Pacific Northwest
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Distribution System Operator Cost Modeling

Pacific Northwest Regional Economics Conference
May 22, 2024

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U.S. DEPARTMENT OF ENERGY BATTELLE

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Agenda

- What is Transactive Energy?
- What is DSO?
- DSO + Transactive study overview and results
- Ongoing applications of DSO cost model developed

Transactive Energy

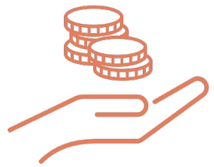
A system of economic and control mechanisms that allow for the dynamic balance of supply and demand across the entire electrical infrastructure using value as a key operational parameter

- GridWise Architecture Council

Coordinate flexible assets to improve grid operations,

reduce peak loads,

Less infrastructure costs, lower utility bills



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News Flash!

PNUCC's 2024 Northwest Regional Forecast projects demand for electricity in the Pacific Northwest could grow by over 30% in the next decade. The increase is attributed to factors such as data center development, high-tech manufacturing growth and the continued trend toward electrification.

PNUCC *Pacific Northwest Utilities Conference Committee*

California ISO
@California_ISO

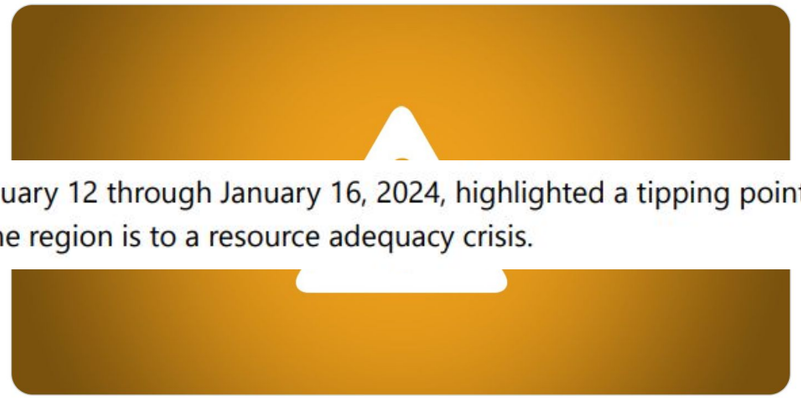
#ISO declares Stage 2 #Emergency; rotating power outages imminent. #Conserve now to relieve stress on the #grid and keep #electricity flowing. bit.ly/3iVLLJE

2:42 PM · Aug 18, 2020

In August 2020, hundreds of thousands of Californians briefly lost power in rolling blackouts amid a heat wave, marking the first time outages were ordered in the state due to insufficient energy supplies in nearly 20 years.

Puget Sound Energy
@PSETalk

We are asking customers to conserve natural gas and electricity use through the evening hours. Due to the extreme cold temperatures facing our area, regional utilities are experiencing higher energy use than forecasted, and we need to reduce strain on the grid. (1/2)



6:08 PM · Jan 13, 2024 · **449.5K** Views

WRAP

AVISTA®

Avista expects reduced number of outages Wednesday in Spokane and Lewiston Customer conservation and ongoing system modifications reduce strain on electric grid

06/30/21

How customers can help

Avista continues to encourage customers to conserve electricity through Friday, July 2, from 1 to 8 p.m. each day. Additionally, customers can proactively cool their homes overnight and outside of the hours of 1 to 8 p.m. to enhance comfort during those peak hours.

Pacific Northwest Utilities Conference Committee – 2024 Northwest Regional Forecast

- Surge in demand for electricity while cleaning up supply
  - Data centers, electrification, capacity concerns, transmission challenges, extreme weather
- 2022 Forecast 0.9%, 2024 3.1%
- Urgent need to upgrade the regions electricity infrastructure and optimize the system.

