Discussion on flexible ramping product

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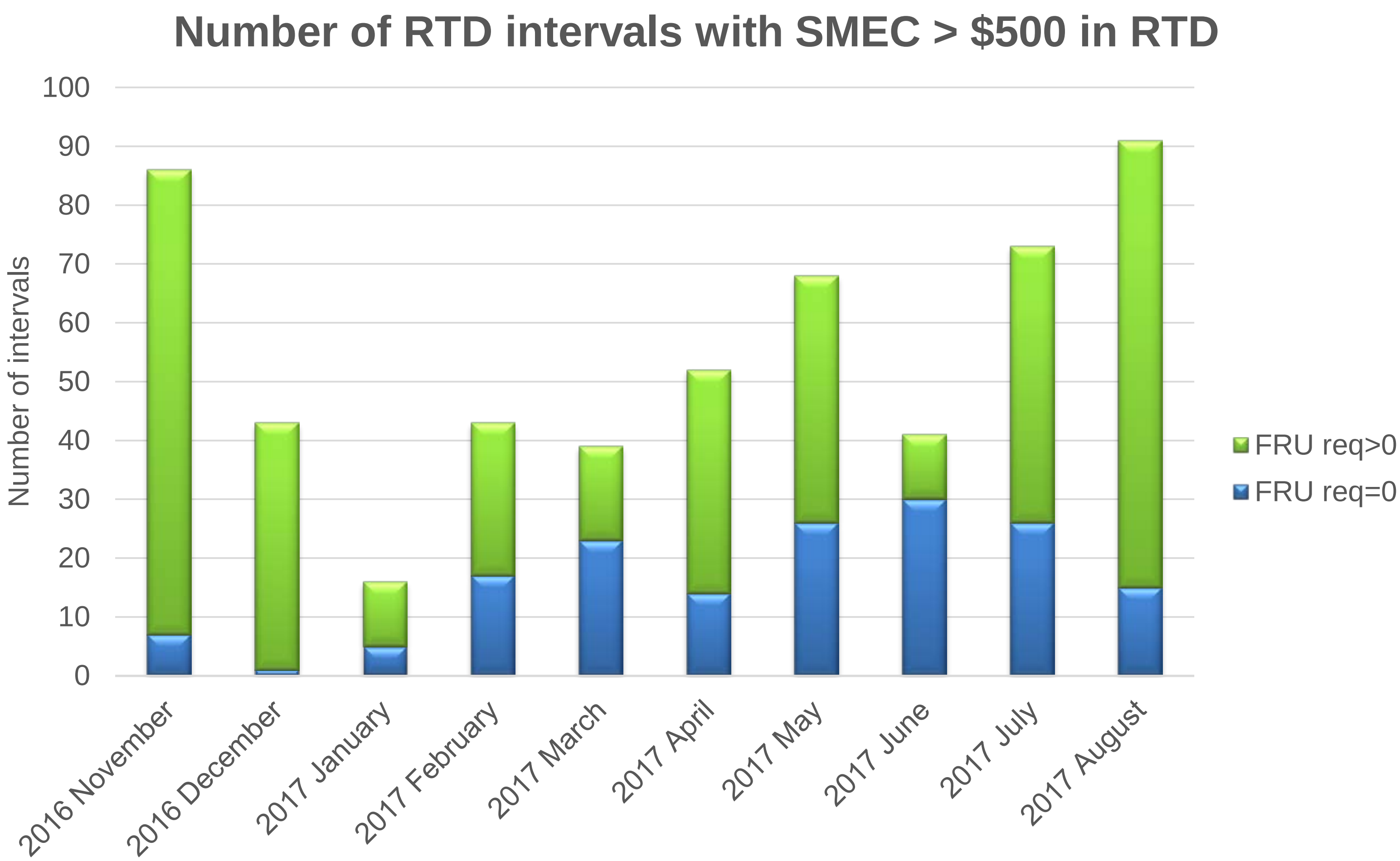
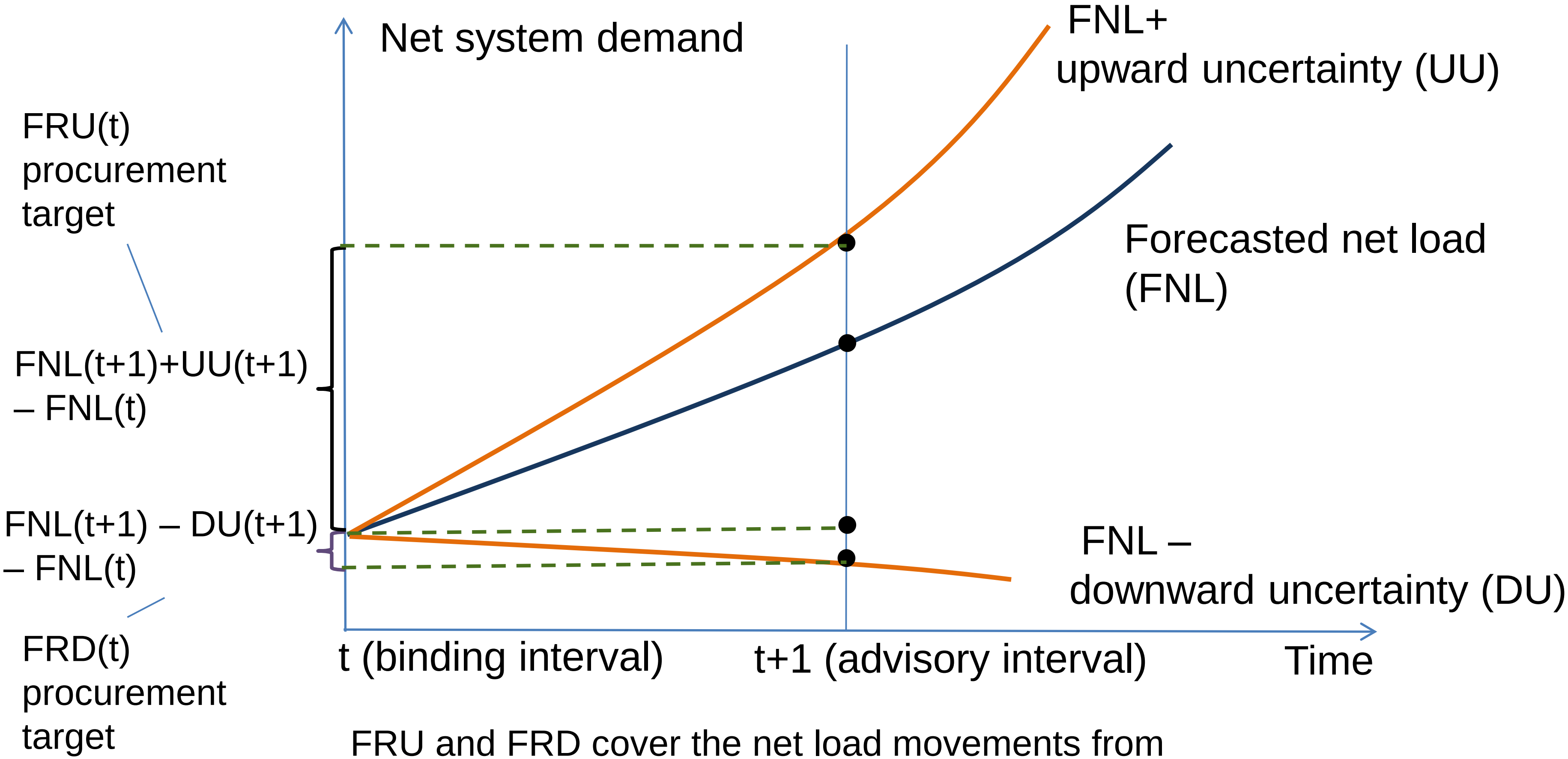
Topics

