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ELECTRICAL ENGINEERING

Optimally Structured Retail Rates to Incentivize Demand Response

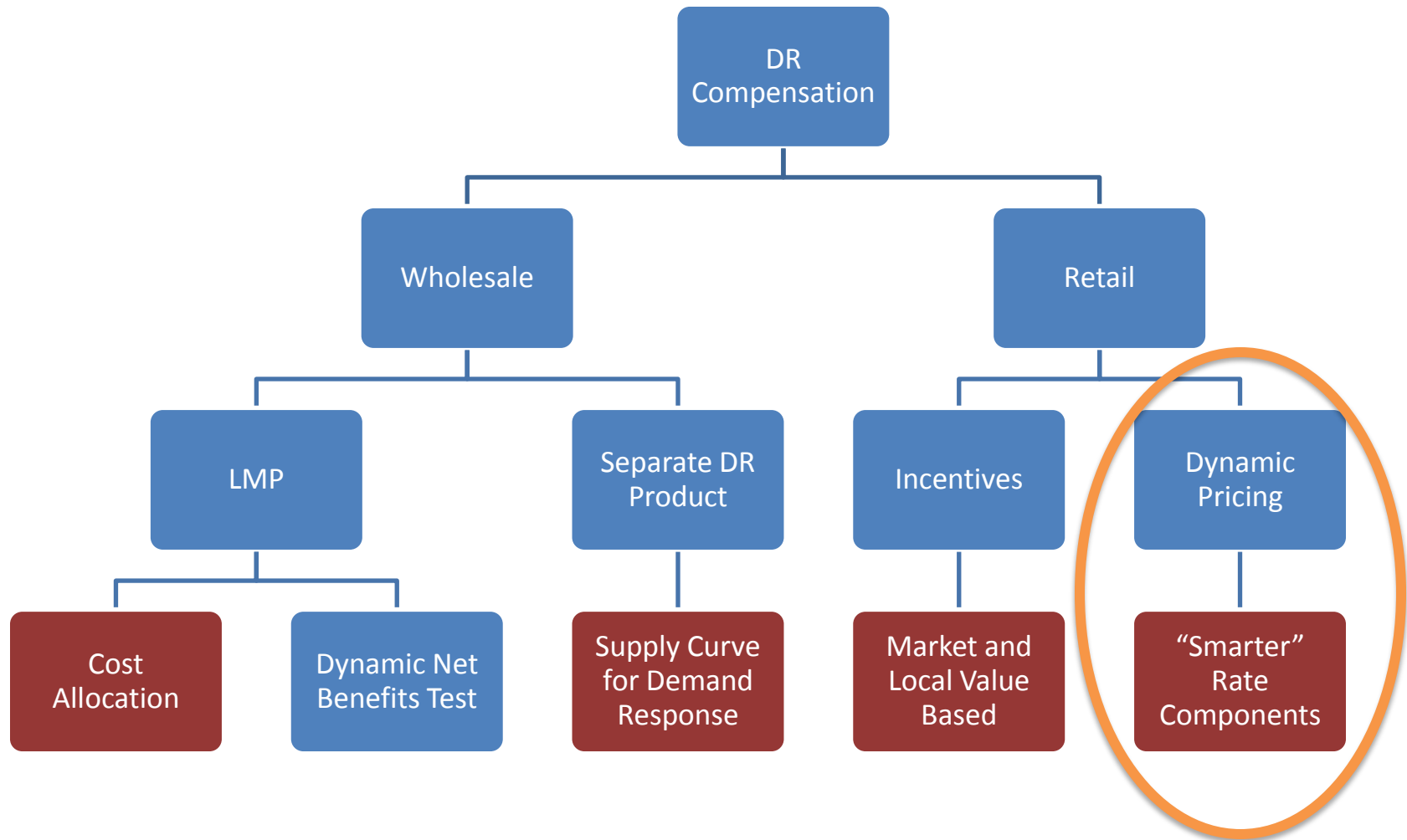
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Research Directions



