



Clean energy and environmental consultants



# Tariff Treatment of Behind-the-Meter Storage and V2G



# What I will cover

---



**Effects of BTM storage and V2G on power flows**



**Effects of BTM storage and V2G on utility costs**

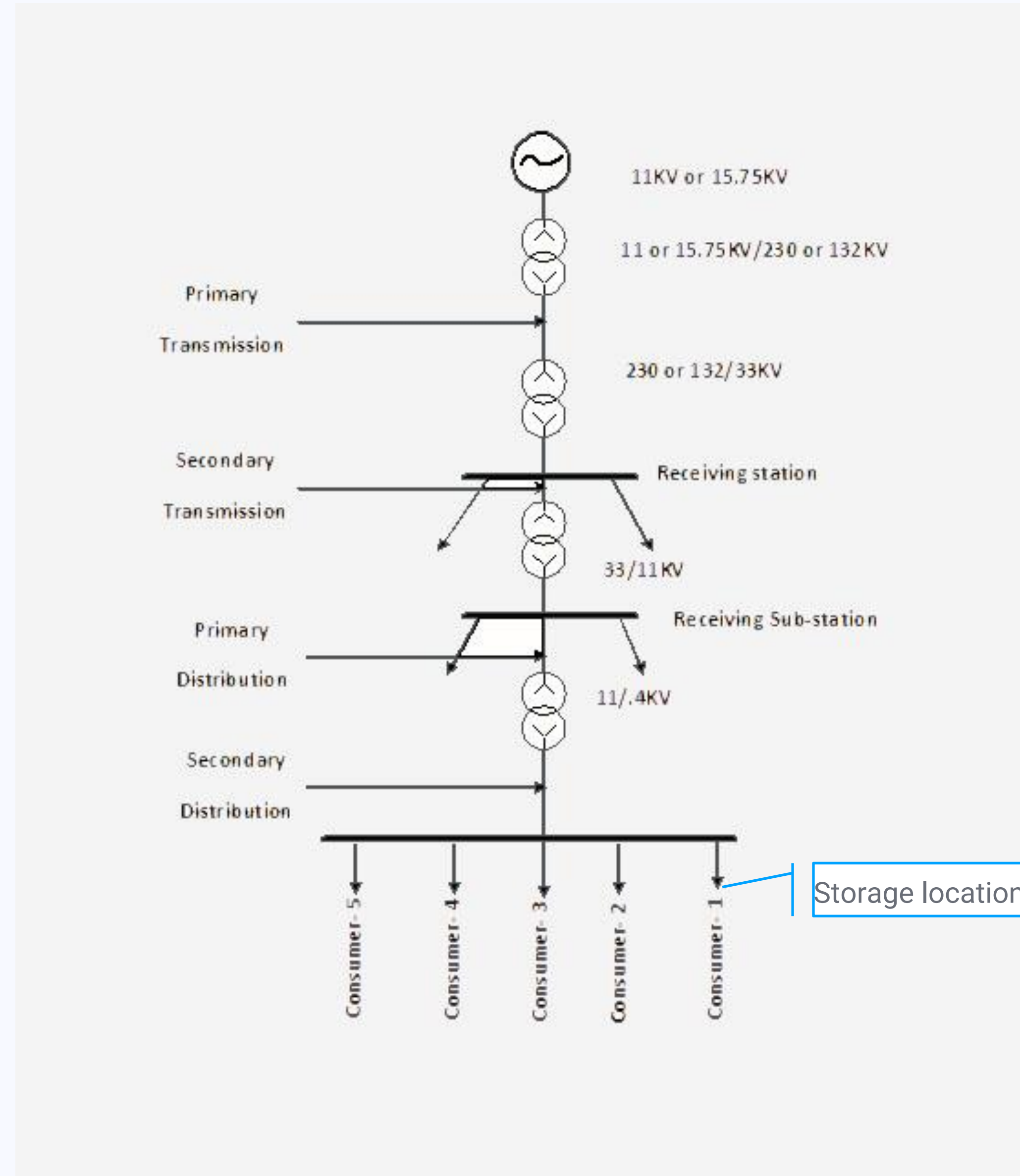


**Effects of tariff design on customer adoption of BTM storage and V2G**

# A Stylized Grid

Power flows from centralized generation at the top, through transmission, subtransmission, primary distribution, and secondary distribution to residential customers.

I am using a residential customer for illustration, but similar analysis applies to customers served at higher voltages. Financial analysis based approximately on Consumers Energy's Smart Hours Rate RSH.



