Rotterdam School of Management
Erasmus University

RSM Erasmus

Increasing Distributed Renewables Leads to Higher Cross-subsidies, Depending on Tariff

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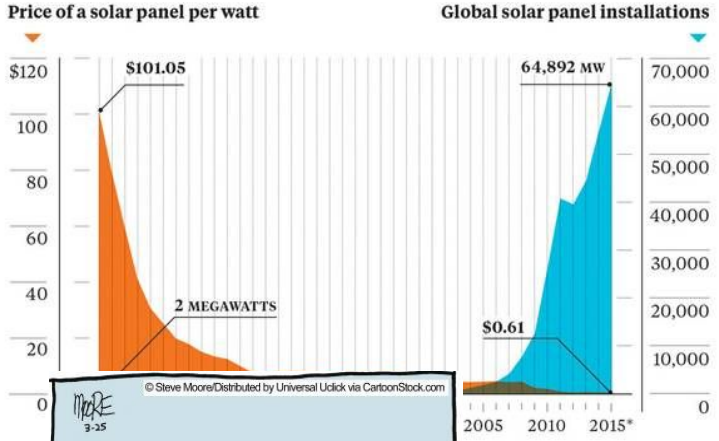
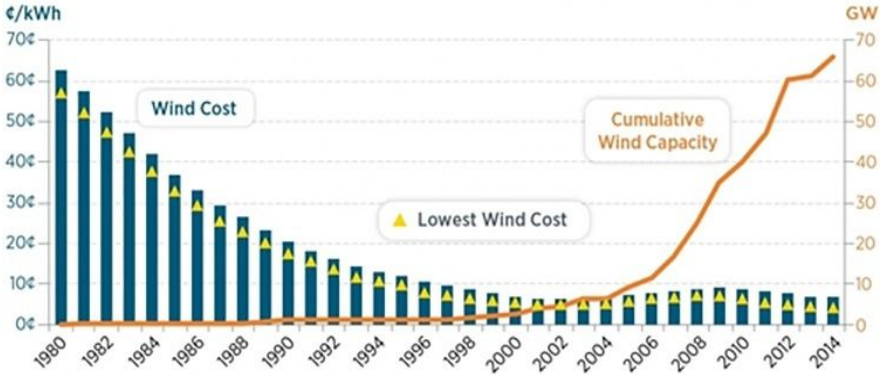
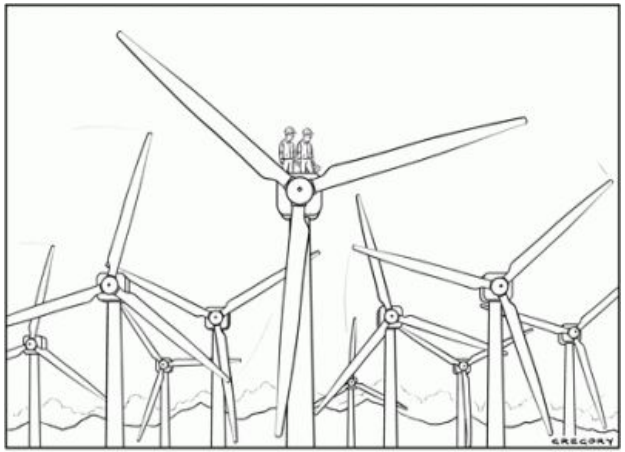
Solar and wind are exploding



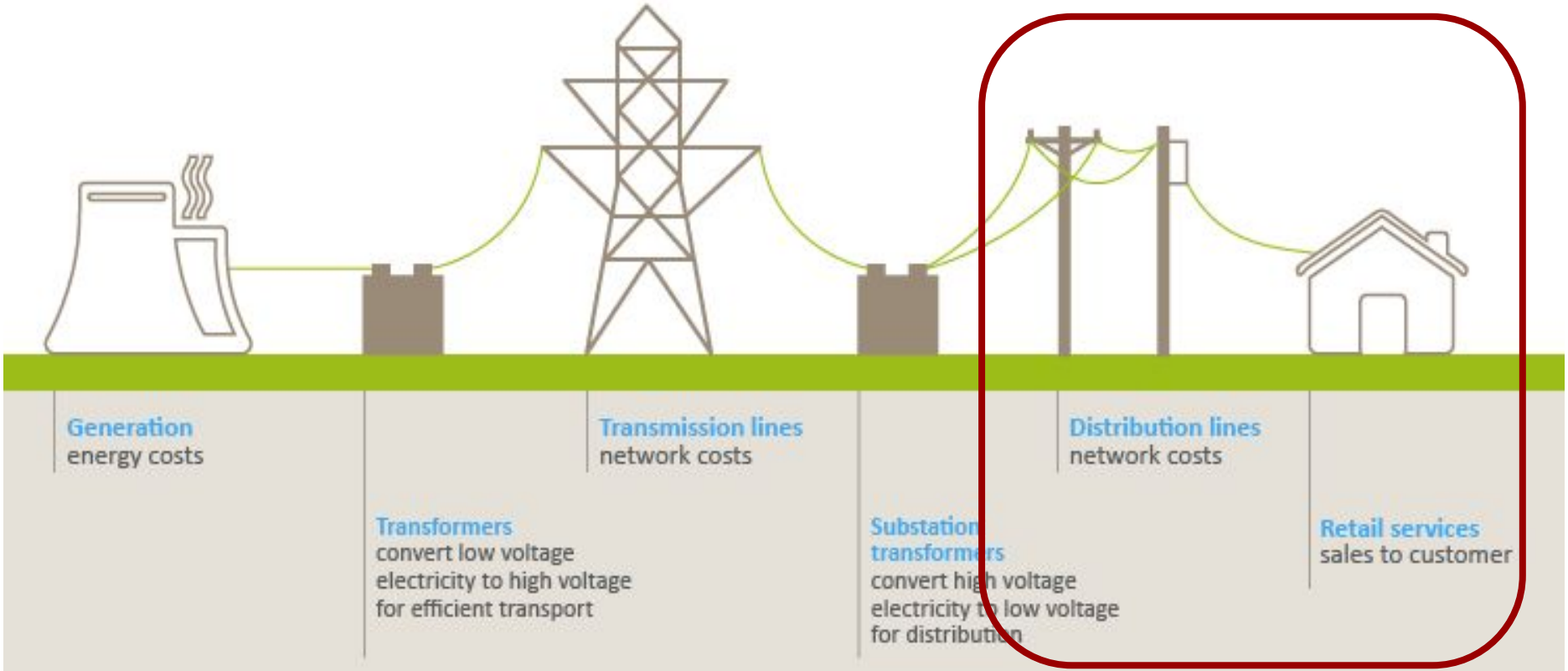
"He's our power hitter — but only on sunny days."





