

Demand Flexibility: Peak Load Shifting & Time of Day Rate Pilot Experience

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Session Agenda

Background

Regional Context for Advanced Rates
 SnoPUD's Economic Rationale

Peak Load Shifting Experience

Regional Demand Response Pilot – BPA - EnerNOC
 Winter Peak Load Shifting Pilot
 FlexEnergy Residential Pilot

□ Focus: SnoPUD's C&I Time of Day Pilot

- □ Program & Rate Design
- □ Initial Results
- □ What's Next...



% of Consumers on Time Varying Rates, 2017



Source: Matisoff, Daniel C., et al. "A review of barriers in implementing dynamic electricity pricing to achieve cost-causality." Environmental Research Letters 15.9 (2020): 093006.

Regional Capacity Picture

- Region is expecting increasing likelihood of a capacity shortages
- Retirements of multiple regional baseload generators (coal)
- Flood of new renewables generate lots of electricity but can't be counted on in any given hour





Cost Causation & Electricity Rates

- Electricity rates are a function of underlying costs structure. Costs can be attributed to:
 - □ Fixed must be incurred regardless of total volume of energy or profile.
 - □ Energy volume of energy
 - Demand (Capacity) for a given interval, maximum energy that might be required
- □ Rate simplicity has been necessary (and still has value)
- However
- Fairer, more accurate price signals can be communicated with more granular rates that vary over time and by component.
 - \Box == More efficient economics



Winter Peaking Challenge

- Excess Energy (over average) during hours of day, 2016 - 2021
- 71.1% between hours
 7-9, 17-20
- 66% of SnoPUD peaking costs are in Nov-Feb
- Reducing peak load= lower peaking cost





Flavors of Time Dynamic Pricing







Risk & Reward For Different Rates

- □ Time of Use (TOU)
- Critical Peak Pricing (CPP)
- Peak Time Rebate (PTR)
- Variable Peak Pricing (VPP)
- □ Real-Time Pricing (RTP)



Conceptual Representation of the Risk-Reward Tradeoff in Time-Varying Rates

Source: Faruqui, A., Hledik, R., Palmer, J., "Time-Varying and Dynamic Rate Design", RAP, July 2012.



PEAK LOAD SHIFTING EXPERIENCE

BPA – EnerNOC Winter Demand Response Pilot

□ BPA Demonstration Project -- Dec 2015 thru April 2017

- □ Purpose: District & customers experience demand response
- □ BPA calls events, EnerNOC manages pilot
- □ Target load reduction 7-10 am and 5-8 pm on weekdays; up to 60 total hours between Dec 1 and April 30
- □ Value for customers:
 - EnerNOC advisory services
 Access to EnerNOC Software
 - Payments for event response





Timeline and Winter Parameters

Requirement for Load Participants

Parameter	Requirement
Months available	December 1 – April 30
Product Hours	0700-1000 and 1700-2000 PT
Maximum Duration (hours)	3
Consecutive Days Available	3
Minimum Advance Notice	20 minutes (changed to 60 minutes in Sept 2015)
Maximum Events Per Day	2
Maximum Hours Per Year	120
Recharge Period (hours)	6
Performance Data	One minute interval data available near real time to BPA.
Eligible Asset Types	Demand Response, Battery Storage, and Demand Voltage Reduction.



New Approaches: Winter Demand Response Pilot



Dispatch Timeline

ENERNOC

Notification from BPA: 6:00 AM » Notification to providers: 6:01 AM » Event start: 7:00 AM » Event end: 10:00 AM



Regional Participants

Participating Location	Serving Utility
Great Western Corp	Central Lincoln Electric
Nippon Paper Industries	City of Port Angeles
Andersen Dairy	Clark Public Utilities
Andersen Plastics	Clark Public Utilities
City of Vancouver Water	Clark Public Utilities
Clark Public Utilities - Water	Clark Public Utilities
Kizer Farms	Consumers Power Inc
Kenyon Zero Storage Inc	Franklin County PUD
Zen Noh Hay	Franklin County PUD
City of Edmonds WWTP	Snohomish PUD
Alderwood WWD	Snohomish PUD
City of Everett	Snohomish PUD
Snohomish PUD - Hardeson Substation battery	Snohomish PUD
King County Wastewater Treatment	Snohomish PUD
Cascade Specialties	Umatilla Electric Cooperative
Pacific Ethanol - Boardman	Umatilla Electric Cooperative
Port of Morrow Warehousing	Umatilla Electric Cooperative