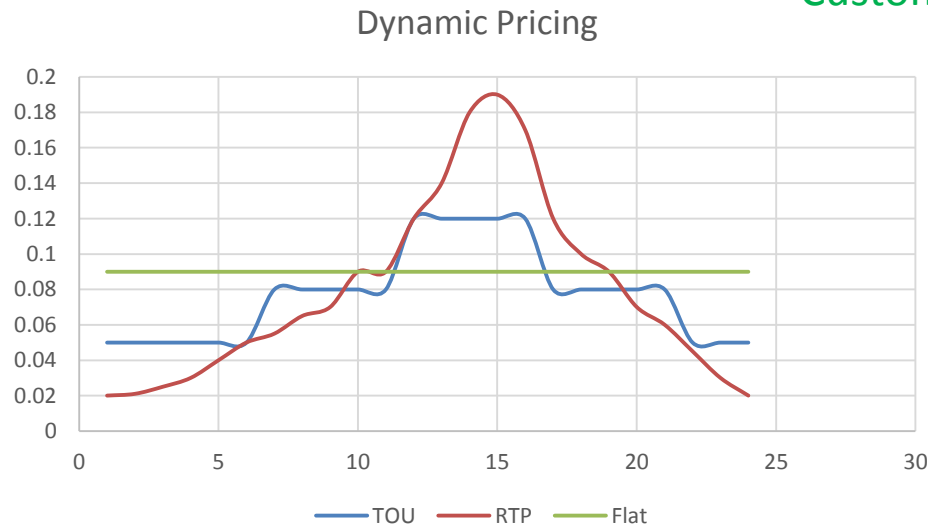
Goal

Current Dynamic Pricing

- Time of Use (TOU)
 - Based on time of day/season
- Real Time Pricing (RTP)
 - Based on wholesale market

Proposed Dynamic Pricing

- Modified Real Time Price
 - Based on:
 - Wholesale conditions
 - Local grid conditions
 - Customer selected price risk



MODIFIED REAL TIME PRICE

CAISO Wholesale Grid State Indicator, G_m



- Locational index to indicate market conditions
- Adjusted by DSO or ESP for local, smart devices
- Used to facilitate consumer energy use decisions



Formulation

$$G_n^t = a \frac{P_{actual}^t}{P_{rated}^t} \quad (1)$$

$$a = e^{\frac{\ln(G_{max})}{r}} \quad (2)$$

$$G = G_{max}(1 - r^{-(G_m + G_n)}) \quad (3)$$

$$mRTP = B * G + R_{min} \quad (4)$$

$$B = \frac{R_{max} - R_{min}}{G_{max}} \quad (5)$$

$$\min_{R_{min}} \left| \sum_{t=1}^{8760} (B * G^t + R_{min}) * Load^t - RR \right| \quad (6)$$

G_n=network grid state index
G_m=CAISO grid state index
r=pu emergency capacity
R_{min}=optimized parameter
B=customer chosen risk level
mRTP=retail rate

CASE STUDY

Test System

- Assumptions:
 - 1) Regulated utility
 - 2) One year rate case
 - 3) Single class of customers (residential)