"Try blowing on it."

Also in distribution grids



Retailer's balance sheet

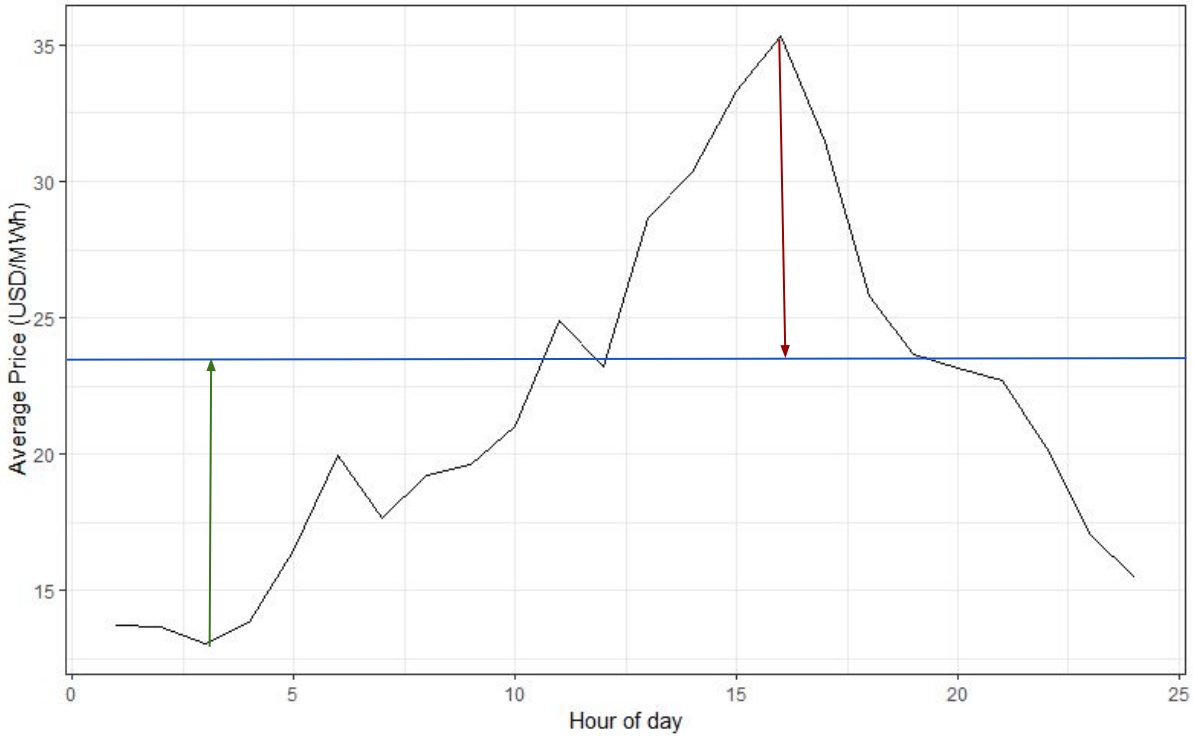
Costs

- Energy (/kWh)
- Capacity (infrastructure, etc.) (/kW)
- Misc. (billing, marketing, etc.) (/connection, others)

Revenue

- Tariffs
  - Usually depends on consumption (/kWh)

Economic efficiency?