- Understand the flexible ramping products implementation
  - Connecting back to the conceptual design
  - Having the correct expectations
- Flexible ramping products observations
  - Focus on the upward flexible ramping product (FRU)
  - The requirement
  - The utilization
- Conclusion and recommendations

Price spike and FRU requirement in RTD

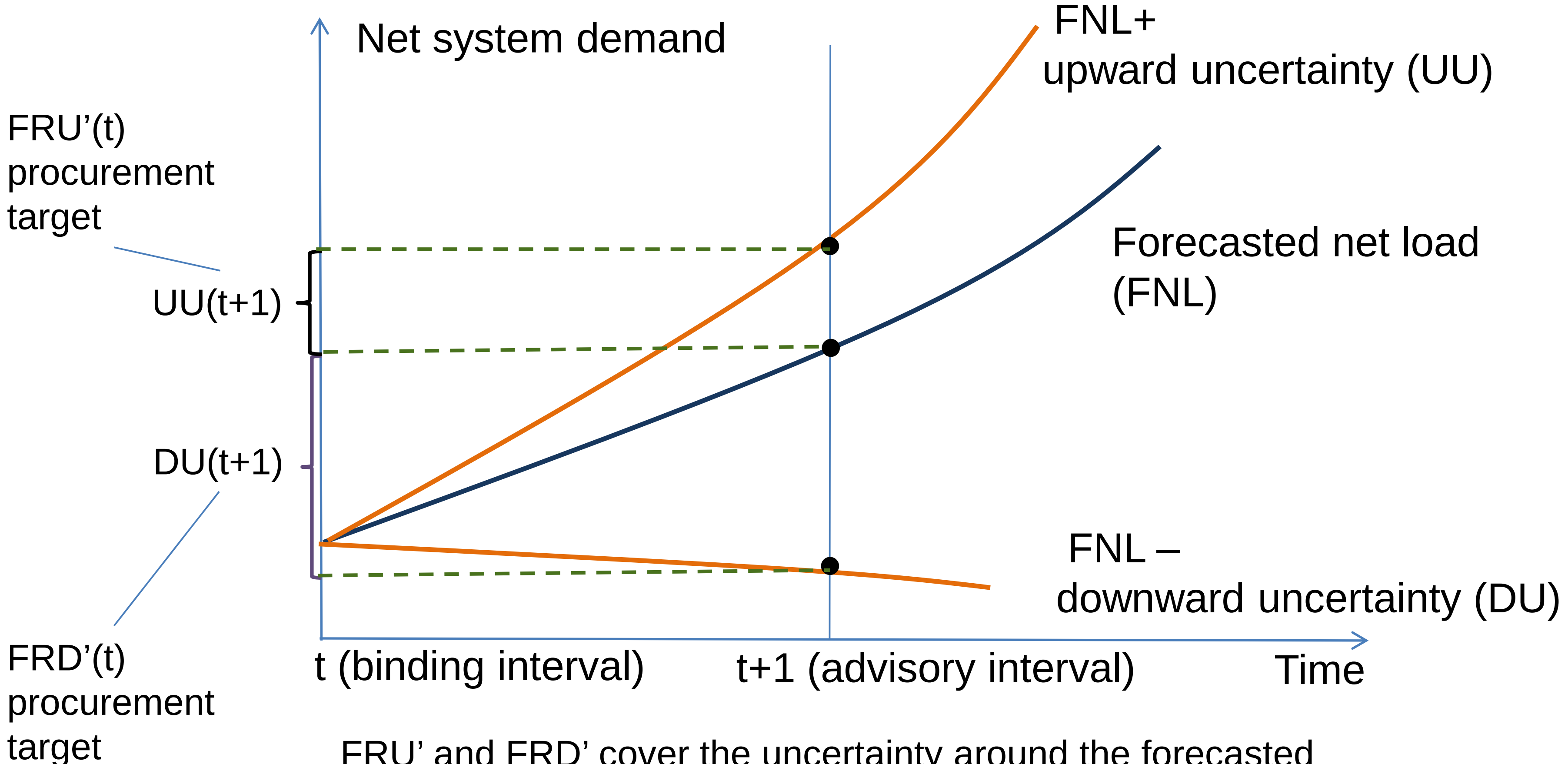


Flexible Ramping Product Conceptual Design



FRU and FRD cover the net load movements from binding interval t to the advisory interval t+1

Flexible Ramping Product Current Implementation



FRU' and FRD' cover the uncertainty around the forecasted net load at t+1 (the advisory interval)