# Hypothetical Power Flows

Flow (kWh/day)	Customer Without Storage			Standalone FTM Storage			Customer with BTM Storage No Outflow			Customer with BTM Storage and Outflow to Grid		
	Off-peak	On-peak	Total	Off-peak	On-peak	Total	Off-peak	On-peak	Total	Off-peak	On-peak	Total
Customer Load	20.000	8.000	28.000	14.444	-13.000	1.444	28.889	0.000	28.889	34.444	-5.000	29.444
Customer Service Line	20.200	8.140	28.340	14.589	-13.228	1.361	29.178	0.000	29.178	34.789	-4.914	29.875
Customer Secondary	20.402	8.282	28.684	14.735	-13.459	1.276	29.470	0.000	29.470	35.137	-5.000	30.137
Distribution Transformer	20.810	8.531	29.341	15.029	-13.863	1.167	30.059	0.000	30.059	35.840	-5.150	30.690
Primary Line	21.018	8.804	29.822	15.180	-14.306	0.873	30.360	0.000	30.360	36.198	-5.315	30.883
Distribution Substation	21.439	9.068	30.507	15.483	-14.736	0.748	30.967	0.000	30.967	36.922	-5.474	31.448
Subtransmission	21.653	9.204	30.857	15.638	-14.957	0.682	31.276	0.000	31.276	37.291	-5.556	31.735
Transmission	21.956	9.358	31.314	15.857	-15.206	0.651	31.714	0.000	31.714	37.813	-5.649	32.164
Generation	22.395	9.573	31.968	16.174	-15.556	0.618	32.349	0.000	32.349	38.569	-5.779	32.790

**Storage increases total power flow to the customer, by the amount of storage round-trip losses adjusted for line losses. Because line losses are higher at peak times, storage-induced power flow at generation is less than at customer.**

# Hypothetical Financial Analysis – Customer Receives Distribution Credit for Outflow

Incremental Cost \$/day	Customer Without Storage			Standalone FTM Storage			Customer with BTM Storage No Outflow			Customer with BTM Storage and Outflow to Grid		
	Off-peak	On-peak	Total	Off-peak	On-peak	Total	Off-peak	On-peak	Total	Off-peak	On-peak	Total
Production Energy	\$ 1.40	\$ 0.88	\$ 2.28	\$ 1.01	\$ (1.43)	\$ (0.42)	\$ 2.02	\$ -	\$ 2.02	\$ 2.41	\$ (0.55)	\$ 1.86
Production Capacity	\$ -	\$ 1.00	\$ 1.00	\$ -	\$ (2.28)	\$ (2.28)	\$ -	\$ -	\$ -	\$ -	\$ (0.88)	\$ (0.88)
Transmission	\$ -	\$ 0.28	\$ 0.28	\$ -	\$ (0.46)	\$ (0.46)	\$ -	\$ -	\$ -	\$ -	\$ (0.18)	\$ (0.18)
Distribution	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Access Charge	\$ 0.22	\$ 0.04	\$ 0.27	\$ 0.22	\$ 0.04	\$ 0.27	\$ 0.22	\$ 0.04	\$ 0.27	\$ 0.22	\$ 0.04	\$ 0.27
TOTAL	\$ 1.62	\$ 2.20	\$ 3.83	\$ 1.23	\$ (4.12)	\$ (2.88)	\$ 2.24	\$ 0.04	\$ 2.29	\$ 2.63	\$ (1.56)	\$ 1.08
Incremental Cost vs Base			\$ -			\$ (2.88)			\$ (1.54)			\$ (2.75)
Customer Bill w/Distribution Credit												
Production Energy	\$ 1.40	\$ 0.88	\$ 2.28	\$ 1.01	\$ (1.43)	\$ (0.42)	\$ 2.02	\$ -	\$ 2.02	\$ 2.41	\$ (0.55)	\$ 1.86
Production Capacity	\$ 0.60	\$ 0.40	\$ 1.00	\$ 0.43	\$ (0.65)	\$ (0.22)	\$ 0.87	\$ -	\$ 0.87	\$ 1.03	\$ (0.25)	\$ 0.78
Transmission	\$ 0.20	\$ 0.08	\$ 0.28	\$ 0.14	\$ (0.13)	\$ 0.01	\$ 0.29	\$ -	\$ 0.29	\$ 0.34	\$ (0.05)	\$ 0.29
Distribution	\$ 1.30	\$ 0.52	\$ 1.82	\$ 0.94	\$ (0.85)	\$ 0.09	\$ 1.88	\$ -	\$ 1.88	\$ 2.24	\$ (0.33)	\$ 1.91
Access Charge	\$ 0.22	\$ 0.04	\$ 0.27	\$ -	\$ -	\$ -	\$ 0.22	\$ 0.04	\$ 0.27	\$ 0.22	\$ 0.04	\$ 0.27
TOTAL	\$ 3.72	\$ 1.92	\$ 5.65	\$ 2.53	\$ (3.06)	\$ (0.53)	\$ 5.28	\$ 0.04	\$ 5.32	\$ 6.25	\$ (1.13)	\$ 5.12
Incremental Bill vs Base			\$ -			\$ (0.53)			\$ (0.32)			\$ (0.53)