Data from ERCOT RTLMP @ Austin LZ, 2016 average

Capacity costs too

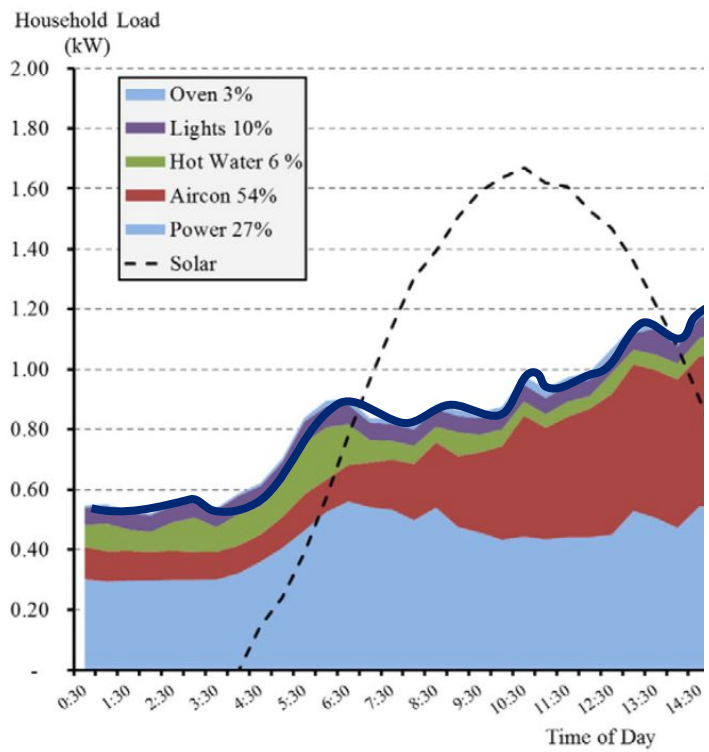


Fig. 5. Average household load—summer weekdays.

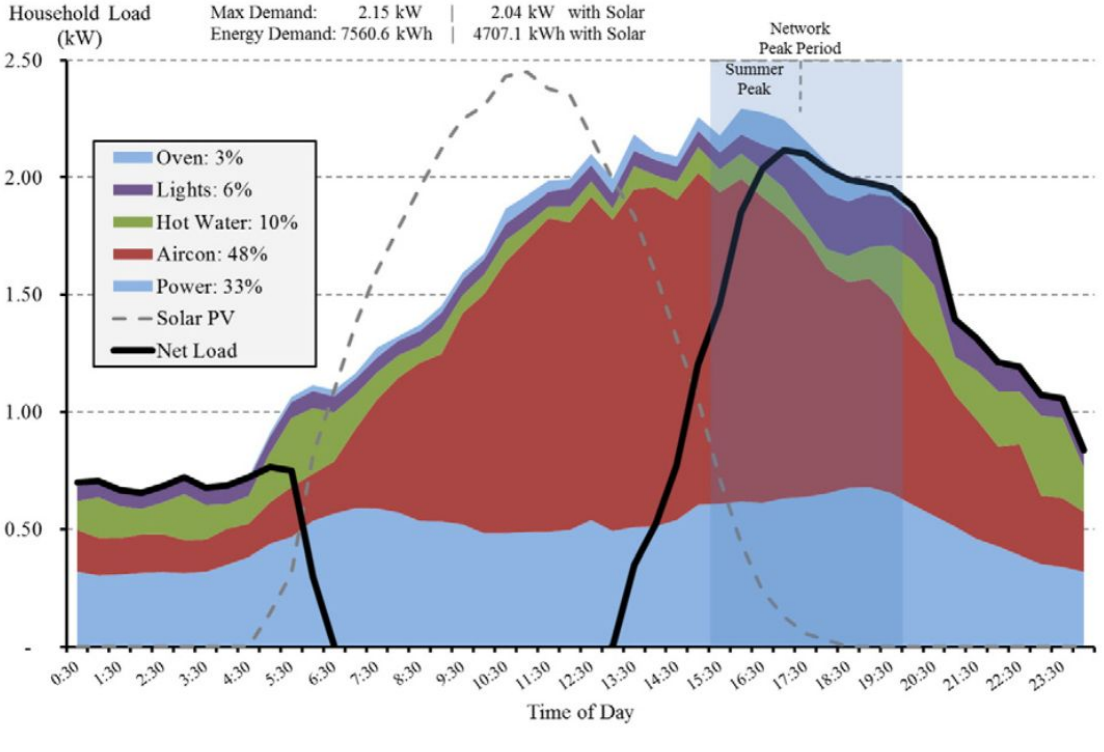
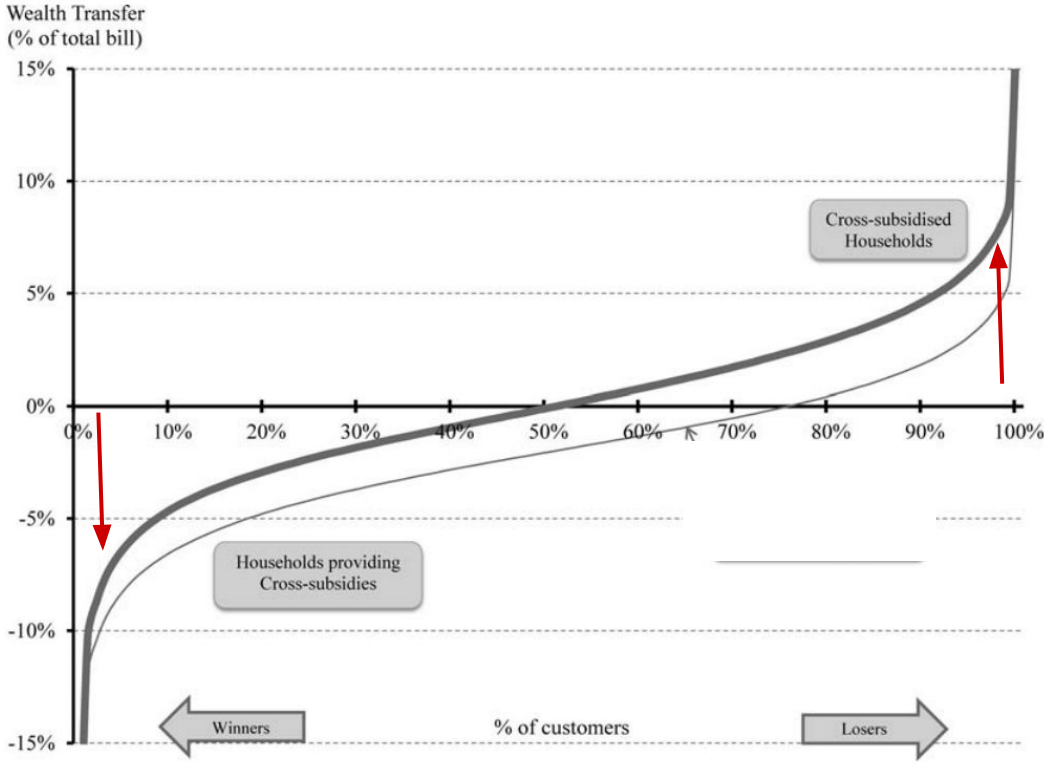