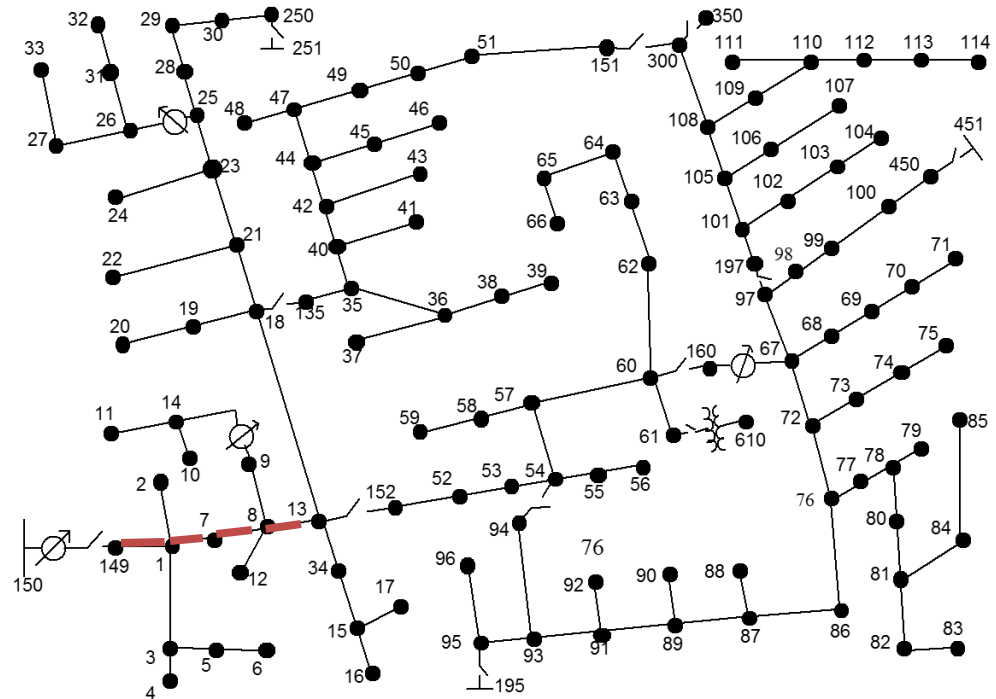


Figure 1. IEEE 123-Bus Test Feeder. Feeder section highlighted in red are near capacity and benefit from load reductions during local peak usage.



Revenue Requirements

Expenses

Operational Expenses

Energy	\$ 330.00
Distribution	\$ 70.00
Customer Accounting	\$ 30.00
Administration	\$ 63.00
Rate Discounts	\$ 7.00

Debt Service

Debt Service (DS)	\$ 175.00
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Capital Projects

Total Capital Expense	\$ 237.00
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Revenue

Wholesale

Wholesale Sales	\$ 100.00
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Retail

Retail Revenue Requirements	\$ 752.60
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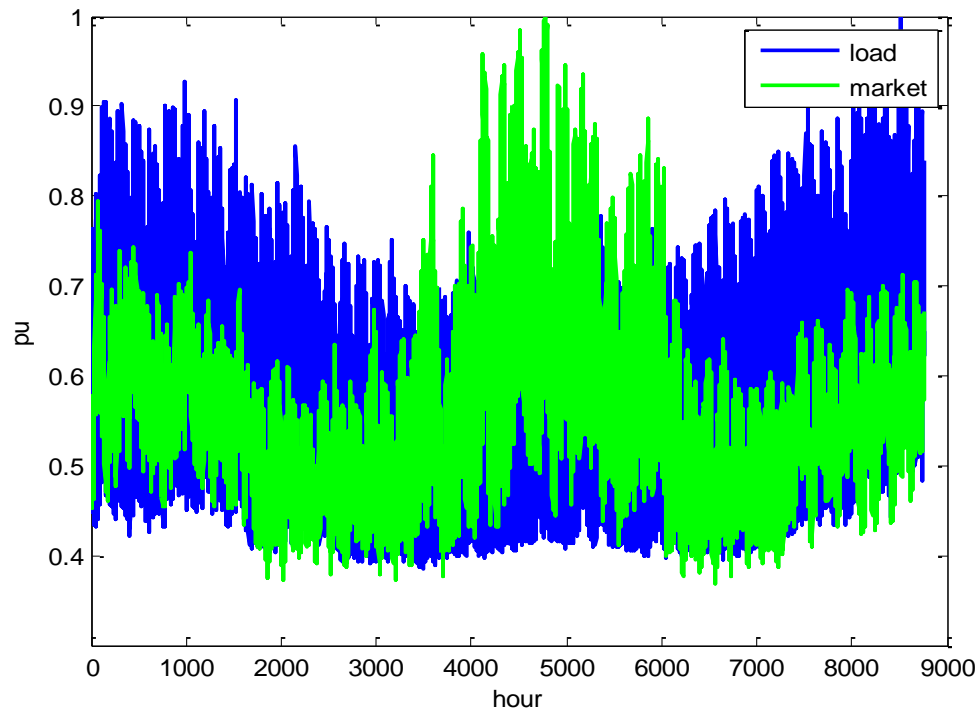
Rate:

