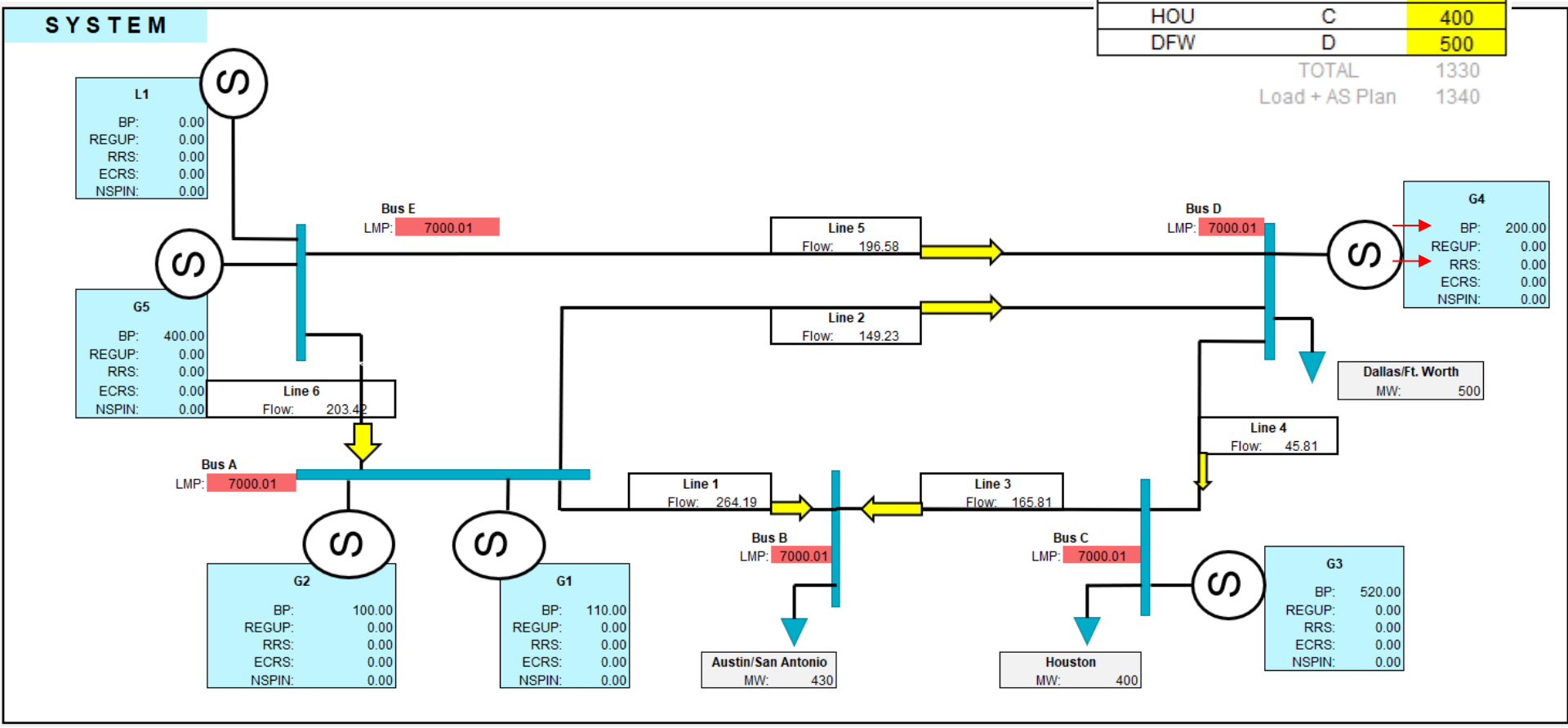
Scenario 3: Prioritization of Energy During Tight Conditions



Load Data		
Load	*Bus*	*Load*
AUS	B	425
HOU	C	400
DFW	D	500
	TOTAL	1325
	Load + AS Plan	1335

Scenario 3: Prioritization of Energy During Tight Conditions

Load Data		
Load	*Bus*	*Load*
AUS	B	430
HOU	C	400
DFW	D	500
	TOTAL	1330
	Load + AS Plan	1340



Illustrative scenario only – ERCOT Operators would undertake firm load shed to maintain reserves

Summary

- Previous examples highlight how RTC will impact prices, awards and dispatch under different scenarios
  - Scheduling:
    - Maximize gains from trade between energy and AS every 5 minutes to efficiently and reliably serve load
    - Ability to better manage congestion and cost by moving AS off of resources with helping shift factors
  - Pricing:
    - Scarcity pricing and the value of reserves is set by individual Ancillary Service Demand Curves (ASDCs) where the cost of Ancillary Service is factored directly into LMPs under RTC
    - MCPCs reflect the opportunity cost providing Ancillary Services (the operating profit -as a function offers - a unit that would have been received from providing energy) so that a resource owner is indifferent to its capacity being utilized for energy or Ancillary Services

Further Information

- RTC Simulator tool is available for download on the Real-Time Co-Optimization plus Batteries Task Force webpage under the ‘Key Documents’ section
- https://www.ercot.com/files/docs/2024/06/10/rtc_simulator_v3.xlsm