Fig. 7. Average household load during 'critical event' summer days.

Source: Simshauser 2016

Why does this matter?

- When overall revenue stays constant, some users are subsidizing other users: cross-subsidization



Source: Simshauser and Downer (2016)

Smart meters

Source: avrotros.nl

Source: Deutsche Telekom

Our question

How does increasing distributed renewable generation affect cross-subsidization for different tariffs?

Two metering choices

	Smart meters (AMI)	Dumb meters (no AMI)
Gen. and cons. Metered together	AMI / net	No AMI / net
Gen. and cons. Metered separately	AMI / FiT	No AMI / FiT

#	Tariff Name	Metering setup	Consumption (E_j)	Generation (G_j)	Net Demand (D_j)	Capacity (C_j)
1	Conventional FiT	No AMI / FiT	Austin Energy residential tariff	Austin energy rate (-11.3)	0	0
2	Flat-rate FiT	No AMI / FiT	Flat rate	^^ Same (-11.3)	0	0
3	TOU FiT	AMI / FiT	Expensive day rate, cheaper night rates	Real-time pricing + Renewable energy certificates	0	capacity costs (distributed equally)
4	RTP FiT	AMI / FiT	RTP hourly rate close to ERCOT RTLMP	^^ Same	0	^^ Same
5	Flat-rate Net	No AMI / net	0	0	Similar to E_2	0
6	TOU Net	AMI / net	0	0	Similar to E_3	Similar to Tariff 3
7	RTP Net	AMI / net	0	0	Similar to E_4	Similar to Tariff 3
8	RTP Net + DC	AMI / net	0	0	SImilar to E_4	Monthly peak demand
-	*Real costs*	-	*ERCOT RTLMP (E_r)*	*-(E_r + 2.5)*	*0*	δ_p

Methods

Cross-subsidization:

Costs transfer

$$\forall\, j \in N; i \in M: \lambda_{j,i} = \frac{O_{r,i} - O_{j,i}}{\left|O_{r,i}\right|}$$