Total Load (MWH)	9,200,000
Average rate (\$/MWH)	81.8

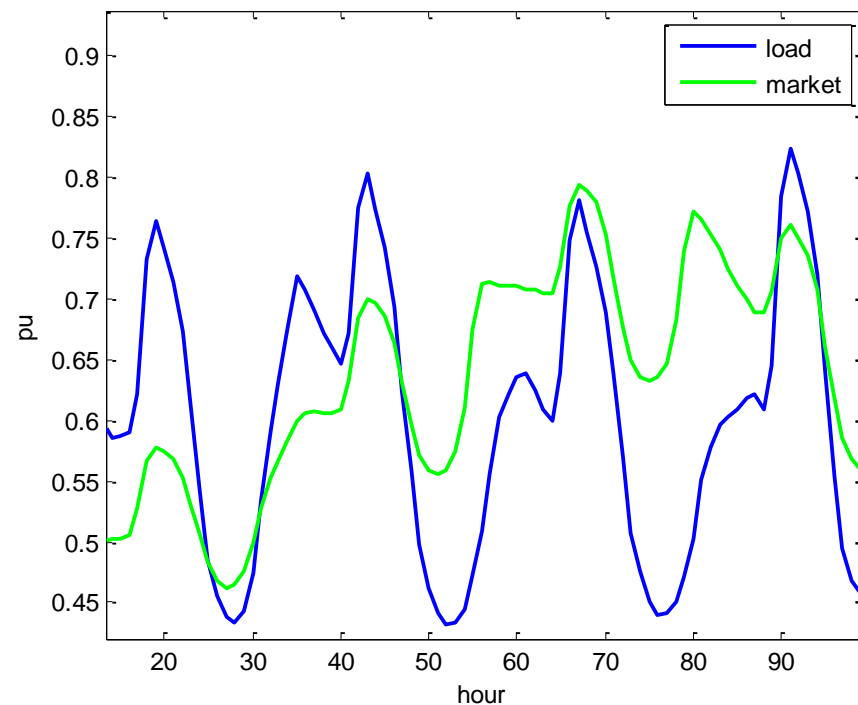


Price and Load Data

Comparison of normalized hourly load and market price over the entire test year.

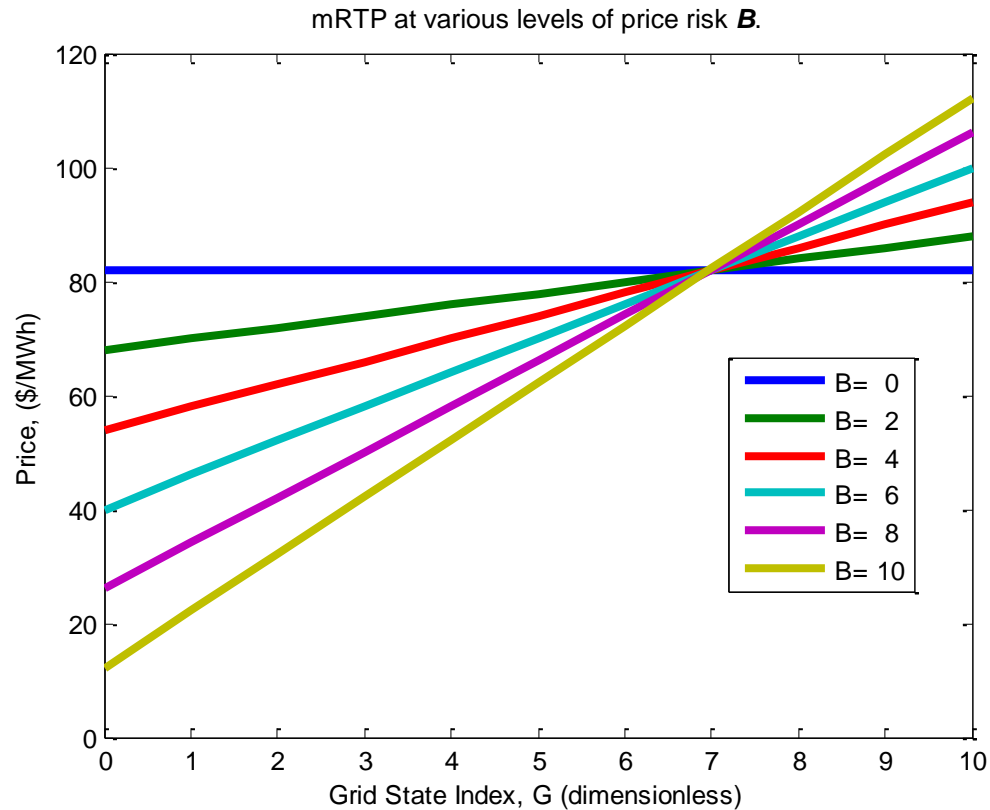


Comparison of normalized hourly load and market prices. (First 4 days of the test year)