Comparing conceptual design and implementation

- The difference in variable
  - FRU(g,t) = FRU’(g,t) + EN(g,t+1) – EN(g,t)
  - This is a variable substitution, and should not affect optimization results
- The difference in requirement
  - FRU’ requirement is the uncertainty portion at t+1
  - FRU requirement is the uncertainty at t+1 plus FNL(t+1) – FNL(t)
- The difference in one constraint
  - Current implementation enforces FRU’(g,t) <= Ramp(g,5). This is a constraint NOT in the conceptual design.
  - This constraint is overly limiting. It is equivalent to FRU(g,t) – [EN(g,t+1) – EN(g,t)] <= Ramp(g,T). When a unit ramping down at full speed from t to t+1 with EN(g,t+1) – EN(g,t) = – Ramp(g,T), the constraint limits FRU(g,t) <= 0. So ramping down units cannot provide FRU, and similarly ramping up units cannot provide FRD.

Flexible ramping up example

Generation	Energy Bid	Initial Condition	Ramp Rate (MW/min)	Pmin	Pmax
G1	$25	500 MW	100	0	500 MW
G2	$30	120 MW	10	0	500 MW
G3	VER price-taker	100 MW	200	0	200 MW

There are two 500 MW flexible resources G1 and G2 in the system that could provide FRU. G1 has 100 MW/minute ramp rate, and G2 has 10 MW/minute ramp rate. G1 has lower energy cost than G2. Generator G3 is a price-taking variable energy resource, which will be dispatched at its VER forecast.

FRU example – comparing the results

Binding interval t = 1:00. Two-interval RTD optimization with load (t) = 750 MW and load (t+5) = 750 MW

Scenario 1: conceptual design

S1: FRU=90	Interval t (LMP=$64, FRUP=$39 demand curve)		Interval t+1 (LMP=$30)	
Generation	**Energy**	**Flex-ramp up**	**Energy**	**Flex-ramp up**
G1	480 MW	20	500 MW	N/A
G2	170 MW	50	100 MW	N/A
G3	100 MW	0	150 MW	N/A