Figure 1: 2024 Load Forecast Compared to 2023 and 2022

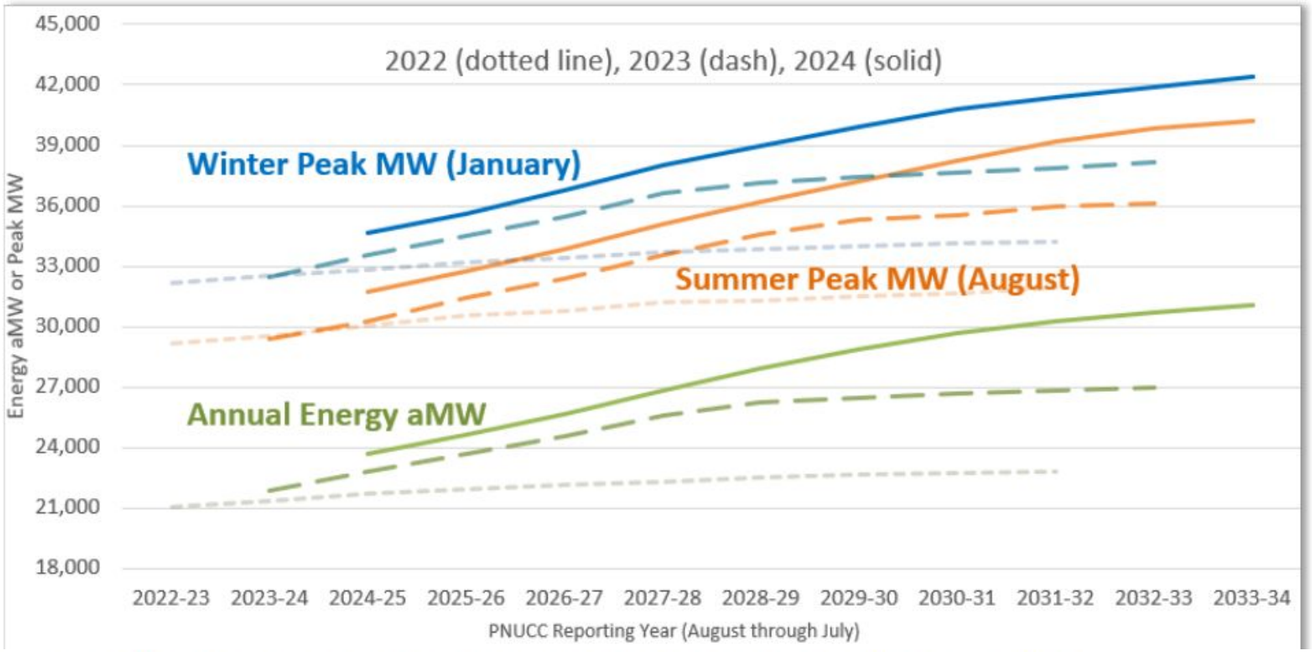
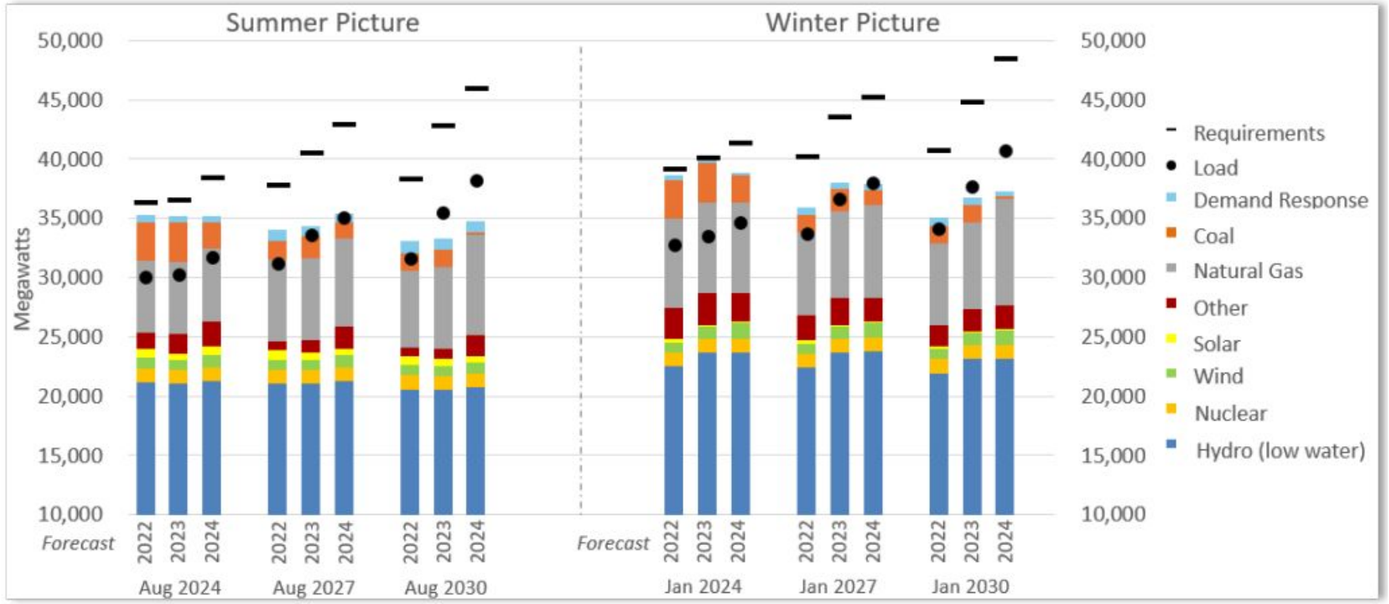