RESULTS

Results: mRTP





Results: Comparison of Rates

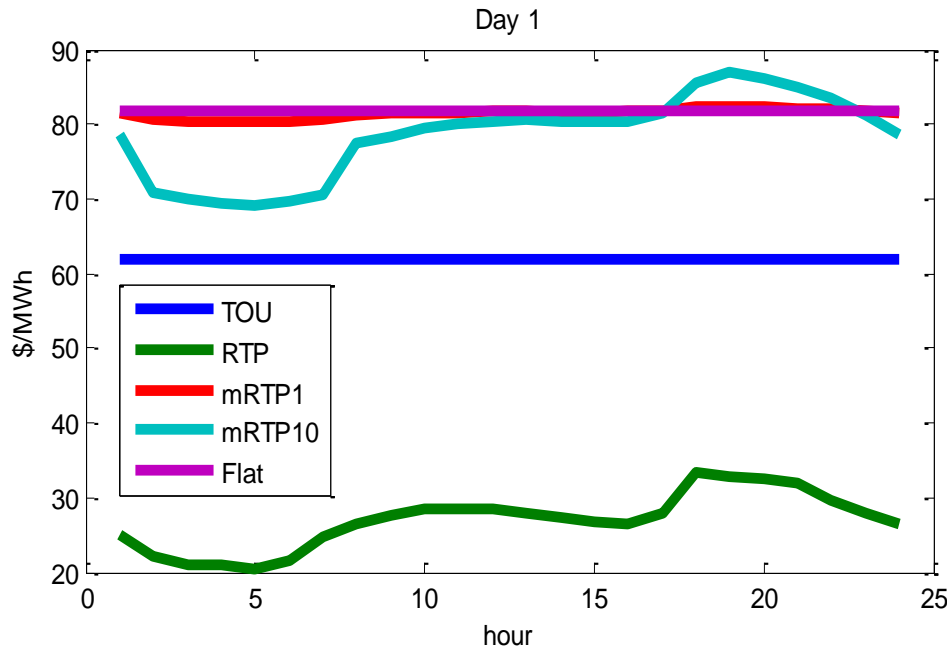


Figure 2. Comparison of proposed mRTP, RTP, TOU and flat rates. (Day 1 is a Saturday and the TOU rate used is flat during weekends.)