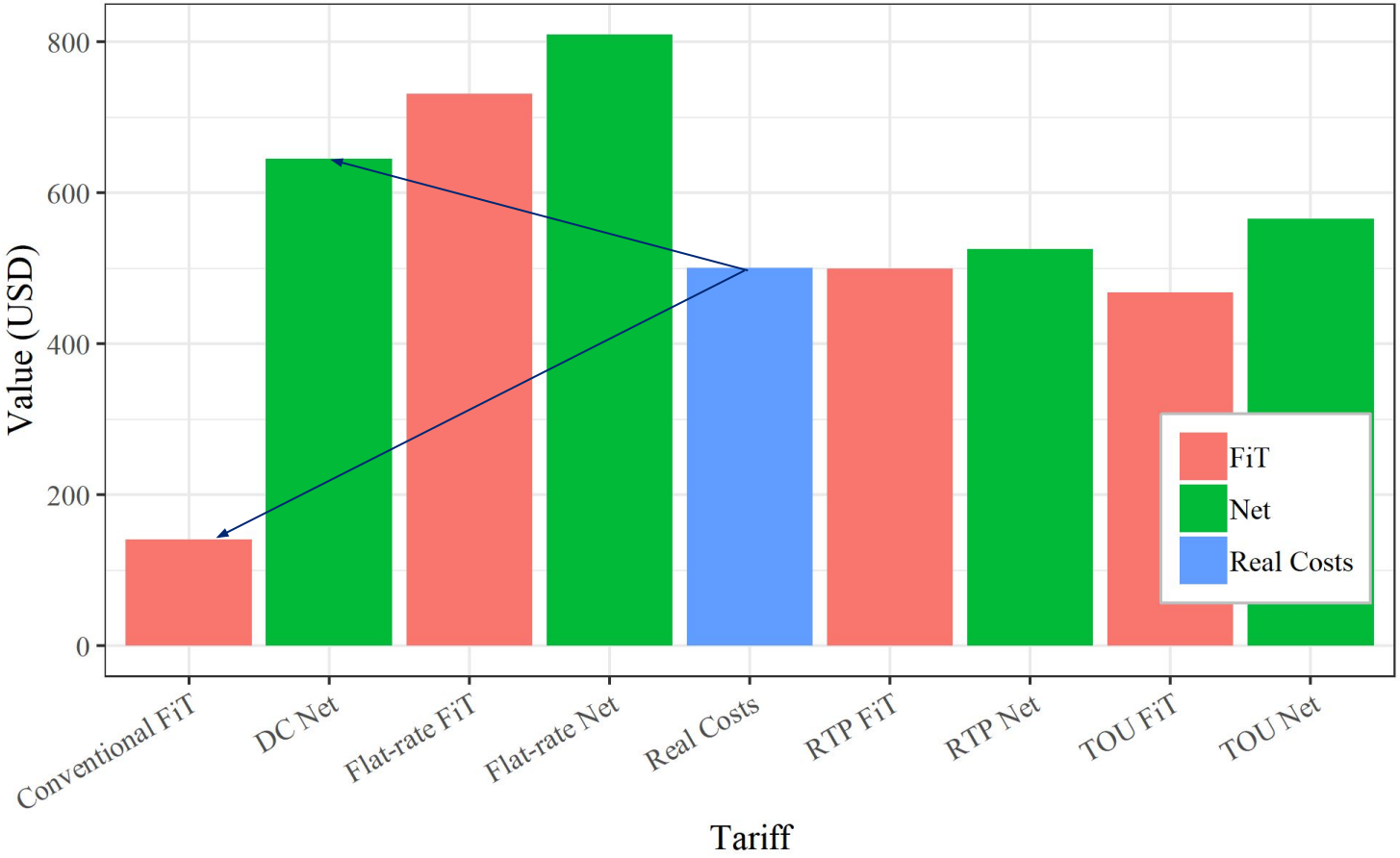
Households given generation units

- 0 -> 100% prosumers

Data

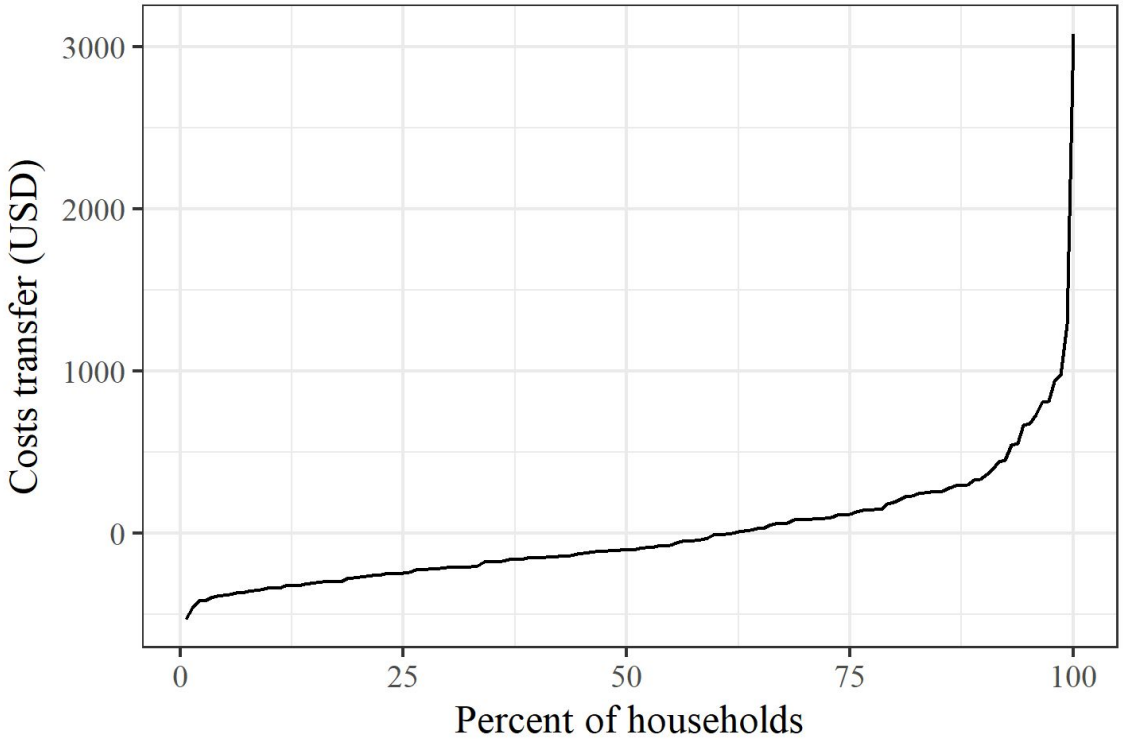
- Household electricity data from Pecan Street Dataport
  - 144 households, consumption + generation data
  - Location: Austin, TX, USA
  - 1-minute resolution over 2016
- Electricity price data
  - 2016 retail rates (for comparison/calibration) from Austin Energy, a local public utility
  - ERCOT (transmission grid operator) prices for electricity
    - 15-minute resolution locational-marginal prices for Austin load zone
    - 2016

Household pays too little (or too much)