Figure 7: 2024 Load and Resource Forecast Compared to 2023 and 2022

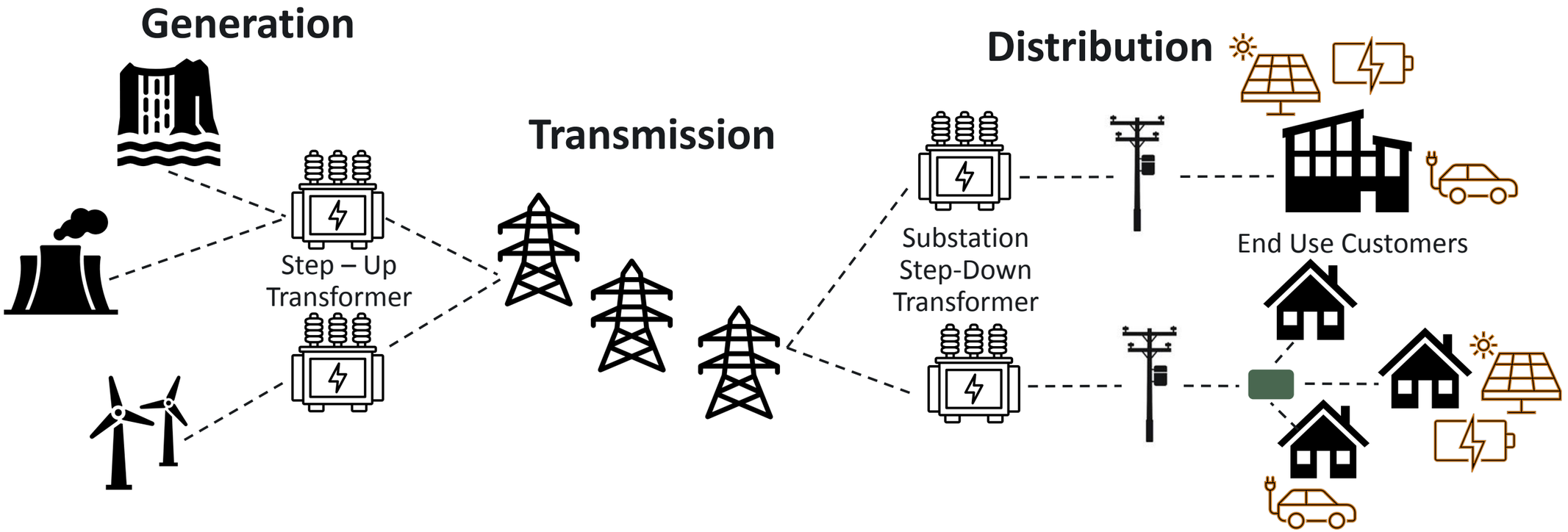


https://www.pnucc.org/wp-content/uploads/2024-PNUCC-Northwest-Regional-Forecast-final.pdf

Distribution System Operator Cost Modeling

Distribution System Operator: An entity that coordinates the planning and operation of the distribution system that is modernized to accommodate and manage the operations of high levels of DERs.

Definition of a DSO is actively discussed, some view it as an evolved version of a utility, some imagine the roles being served by independent entities.



DSO+T Study

https://www.pnnl.gov/projects/transactive-systems-program/dsot-study
Executive Summary, Vol 4, Vol 5

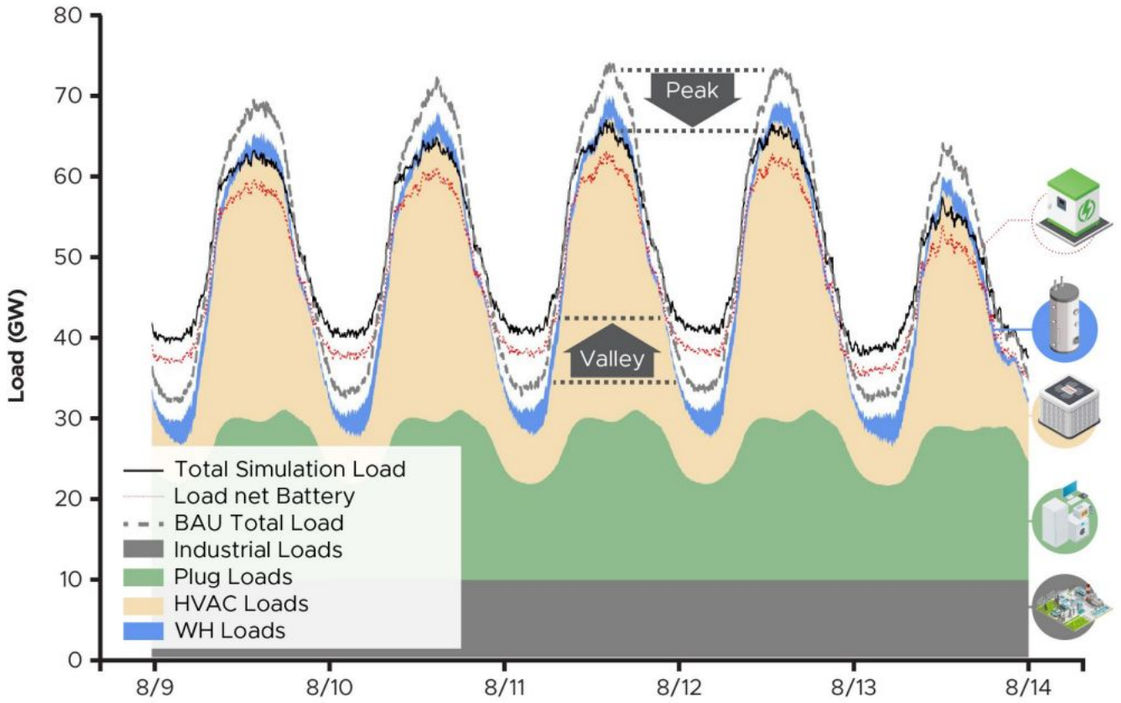
Large scale simulation of the grid to assess the engineering and economic feasibility of using a transactive energy system to coordinate DERs.

Customer-owned assets participate in grid operations and are compensated for doing so.

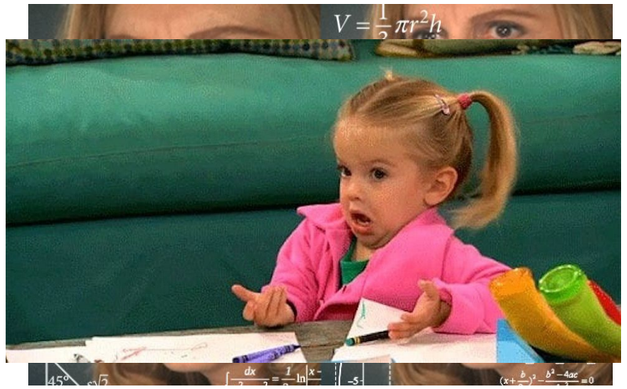
Key Results:

- 9-15% reduction in peak load
  - 20-44% reduction in daily load variation
- 7-14% reduction in wholesale electricity costs
- 10-17% reduction in utility bills
- $3.3-5B annual benefit in a TX sized region

Reduces the investment needed in renewable generation and associated transmission and distribution system upgrades required to meet decarbonization goals.



What it was like being the economist in the room on day 1. How much does the grid cost? How much will that change with TE?



Distribution System Operator Economic Model

Annualized expenses and revenues were calculated for each DSO, monetary exchanges are shown in visual model.