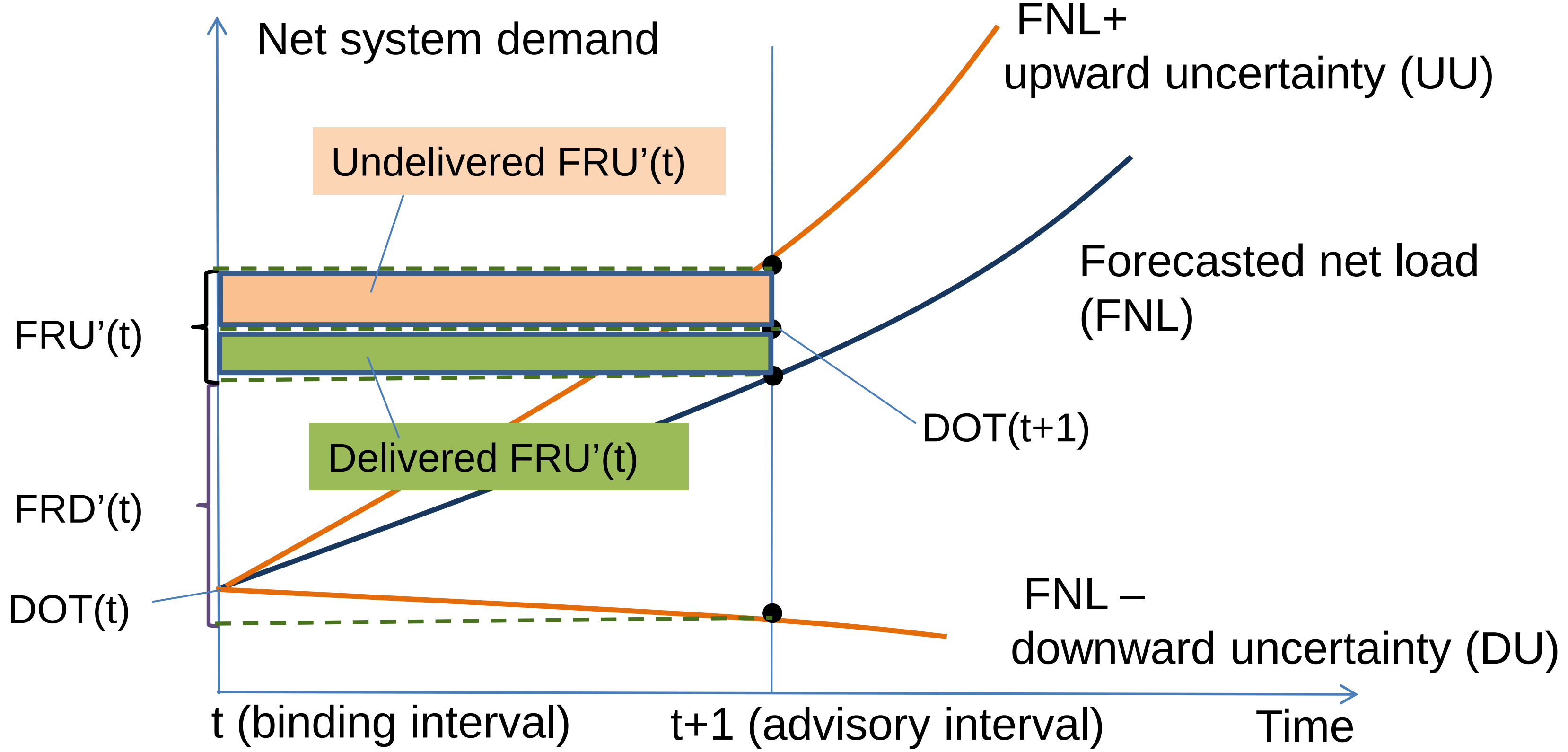
Scenario 2: current implementation

S2: FRU'=140	Interval t (LMP=$64, FRUP=$39 demand curve)		Interval t+1 (LMP=$30)	
Generation	**Energy**	**Flex-ramp up**	**Energy**	**Flex-ramp up**
G1	480 MW	0	500 MW	N/A
G2	170 MW	120	100 MW	N/A
G3	100 MW	0	150 MW	N/A

FRU example – understand and expect the differences

- The requirement
  - Load could be higher than forecast by 140 MW at t+1, so we need FRU’ = 140 MW
  - Forecasted net load = load – G3’s forecast. FNL(t) = 750 – 100 = 650, FNL(t+1) = 750 – 150 = 600. So we need FRU = 600 – 650 + 140 = 90 MW
- Who gets flex ramp award
  - Out-of-merit G1 gets FRU award, but not FRU’ award
  - The total flex ramp payment to G1 is the same
    - FRU payment = 20MW * $39/MWh
    - FRU’ payment = 0, movement payment = 20MW * $39/MWh
- Resources
  - Energy dispatches are the same in conceptual design and current implementation (without the unnecessary constraint)