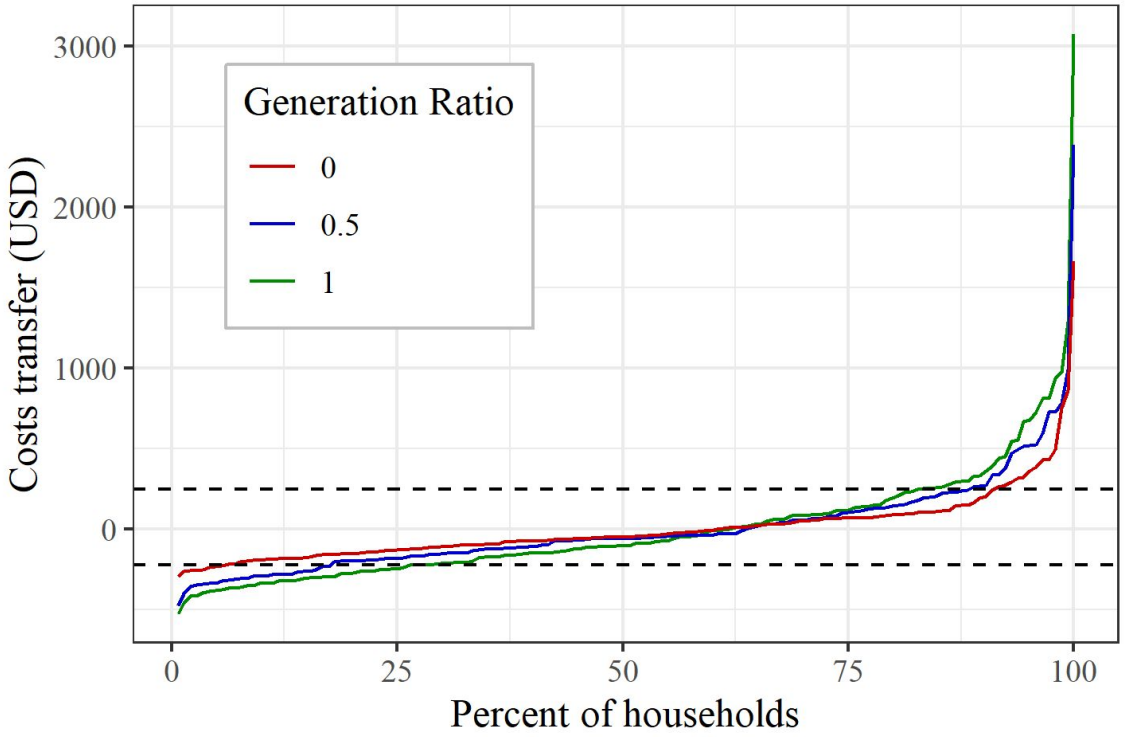
Results (Gen ratio = 1)

Cost transfers between households are high



Results

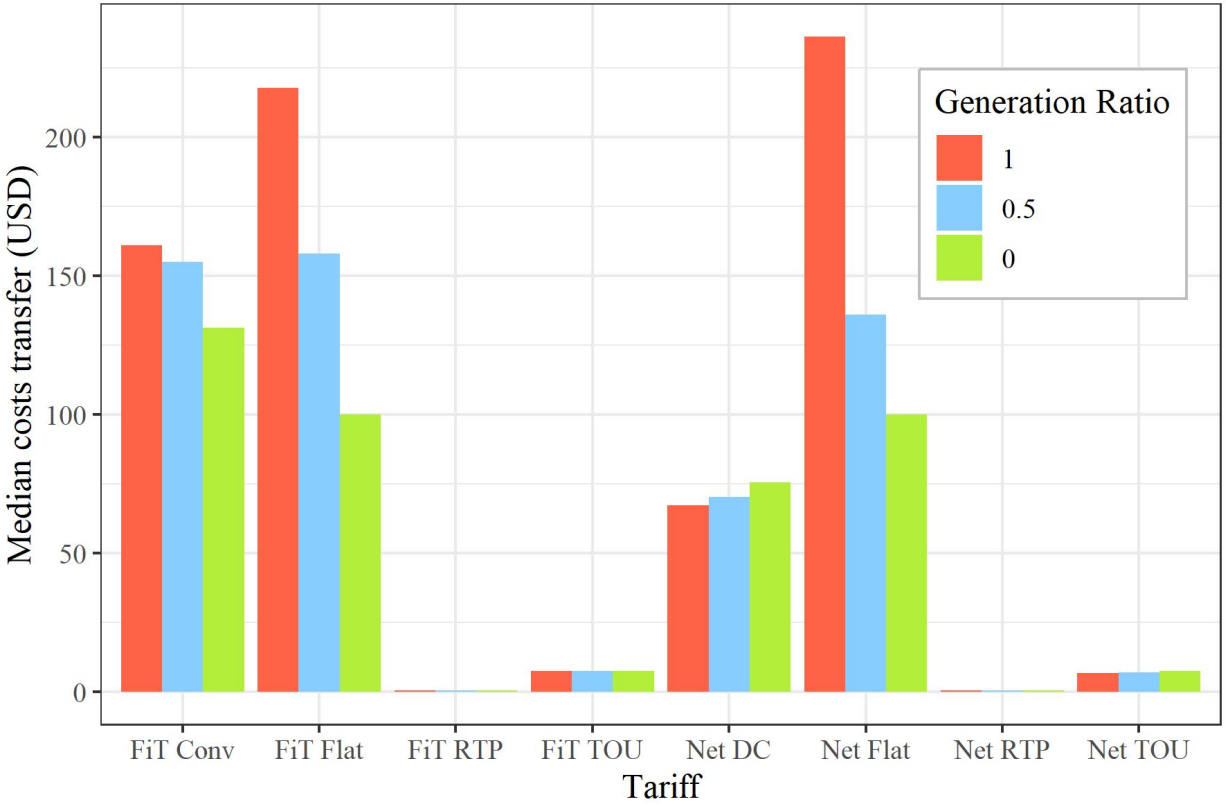
Cross-subsidies get worse as generation ratio increases (Flat-rate net tariff on right, dashed lines are median values for green)