DSO Type: Urban, Suburban, Rural

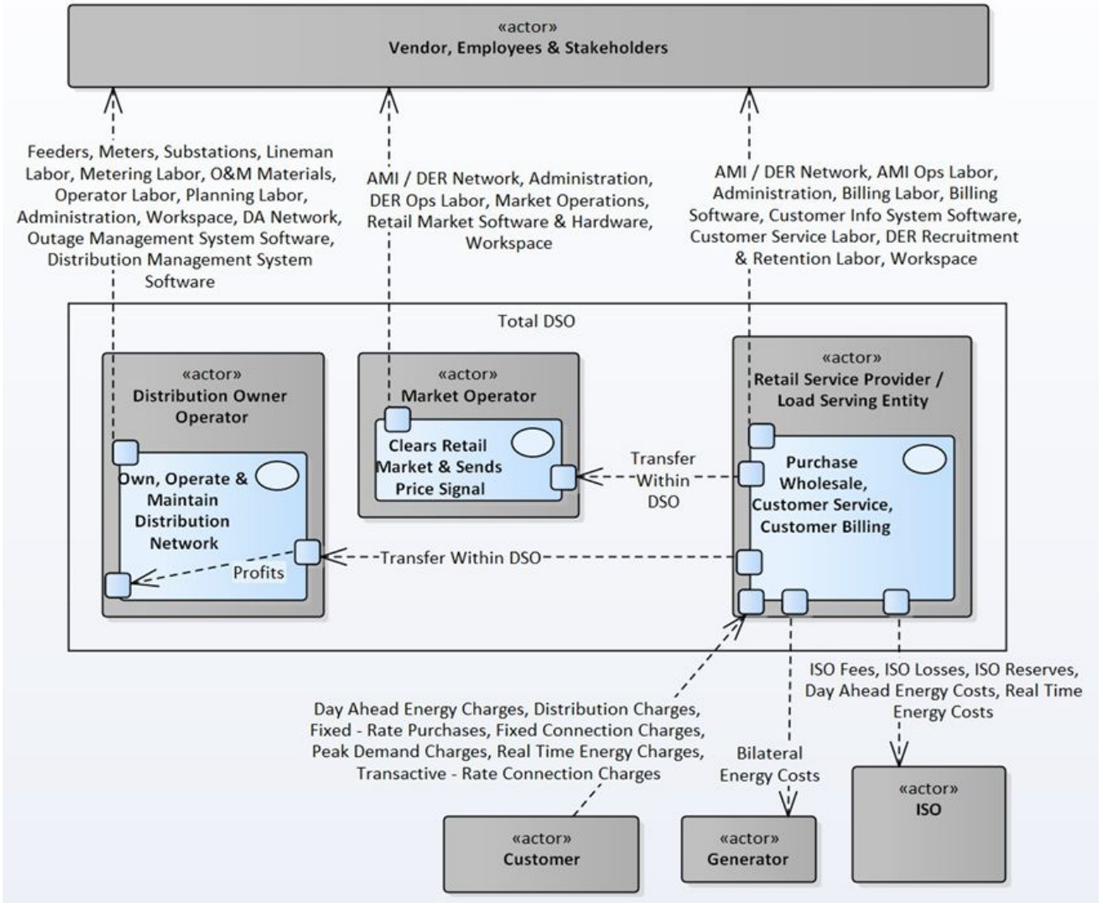
- Varies the customer and load density
- Direct affect on expenses, some examples:
  - Rural substations capacity may be less
  - Distribution circuit costs are dependent on length
  - Communication network costs per customer vary by population density
  - Assumptions around operational costs for labor and workspace differ
  - Customer population RCI mix and building characteristics based on DSO type

DSO Ownership: Investor-owned, municipal, cooperative

- Determines interest rates for capitol investments
- Tax impacts based on nonprofit status
- Correlated with DSO Type

Seasonality of Peak Load: Summer, Winter, Dual

- Winter and Summer peak load assigned by EIA data for TX
- Correlated to DSO Type (winter peaking in rural)