Winter Demand Results

=		Total Load	% Nominated
Pilot Yr	Events	Reduction MW	Reduction
Year 1 - 2015-16	11	6.6	72
Year 2 - 2016-17	14	21.8	80

Hardeson Substation Battery (Year 2 Participation Only)				
2016-17	14	3.7	89	





DR Pilot – Learnings - Overview

Customers (Pilot Participants)

- Event Advance Notice 'longer advance notice the better'
 Notice changed from 20 minutes to 60 minutes
- Personnel scheduling for afternoon-evening events
- Coordinating interactive system impacts of DR
- PUD (Pilot Co-sponsor)
 - □ Customer response and issues
 - □ Control coordination for Hardeson battery system
 - □ Internal tracking of reduced loads for various reasons



Snohomish PUD Peak Load Months





Winter Peak Load Shifting Pilot

PUD pilot program for customer willing to shift energy loads

to non-peak hours in exchange for financial incentives.

Pilot Period – Second Season Example

- ✓ Nov 1, 2019, through Feb 28, 2020 (86 days, 430 hours total)
- Weekdays (M thru F) 5 hrs. max/day (7 --9 a.m. 5 -- 8 p.m.)

Eligibility & Requirements

- □ CI customers on rate schedule 20 and 36 with interval meters
- □ Capable of at least 50 kW reduction minimum
- Fuel-switching and backup-generator use during pilot program peak hours not eligible for incentives





Winter Peak Load Shifting Pilot, cont.

Incentive Rates, Caps & Payments

- □ Up to \$60 per kilowatt reduction for entire season
- □ \$33,000 cap per customer location (\$30,000 cap for kW reduction and \$3,000 cap for power monitoring equipment)
- □ Kilowatt reduction must be measurable and verified
- One payment at end of season



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Winter Peak Load Shifting Pilot Program Winter 2019/2020

Winter Peak Period:

- Hours ending 08, 09, 18 and 20 (7 AM 9 AM, 5 PM 8 PM)
- Weekdays Monday through Friday
- November 1, 2019 through February 28, 2020 (86 days, 5 hours/day, 430 hours total)

Eligibility & Requirements:

- Schedule 20 and 36 customers with interval meters
- 50-kW reduction minimum
- December 1, 2019 participation deadline
- One season agreement. Prorated for partial season.
- Fuel switching and back-up generator use during these peak hours is not eligible for incentives

Facility Name

Facility Address

	Date 12/1/2019	Assigned Staff
	Project Name	
	Winter Pe	eak Load shifting
Incentive Rates	Caps & Payments:	
• Up to \$60 per k	N reduction for the whole	season
• \$30,000 cap for	kW reduction	
• \$3,000 cap for p	ower monitoring equipme	nt (pre-approval required
• \$33,000 possible	e total cap per customer lo	cation
Performance ba reduction)	sed (incentive prorated ba	sed on verified kW
 One payment at and verification 	the end of season after co	mpletion of measuremen
One progress pa	yment may be arranged at	end of December 2019
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Pilot Participants – Industrial & Commercial



- Aggregate Facility Motor load for conveyor and pumps
- Flood Control Districts Water pump motors
- High School Building HVAC and lighting
- Wastewater Treatment Facility Motor loads



Thumbnail of Participant Incentive Processing & Results

Incentive calculation based on:

- actual load reduction achieved vs projected reduction
- weighted % actual hours reduced vs total pilot hours
- Participants estimated load reduction available
 - no min load reduction hours
 - □ no penalties
- No data adjustments for weather

- For four pilot participants -average load reductions for pilot periods from 67 kW to 150 kW
- Seasonal incentive payments from \$3100 to \$6900