Results

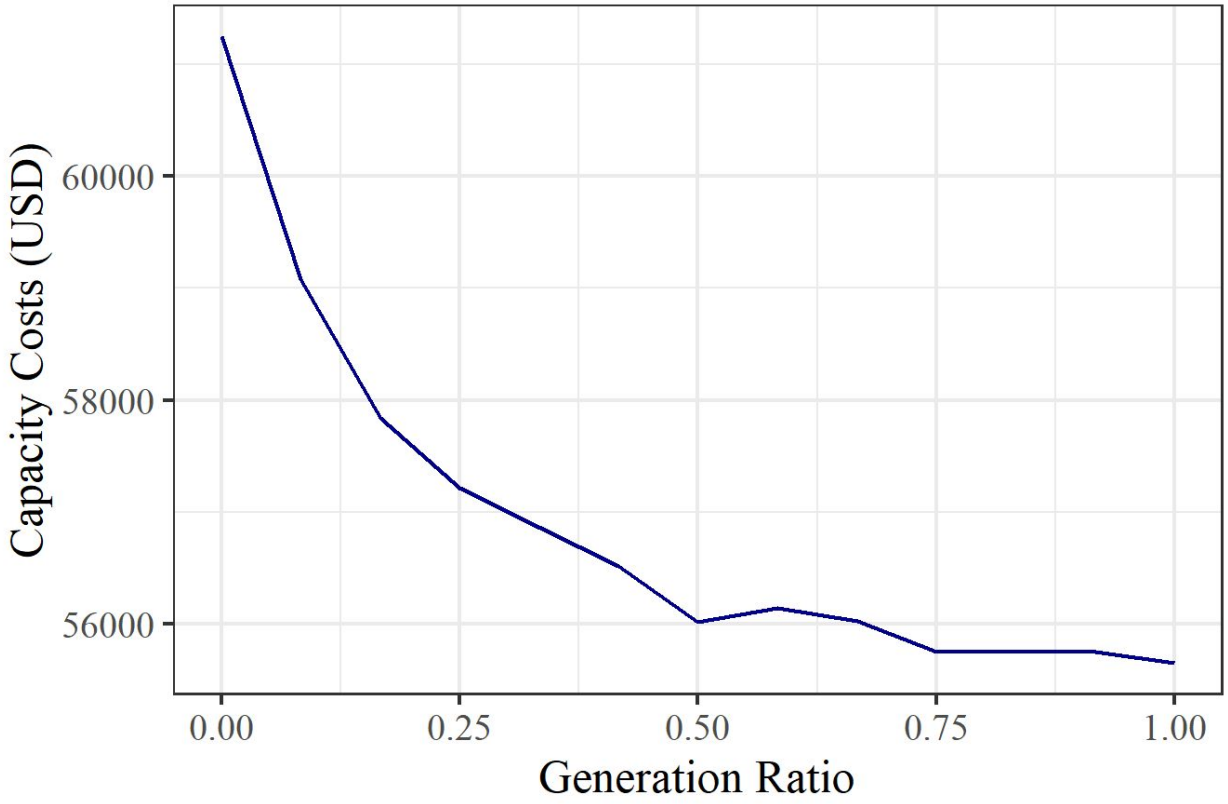
But only for the conventional tariffs!

DC tariff's costs transfers actually decrease...



Results

Capacity costs decrease as RES generation increases



Conclusions

1. Cross-subsidies for conventional tariffs get far worse as renewables increase (= over time)
    - A switch to AMI Tariffs is necessary at some point
2. Cross-subsidies for AMI-based tariffs don't change as renewables increase
3. Except for DC tariff, which has fewer cross-subsidies as renewables increase, because capacity costs go down

? | !