Distribution System Operator Costs

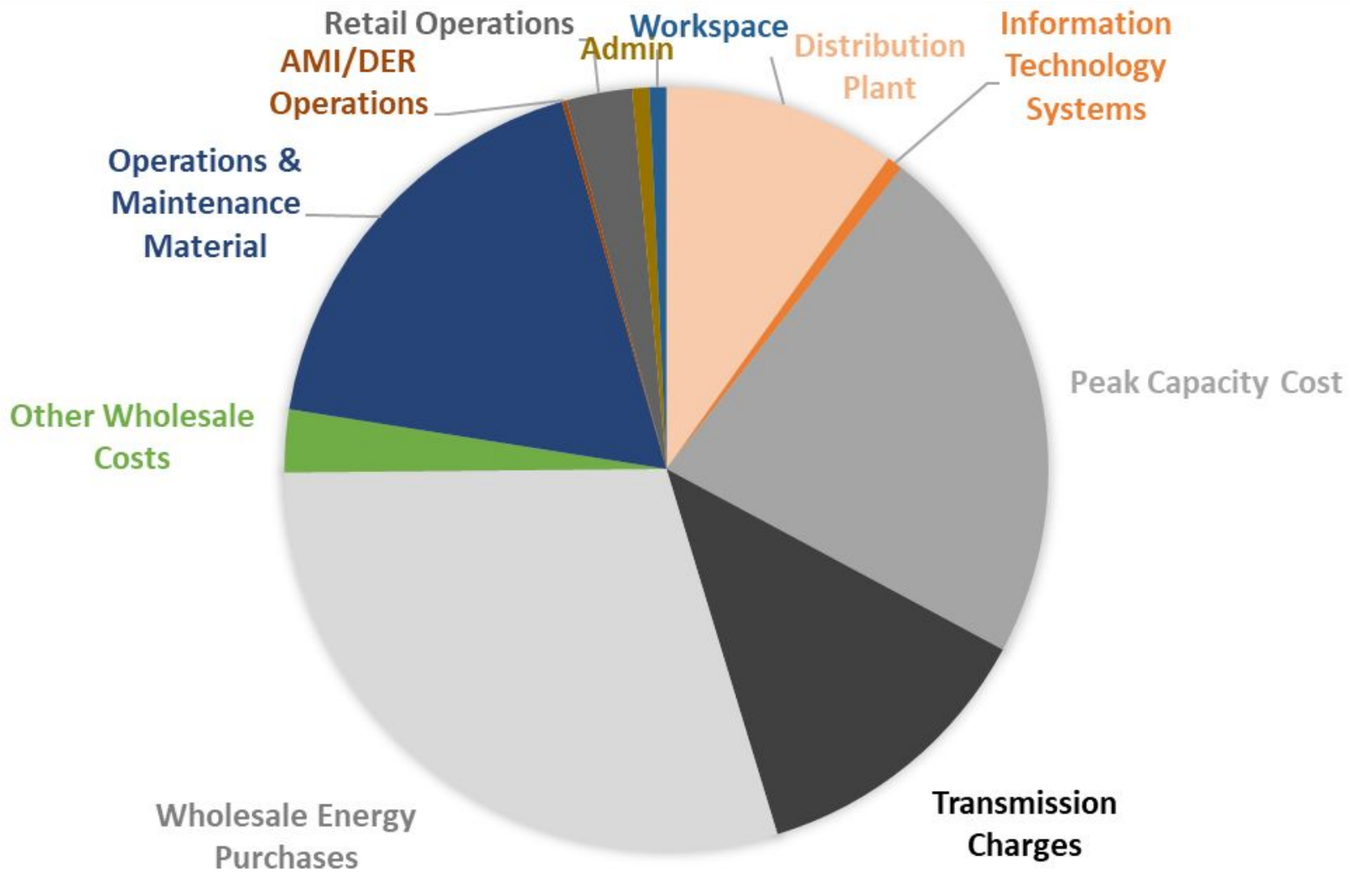
Capital Expenses (CAPEX)

- Substations
- Feeders, Circuits and Meters
- Information Technology Systems

Operational Expenses (OPEX)

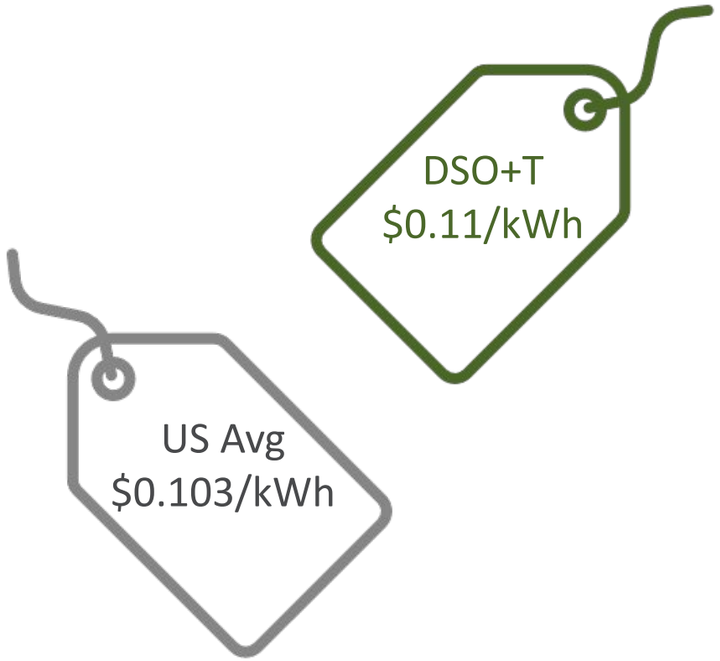
- Wholesale Purchases
- Labor and Workspace
- Operations and Maintenance Materials

CAPEX & OPEX are the Utility's required revenue, a key input to retail ratemaking



Within 10% of reported PJM data on wholesale energy costs

An applicable cost model



The system-wide effective cost of energy sold for the BAU case was within 10% of the national average. This level of agreement indicates the model is representative of typical electrical system operating expenses.