**Because marginal costs are spread across all times in rates, utility avoided costs due to storage are much greater than avoided bill, even if the customer is credited distribution on outflow. Customer benefits are too small to justify customer investment in storage or V2G for energy cost avoidance. Customer is subsidizing the utility.**

# Financial Analysis – Customer Receives No Distribution Credit for Outflow

Incremental Cost \$/day	Customer Without Storage			Standalone FTM Storage			Customer with BTM Storage No Outflow			Customer with BTM Storage and Outflow to Grid		
	Off-peak	On-peak	Total	Off-peak	On-peak	Total	Off-peak	On-peak	Total	Off-peak	On-peak	Total
Production Energy	\$ 1.40	\$ 0.88	\$ 2.28	\$ 1.01	\$ (1.43)	\$ (0.42)	\$ 2.02	\$ -	\$ 2.02	\$ 2.41	\$ (0.55)	\$ 1.86
Production Capacity	\$ -	\$ 1.00	\$ 1.00	\$ -	\$ (2.28)	\$ (2.28)	\$ -	\$ -	\$ -	\$ -	\$ (0.88)	\$ (0.88)
Transmission	\$ -	\$ 0.28	\$ 0.28	\$ -	\$ (0.46)	\$ (0.46)	\$ -	\$ -	\$ -	\$ -	\$ (0.18)	\$ (0.18)
Distribution	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Access Charge	\$ 0.22	\$ 0.04	\$ 0.27	\$ 0.22	\$ 0.04	\$ 0.27	\$ 0.22	\$ 0.04	\$ 0.27	\$ 0.22	\$ 0.04	\$ 0.27
TOTAL	\$ 1.62	\$ 2.20	\$ 3.83	\$ 1.23	\$ (4.12)	\$ (2.88)	\$ 2.24	\$ 0.04	\$ 2.29	\$ 2.63	\$ (1.56)	\$ 1.08
Incremental Cost vs Base			\$ -			\$ (2.88)			\$ (1.54)			\$ (2.75)
Customer Bill w/out Distribution Credit												
Production Energy	\$ 1.40	\$ 0.88	\$ 2.28	\$ 1.01	\$ (1.43)	\$ (0.42)	\$ 2.02	\$ -	\$ 2.02	\$ 2.41	\$ (0.55)	\$ 1.86
Production Capacity	\$ 0.60	\$ 0.40	\$ 1.00	\$ 0.43	\$ (0.65)	\$ (0.22)	\$ 0.87	\$ -	\$ 0.87	\$ 1.03	\$ (0.25)	\$ 0.78
Transmission	\$ 0.20	\$ 0.08	\$ 0.28	\$ 0.14	\$ (0.13)	\$ 0.01	\$ 0.29	\$ -	\$ 0.29	\$ 0.34	\$ (0.05)	\$ 0.29
Distribution	\$ 1.30	\$ 0.52	\$ 1.82	\$ 0.94	\$ -	\$ 0.94	\$ 1.88	\$ -	\$ 1.88	\$ 2.24	\$ -	\$ 2.24
Access Charge	\$ 0.22	\$ 0.04	\$ 0.27	\$ 0.22	\$ 0.04	\$ 0.27	\$ 0.22	\$ 0.04	\$ 0.27	\$ 0.22	\$ 0.04	\$ 0.27
TOTAL	\$ 3.72	\$ 1.92	\$ 5.65	\$ 2.75	\$ (2.17)	\$ 0.58	\$ 5.28	\$ 0.04	\$ 5.32	\$ 6.25	\$ (0.81)	\$ 5.44
Incremental Bill vs Base			\$ -			\$ 0.58			\$ (0.32)			\$ (0.20)

**If the customer is not credited for distribution on outflow, outflow is irrational. Customers will not use excess battery capacity to meet grid needs. Customers will not provide V2G.**