May 2019
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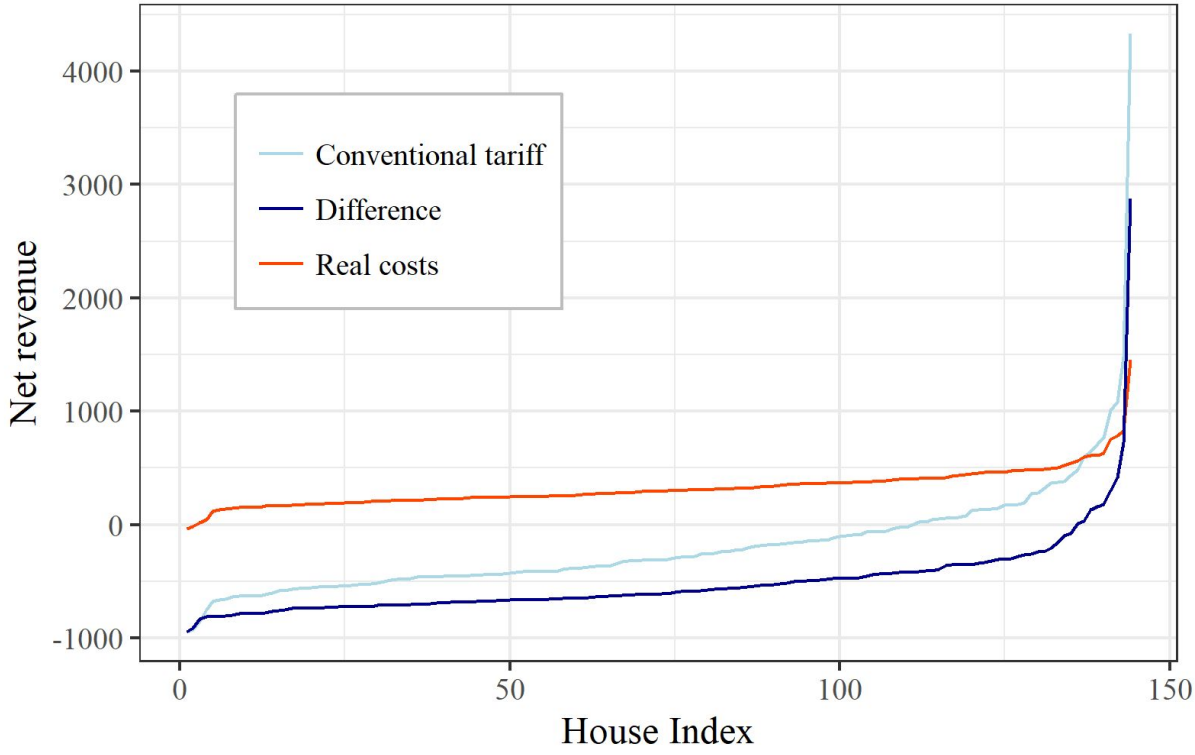
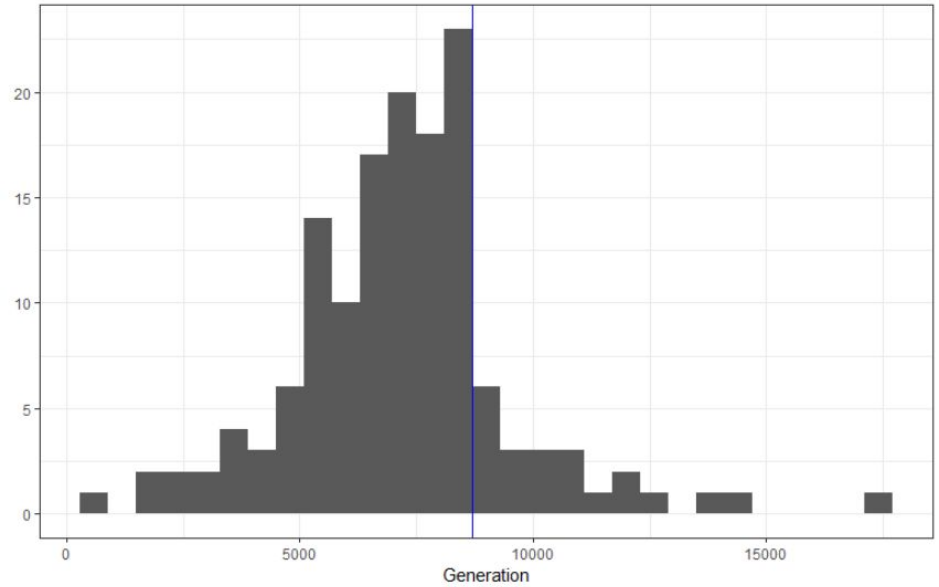
Tariff formula

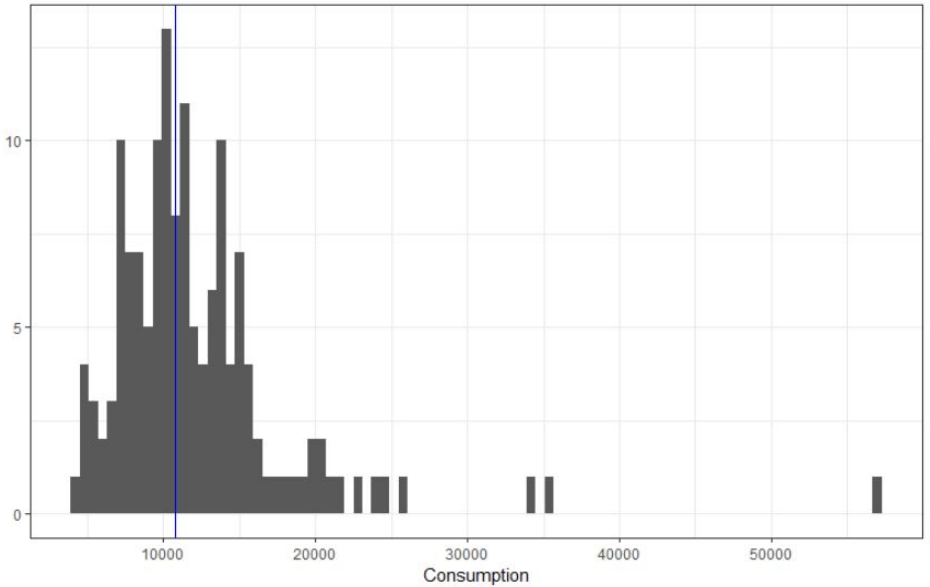
$$O_{j,i} = \sum_{t \in T} E_j x_i(t) + \sum_{t \in T} G_j g_i(t) + \sum_{t \in T} D_j d_i(t) + \sum_{\tau \in T} C_j p_{max,i}(\tau) + \alpha_{j,i}$$

Results

Austin Energy's conventional tariff will bleed money




20
15
10
5
0
0
5000
10000
15000
Generation


10
5
0
10000
20000
30000
40000
50000
Consumption

Cross subsidies for non-AMI tariffs