Winter Peak Load Shifting Pilot – Learnings

Pilot Participants

Amount of time and focus to schedule process and equipment
 Coordinating interactive system impacts can be challenge
 Incentive assessment at end of season limited adjustments

PUD Pilot Sponsor

Coordination with customer's team and operations requirements
 Complexity of analyzing load reduction actions – why, what, when
 Based on pilot predict less analysis need with rate-based approach



BRIEF UPDATE ON RESIDENTIAL PEAK LOAD SHIFTING

FlexEnergy Residential Pilots





FlexEnergy Recruitment





FOCUS: SNOPUD'S C&I TIME OF DAY PILOT



Time of Day Rate Pilot

District is exploring rate designs to:

Offer additional value to customers
 Reduce pressure on District's costs

- Time of Day (TOD): different prices for energy at different times of day
- □ Basic structure:
 - Nights and weekends discount
 Peak periods morning and evening over Nov – Feb
- Facilitates Load Shifting behaviors from "Peak" to "Off-peak"





TOD Load Shifting Opportunities

- TOD is an Energy Price
 Modifier to existing Rate
 Schedule (Sch20):
 - Nights & Weekends:
 \$0.0166 (46% of hrs)
 - Weekdays: +\$0.0034 (49% of hours)
 - □ Peaks: +\$0.1024 (5% of hours)
- Revenue-neutral based on
 2019 usage





Program Structure

- □ Pilot in place for 4 years from Jan 2020 Dec 2023
- Open to C&I Customers by invitation
- □ Maximum 25 participants initially
 - Invitees selected based on size, load profiles, perceived ability to shift load
 First come, first serve
 - □ Schedule 36 customers get priority
- □ Access to online detailed usage data via AEI Load Profiler
- Opt-In and Rate Comparison options
- One-time "mulligan" so that customers can try Opt-In at no risk



PUD

TIME OF DAY Pilot Program

Save money by shifting demand to off-peak hours

The Time of Day (ToD) pilot program

is designed to assess the value of a proposed Snohomish County PUD Time of Day rate schedule that will enable customers to manage their PUD power bills based not only on how much energy is consumed but also when it is consumed.



Why a Time-of-Day Rate?

Time-of-Day electricity rates are based on the time when energy is used. Similar to peak pricing for air travel and lodging, time-of-day electricity rates mean that customers will pay lower rates during "off-peak" periods of low demand and higher rates during "on-peak" periods of maximum demand.



The cost of producing electricity can vary significantly throughout the day. **Higher costs occur during morning and evening peak periods** – 7 a.m. to 9 a.m. and 5 p.m. to 8 p.m. – and lower costs during nights and weekends. Time-of-Day pricing will reflect the PUD's actual electricity costs more accurately and motivate customers to shift to the lower cost off-peak periods that will reduce their onpeak costs and reduce the PUD's on-peak power purchases.

How Does the ToD Pilot Work?

For a limited time, the PUD will partner with a select group of commercial customers who wish to participate in the ToD pilot program.

As part of the pilot, participants will have online access to their energy and demand data through a third-party web-based tool. Load profile and dashboard energy analytics will enable participants to avoid on-peak periods by scheduling the operation of equipment during off-peak hours (e.g., machinery, refrigeration, lighting, thermostats, EV charging).



How Do I Get Started?

Outreach will commence in late 2019 to customers on an invitation-only basis. The program will launch in January 2020 with two pilot options, both of which will include load profile and analytics tools.

- ToD Rate Opt-In: Customers can take advantage of lower off-peak rates by opting in at the time of program launch.
- ToD Rate Comparison: Customers can stay on their existing rate and compare it to the potential ToD rate using a Bill Impact Calculator. Those who elect this option will be eligible to enroll during the July 2020 Opt-In period.

Additional enrollment periods may be offered for those who miss the Opt-In launch or who wish to extend the Rate Comparison period.

During the initial engagement, interested parties will be asked to acknowledge their interest in this pilot program by initiating a Letter of Intent. A signed Participation Agreement will be required for participation, in either pilot option for a minimum term of one year.