FRU' delivered portion and undelivered portion

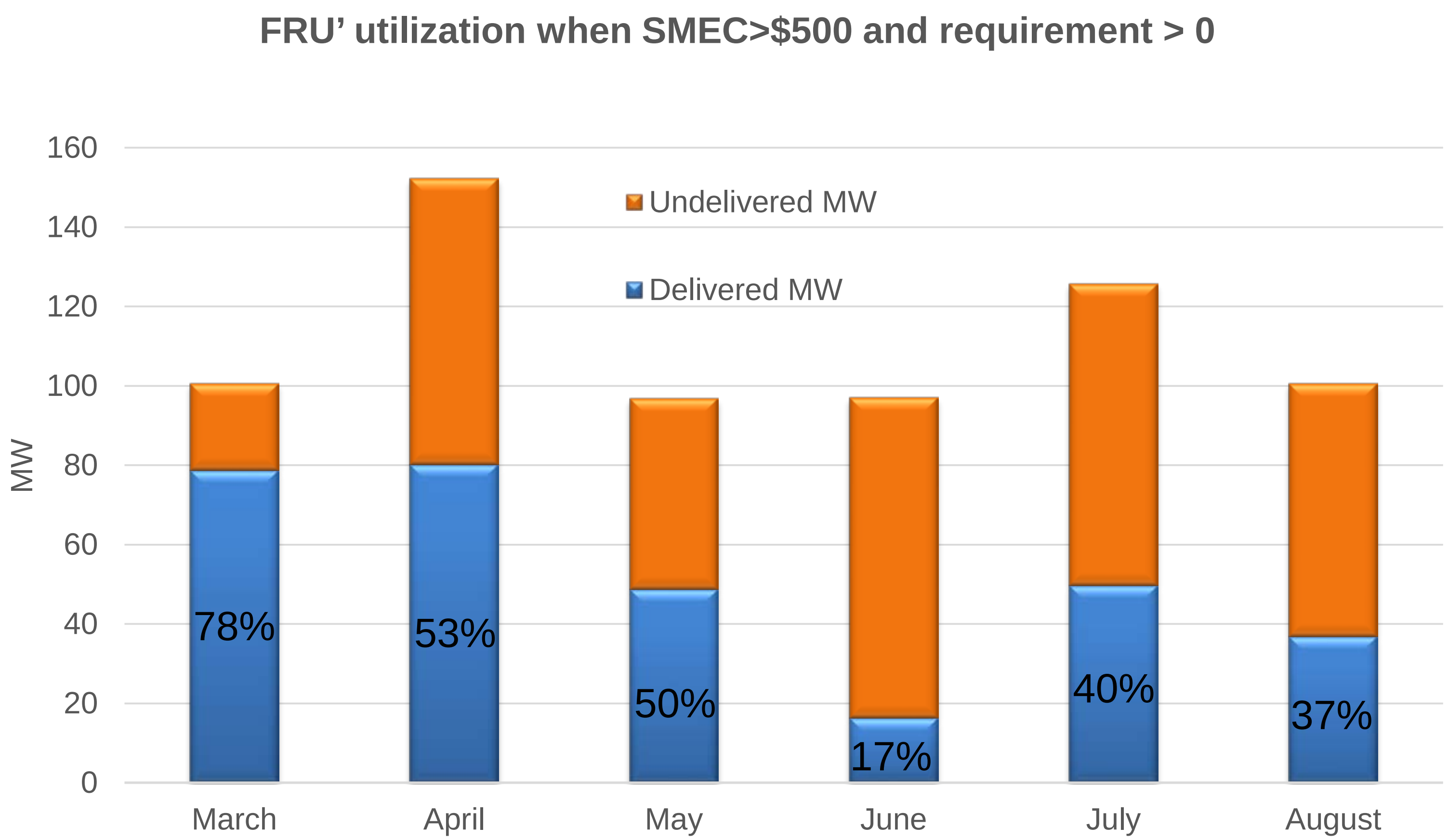


FRU' and FRD' cover the uncertainty around the forecasted net load at t+1 (the advisory interval)