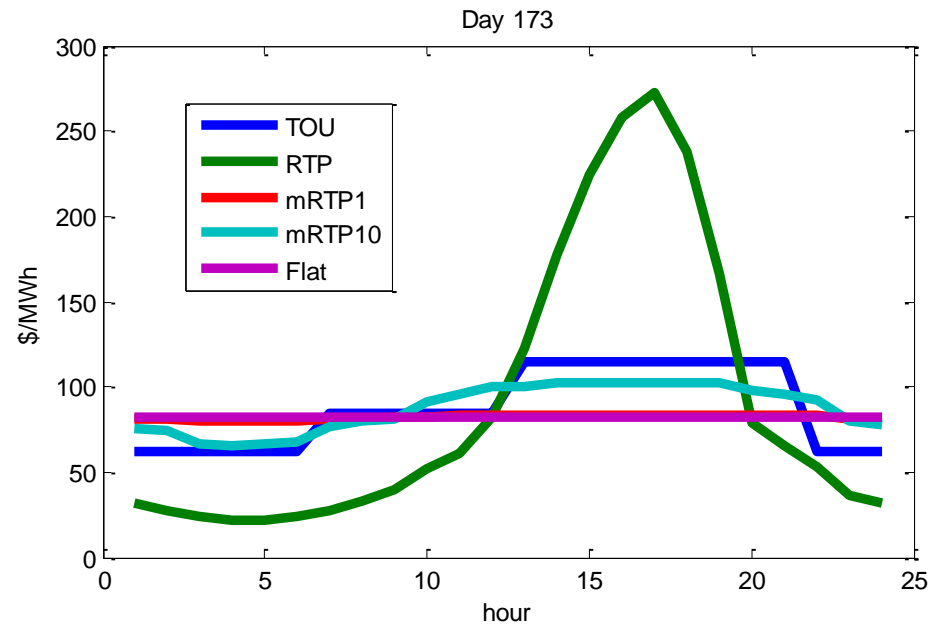
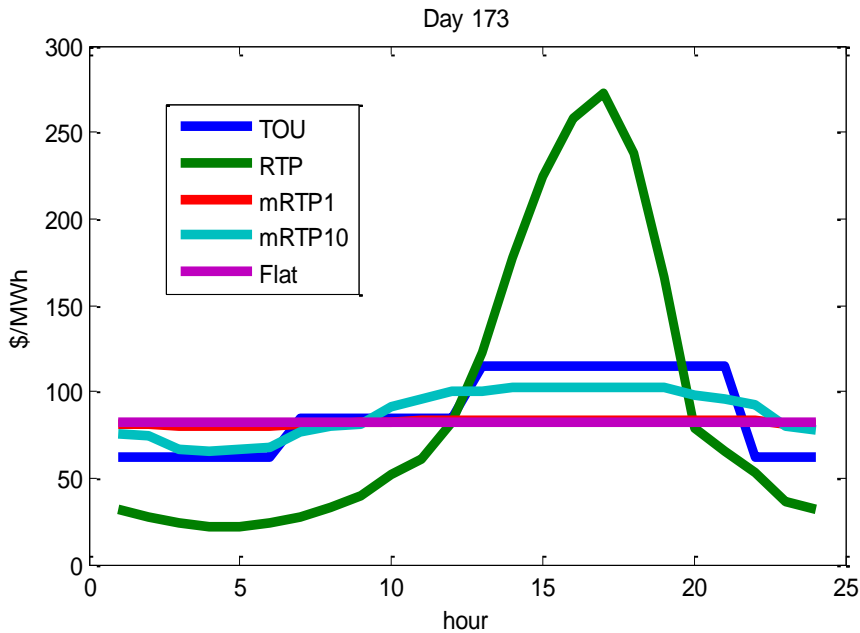


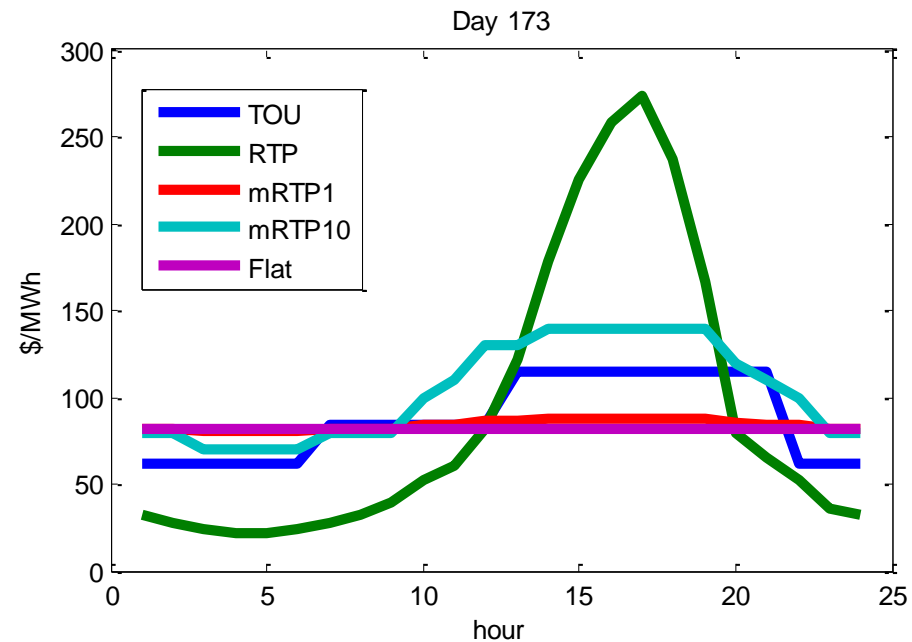
Figure 3. Comparison of proposed rate, RTP, TOU and flat rates. (Summer weekday)



Results: (Un)Correlated G_n & G_m



Uncorrelated Local and Market Conditions



Correlated Local and Market Conditions



Conclusion

- Modified Real Time Price
 - Hybrid between TOU and RTP
 - More price security than RTP
 - More accurately reflects true costs than TOU
 - Allows for customer choice
 - Reflects local value of demand response



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Thank you