TIME OF DAY Pilot Program FAQs *Save money by shifting demand to off-peak hours*

Research Areas

What is the Time of Day Pilot?

The Time of Day (TOD) Pilot is a program designed to research the value of a proposed Snohomish County PUD TOD rate schedule based on the cost of when energy is actually used. Electricity costs can vary significantly throughout the day. Higher costs occur during weekday morning and evening peak times – 7 a.m. to 9 a.m. and 5 p.m. to 8 p.m. – and lower costs during off-peak. The pilot is available to select customers and scheduled to run from 2020 through 2023.

What is the objective of the research?

Participants in the TOD Pilot will assist the PUD in associated research around what worked and what didn't for both the PUD and its customers. The research is designed to generate learning to inform any future implementation of TOD rates.

What research is planned?

Six major research areas will be evaluated during the pilot:

1. Customer Usage	2. Impact to	3. Effective Customer
Shifting Performance	PUD Costs and Revenues	Methods for Shifting Demand
 Energy shifting from Onpeak to Off-peak periods Shifting during seasonal periods (especially winter), high-/low-demand periods \$ savings per customer 	 Winter peak capacity savings Modeling approaches for forecasting load shifting from TOD Revenue impact to PUD and customer charges 	 Timers and controls Use of automation Business Process changes Adjusting Employee shifts
4. Communication of Needs	5. Implementation Process	6. Battery Energy Storage
and Benefits with TOD Rates	of TOD Rates	with TOD Bates
		with rob hates

TIME OF DAY CALCULATOR









Monthly	Bill Impact				
Month	Veekday (kVh)	Peak (k∀h)	Veekend S (kWb)	Bill Compari	% vs 2018
1	1,013,440	422,490	1,435,583	\$25,462	13.70%
2	912,218	370,803	1,235,059	\$22,836	13.68%
3	1,504,945	-	1,449,493	(\$16,286)	-8.50%
4	1,385,836	-	1,371,767	(\$15,578)	-8.68%
5	1,536,619	-	1,479,661	(\$16,623)	-8.51%
6	1,439,751	-	1,452,818	(\$16,618)	-8.88%
7	1,302,678	-	1,423,365	(\$16,745)	-9.58%
8	1,406,894	-	1,251,997	(\$13,607)	-7.99%
9	1,148,355	-	1,377,817	(\$16,694)	-10.27%
10	1,370,332	-	1,214,249	(\$13,171)	-7.90%
11	928,201	387,043	1,319,257	\$23,260	13.51%
12	919,033	380,824	1,551,940	\$18,926	10.29%
	Time of Day Rates Im	pact - W ////	load shifting	(\$34,838)	-1.63%
	Time of Day Rates Ir	npact - Ales	load shifting	(\$34,838)	-1.63%

Billing Det	erminates			
				Veeken
De	: ds			
Rates				
Modifier	\$0.0000	\$0.0043	\$0.1033	(\$0.0157)



Participation Process

- □ Key Accounts presents opportunity
- □ Review bill calculator summary w/customer
- □ Pilot Participation Agreement w/Data Release form
- □ Establish calendar month billing and meter upgrade if needed
- □ Training on load profiler tool for daily data display
- □ Provide monthly analysis report



Ten TOD Pilot Participants Currently

Opt-in to TOD Rate

- Opt-In July 2020
 - Manufacturer #1
- Opt-In Jan 2021
 - Indoor Ag Grower Start RC move to Opt-In Jan 1, 2021
 - Transit Agency Start RC move to Opt-In Jan 1, 2021
 - Flood Control District #1
 - □ Flood Control District #2

Rate Comparison (RC)

- □ Rate Comparison Jan 2020
 - Manufacturer #2
 - □ Wastewater Treatment Facility
 - □ Manufacturer #3
- □ Rate Comparison Jan 2022
 - □ Water System #1
 - □ Water System #2