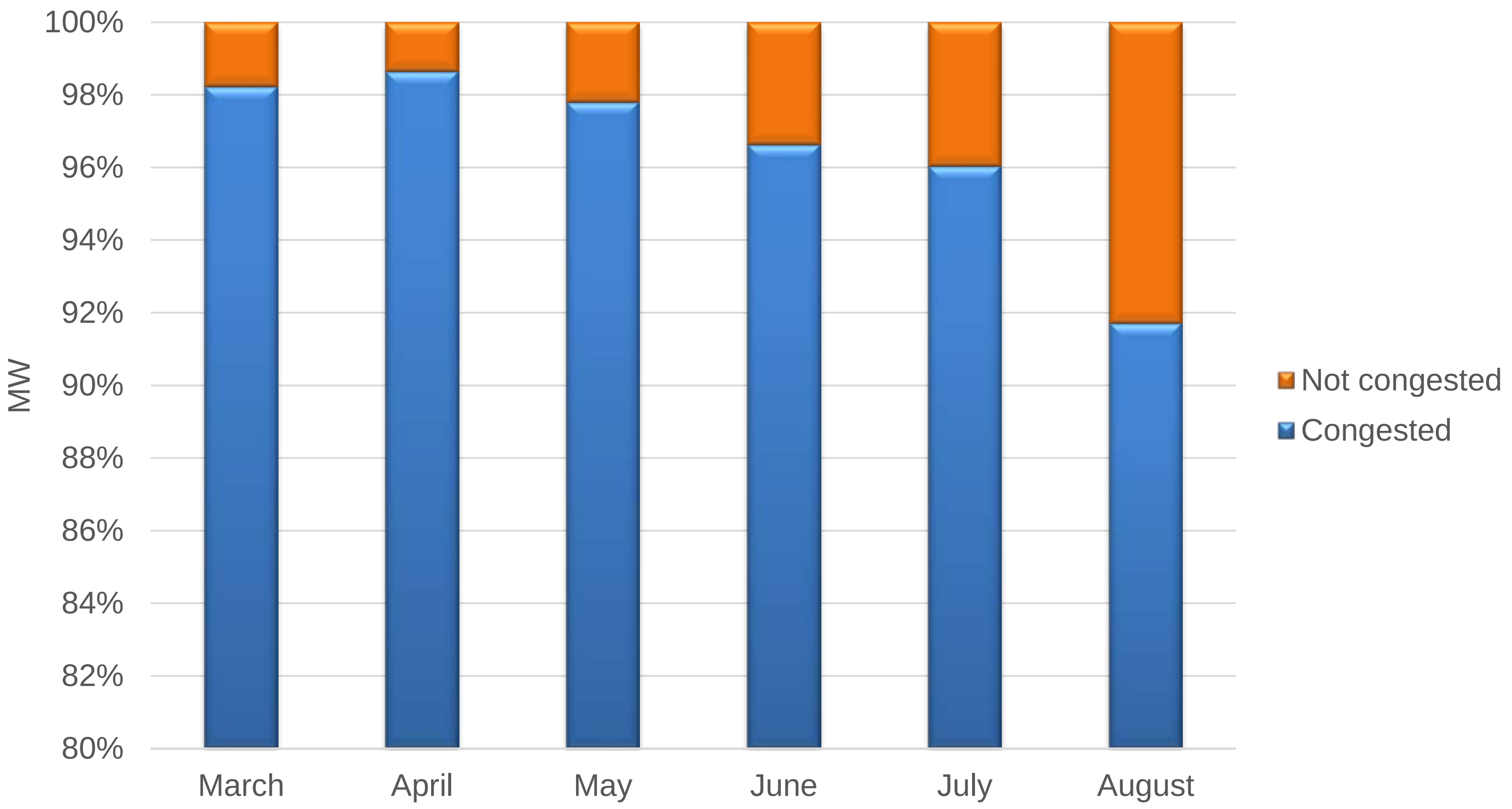
FRU' performance – measure the utilization

- The utilization metric
  - Delivered_FRU'(t+1) = min(FRU'(t), max(DOT(t+1) - EN(t+1),0))
  - Undelivered_FRU'(t+1) = FRU'(t) – Delivered_FRU'(t+1)
  - FRU' utilization = sum(Delivered_FRU'(t+1)) / sum(FRU'(t))
- FRU' utilization is a key metric to measure performance
  - FRU' utilization can directly measure the FRU' performance only when system is short of energy and FRU' award > 0
  - When system is short of energy,
    - if all FRU' awards are performing perfectly, FRU' utilization should approach 100%.
    - if FRU' awards are not performing perfectly, they will have the FRU's utilization value less than 100%, which may be caused by certain issues