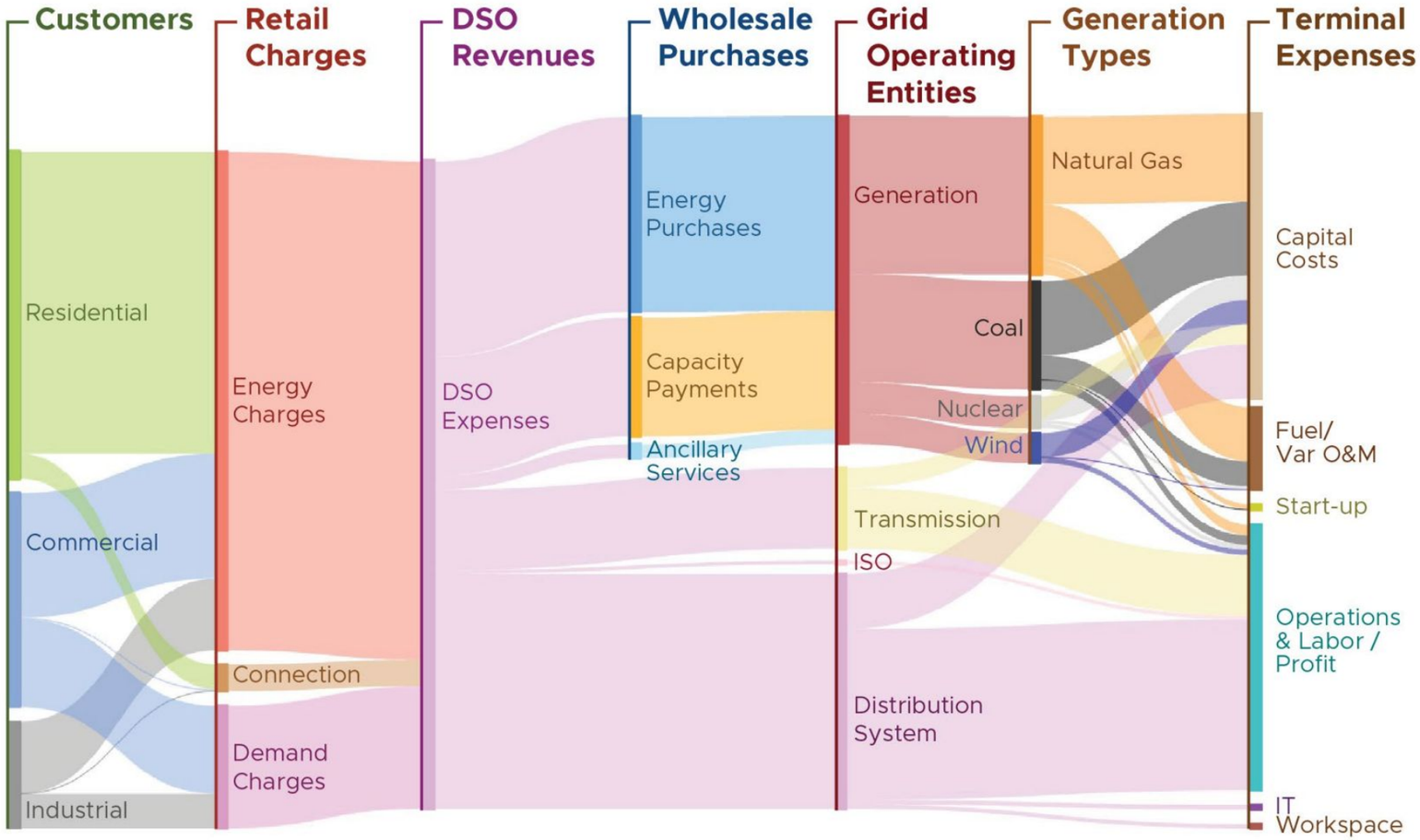
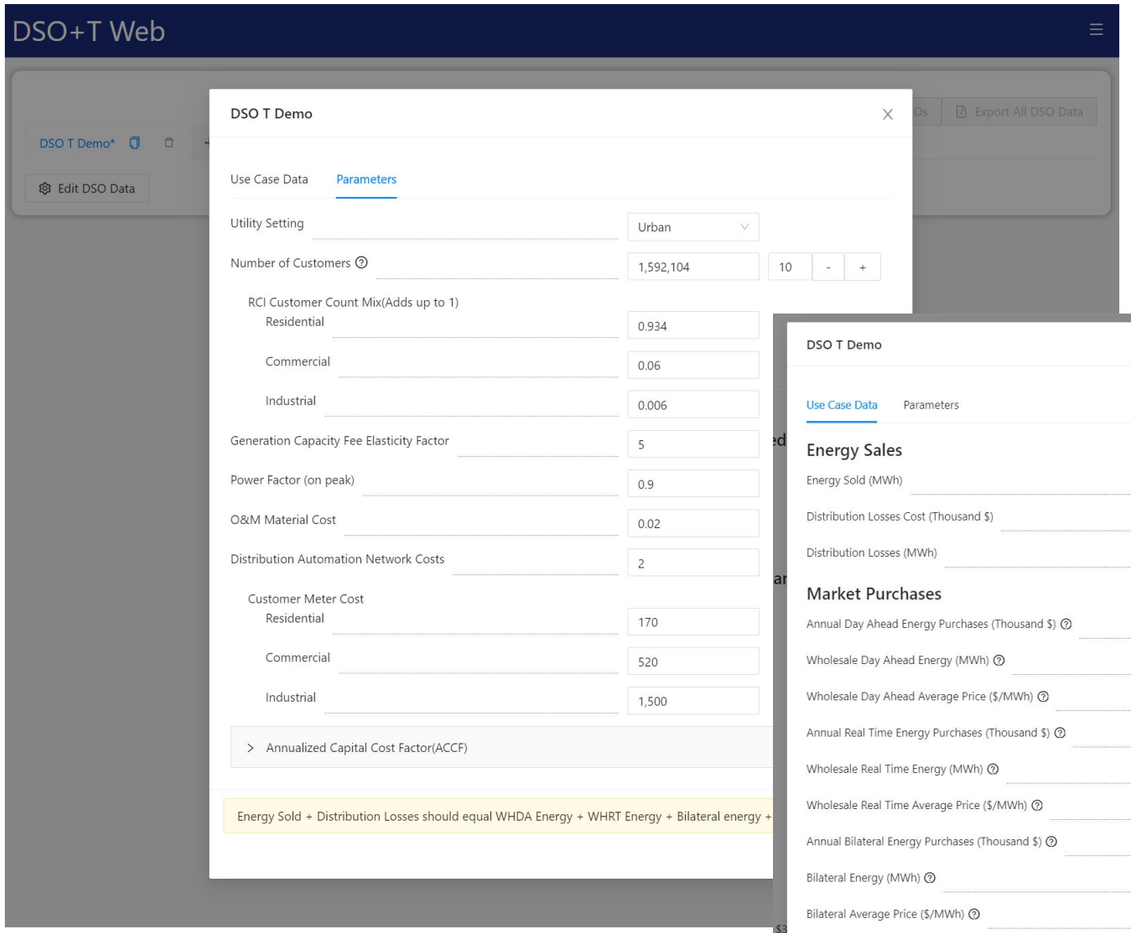
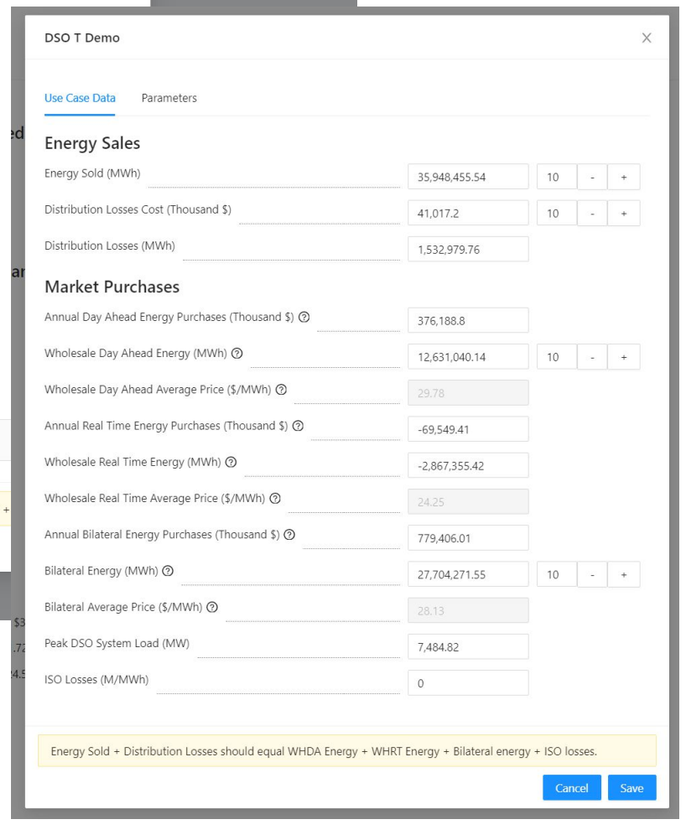


Figure 6. Integrated valuation analysis of DSO revenues and expenses (moderate renewables BAU case).

Distribution System Operator Cost Model





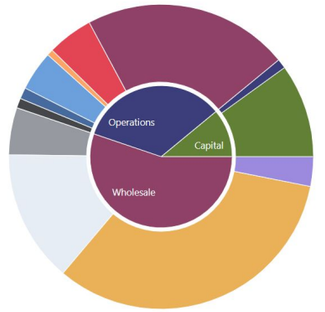
DSO Levelized Annual Costs in Thousands of $

Total Annual Costs: $3,290,708.22

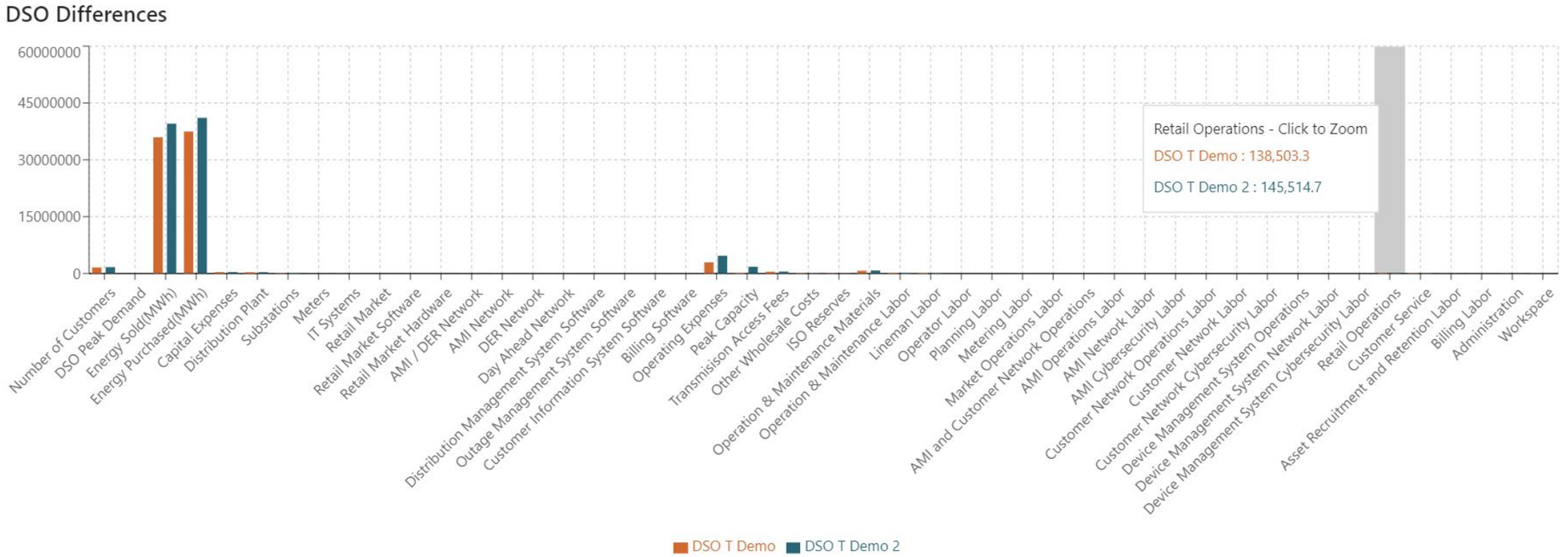
Capital Expenses: $361,136.48
- **Distribution Plant:** $327,674.53
  - **Substations:** $123,480.12
  - **Feeders:** $175,952.60
  - **Meters:** $28,241.81
- **IT Systems:** $33,461.95
  - **Retail Market:** $302.46
    - **Retail Market Software:** $280.94
    - **Retail Market Hardware:** $21.52
  - **AMI / DER Network:** $27,129.45
    - **AMI Network:** $21,703.56
    - **DER Network:** $5,425.89
  - **Day Ahead Network:** $4,521.58
  - **Distribution Management System Software:** $329.98
  - **Outage Management System Software:** $311.72
  - **Customer Information System Software:** $724.59
  - **Billing Software:** $142.17