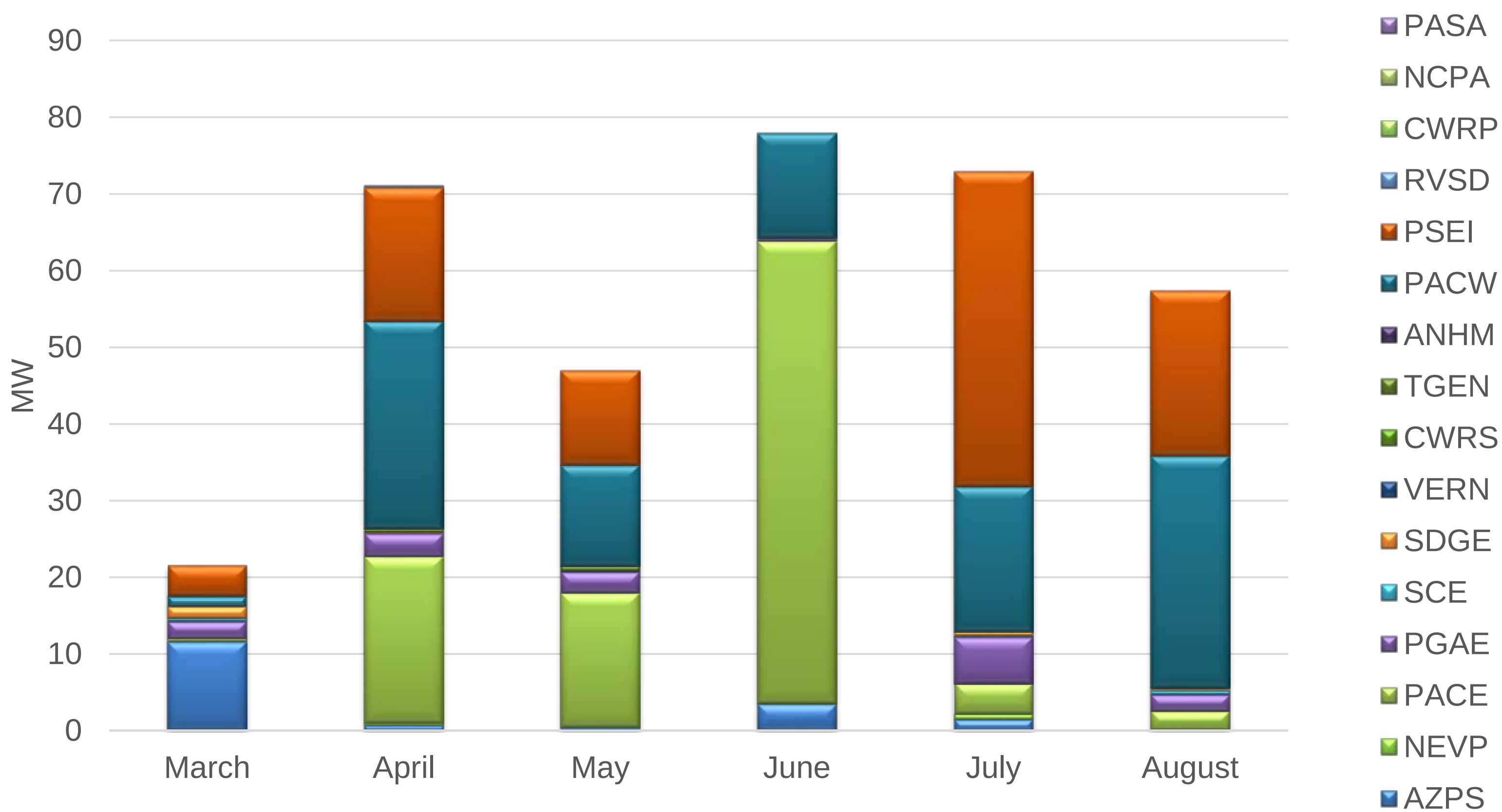
FRU' utilization when price spikes happen



Most of undelivered FRU were awarded to units limited by transmission constraints, and thus cannot deliver



Undelivered FRU awards due to congestion by area



Undeliverable FRU' due to reasons other than congestion

- Limited by other constraints
  - Generator has ancillary service in interval t+2 and has a slow ramp rate. It receives FRU' award at t to cover t+1 uncertainty, which is capacity at t+1 with the advisory dispatch being pressed down to free up capacity needed for t+2 ancillary service.
  - Daily energy limitation. Generator hits the daily energy limitation in its dispatch, so it is dispatched lower than Pmax. Optimization awards the undispatched capacity as FRU, but it cannot be delivered due to the energy limitation.

FRU observations

- FRU' utilization largely impacted by transmission congestion
  - The behind-constraint supply appears to be more economic to provide FRU, and thus gets most of the FRU awards
  - The behind-constraint supply cannot deliver when the system needs energy
  - Transmission congestion disconnects the behind-constraint FRU' supply from the system wide energy demand, and breaks the price correlation linkage between them
- There are other constrains impacting FRU' utilization
  - Not as significant as congestion

Recommendations

- Address FRP deliverability in market optimization
  - Only give awards to the deliverable resources
- Review FRP uncertainty requirement calculation
- Remove the overly limiting constraint from FRP implementation
- Monitor FRP with the new utilization metric