Operating Expenses: $2,929,571.74
- **Operation & Maintenance Materials:** $718,969.11
- **Operation & Maintenance Labor:** $159,841.34
  - **Lineman Labor:** $136,698.41
  - **Operator Labor:** $4,576.63
  - **Planning Labor:** $5,165.49
  - **Metering Labor:** $13,400.81
- **Market Operations Labor:** $2,860.23
- **AMI and Customer Network Operations:** $13,315.04
  - **AMI Operations Labor:** $10,546.77
    - **AMI Network Labor:** $7,403.76
    - **AMI Cybersecurity Labor:** $3,143.01
  - **Customer Network Operations Labor:** $2,768.27
    - **Customer Network Labor:** $1,801.12
    - **Customer Network Cybersecurity Labor:** $967.15
- **Device Management System Operations:** $6,128.84
  - **Device Management System Network Labor:** $4,194.02
  - **Device Management System Cybersecurity Labor:** $1,934.82
- **Retail Operations:** $138,503.30
  - **Customer Service:** $106,347.34
  - **Asset Recruitment and Retention Labor:** $20,699.73
  - **Billing Labor:** $11,456.23
- **Administration:** $39,359.21
- **Workspace:** $34,197.28

Wholesale: $1,816,397.39
- **Peak Capacity:** $164,570.27
- **Transmisison Access Fees:** $462,732.70
- **Wholesale Energy Purchases:** $1,086,045.40
  - **Day Ahead Energy Purchases:** $376,188.80
  - **Real Time Energy Purchases:** -$69,549.41
  - **Bilateral Energy Purchases:** $779,406.01
- **Other Wholesale Costs:** $103,049.01
  - **ISO Reserves:** $81,485.31
  - **ISO Fees:** $21,563.70



Distribution System Operator Cost Model



	DSO T Demo	DSO T Demo 2
Number of Customers	1,592,104	1,671,709
DSO Peak Demand	7,484.82	10,484.82
Energy Sold(MWh)	35,948,455.54	39,543,301
Energy Purchased(MWh)	37,467,956.27	41,076,279.58
Capital Expenses	361,136.48	388,917.1

Δ DSO T Demo 2 27,780.62 (7.14%)

Conclusions

- A relatively user-friendly distribution system cost model that provides the difference in cost of energy served for simple use cases
- Model accounts for
  - Population differences
  - Geographic differences
  - Economies and diseconomies of scale

Ongoing research efforts are utilizing DSO+T Valuation

- National decarbonization pathway costs
- Regional planning and analysis support efforts
- Additional simulation study comparing rate options

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Thank you

Additional Results

Table 23. Summary of DSO costs ($B) and percent savings by DSO type.

Type	MR BAU	MR Battery	MR Flex	HR BAU	HR Battery	HR Flex
Urban	19.9	17.4 (12.4%)	17.2 (13.4%)	18.9	15.5 (18.1%)	15.4 (18.6%)
Suburban	9.2	8.1 (12.2%)	7.9 (14.2%)	8.4	6.9 (17.6%)	6.7 (19.6%)
Rural	1.6	1.4 (11.4%)	1.4 (12.7%)	1.4	1.2 (13.2%)	1.2 (13.4%)
Total	30.7	26.9 (12.3%)	26.5 (13.6%)	28.7	23.6 (17.7%)	23.4 (18.6%)

Table 24. Summary of DSO costs ($B) and percent savings by DSO ownership model.

Type	MR BAU	MR Battery	MR Flex	HR BAU	HR Battery	HR Flex
Investor-owned	20.2	17.7 (12.3%)	17.5 (13.3%)	19.3	15.8 (17.9%)	15.7 (18.4%)
Cooperative	5.5	4.8 (12.3%)	4.7 (14.8%)	4.9	4 (19.5%)	3.8 (22%)
Municipal	5.0	4.4 (12.3%)	4.3 (13.6%)	4.5	3.9 (15.2%)	3.8 (16%)
Total	30.7	26.9 (12.3%)	26.5 (13.6%)	28.7	23.6 (17.7%)	23.4 (18.6%)

Table 25. Summary of DSO costs ($B) and percent savings by peaking season.

Type	MR BAU	MR Battery	MR Flex	HR BAU	HR Battery	HR Flex
Summer	27.2	23.9 (12.3%)	23.5 (13.6%)	25.6	21 (18.1%)	20.7 (19%)
Winter	2.3	2 (12.1%)	2 (13.3%)	2.1	1.8 (15.1%)	1.8 (15.5%)
Dual	1.2	1 (12.4%)	1 (13.7%)	1.0	0.9 (13.7%)	0.9 (14.2%)
Total	30.7	26.9 (12.3%)	26.5 (13.6%)	28.7	23.6 (17.7%)	23.4 (18.6%)