Highlight on Transit Agency #1: Changes Since TOD

- Electric Vehicle Charging Facility Started Rate Comparison, Jan 1, 2021 moved to Opt-In
- □ Expanding vehicle fleet, induction charging in route
- □ Experimenting w/moving charging to later in evening
- □ Implementing charging management software
- Participant pleased w/pilot data detail access



Customer Experience: Monthly Report



Average Hourly KWH Usage over week - 1/1/22 thru 1/31/22



Average Hourly KWH Profile Jan 2022 (Avg 40° F) comparison to Jan 2021 (Avg 42° F)



Compared to prior period your Nights & Weekends has Decreased by 3,824 KWH Compared to prior period your Morning Peak has Decreased by 2,979 KWH

Compared to prior period your Evening Peak has Decreased by 1,553 KWH

Customer Experience: Billing Detail and Forecast

ecast of TOD Impact	Month	Weekday (kWh)	Peak (kWh)	Nights & Weekends (kWh)	Time of day impact
Actual	Aug	20,726	0	33,832	(\$491)
	Sep	16,553	0	36,202	(\$545)
	Oct	19,318	o	41,877	(\$629)
	Nov	14,893	11,558	39,798	\$574
	Dec	18,948	13,421	39,302	\$786
	Jan	16,973	12,021	37,336	\$669
Forecast	Feb	16,199	5,579	35,613	\$35
	Mar	21,524	0	37,929	(\$556)
	Apr	19,950	0	35,101	(\$515)
	May	18,984	o	36,550	(\$542)
	Jun	21,750	o	33,759	(\$486)
	Jul	20,175	0	35,305	(\$517)

TOD Forecasted Savings (Potential) over 12-month Period

(\$2,219)

(\$507)

Additional savings if 10% of Peak to shifted to Nights and Weekends?



Customer Experience: Near Real Time Online Data Access

- PUD installs cellularconnected meters for participating customers
- Online portal provides access to daily electricity usage
- Data updates each night to allow access to previous day's 15-minute intervals





Second Two Years of TOD Pilot

- □ Communications with participants underway, response is positive
- □ Most customers are making some load shift changes, trying others
- □ Billing processes in place with automation to streamline further
- □ Outreach low-key due to COVID, targeted 15 participants EOY 2021
- Build datasets and refine models
- □ Assess need/options for 'standard' TOD rate(s)



INITIAL RESULTS



Background

□ Want to understand:

How quickly load shifting occurs

□ Scale and shape of load

□ Challenges

- □ Post-COVID irregularities
- Expected longer response to new rate design for larger customers
- □ No "control" customers to compare



Load Shape Changes

- Metric % of energy in every 15-minute increment above or below flat energy for given month.
- Objective of TOD is to shift energy out of yellow bands.
- □ Aerospace #2
 - Noticeable improvement in evening peak since 2021

Proportion of Load in 15-min incremement vs. Flat: Aero_2

by Winter Month





Aero-2 Bill Adjustments

- Periods when opt-in highlighted Yellow
 - 2021 Avg MonthlyConsumption 165 MWh
 - □ Winter Peaking costs \$2,087
 - □ Midday costs \$**6,202**
 - Off-peak savings \$27,780
 - Overall savings \$19,584

Bill Adjustments		TOD Period		
Year/Season	mid	off	peak	Grand Total
y2018	\$682	(\$4,646)	\$932	(\$3,032)
Winter	\$682	(\$4,646)	\$932	(\$3 <i>,</i> 032)
y2019	\$7,727	(\$36,657)	\$2 <i>,</i> 407	(\$26,523)
Non-Winter	\$5 <i>,</i> 935	(\$25,102)		(\$19,167)
Winter	\$1,792	(\$11,555)	\$2 <i>,</i> 407	(\$7 <i>,</i> 355)
y2020	\$5,343	(\$24,055)	\$2,087	(\$16,626)
Non-Winter	\$3 <i>,</i> 785	(\$14,443)		(\$10,657)
<mark>Winter</mark>	<mark>\$1,557</mark>	<mark>(\$9,613)</mark>	<mark>\$2,087</mark>	<mark>(\$5,969)</mark>
<mark>y2021</mark>	<mark>\$6,202</mark>	<mark>(\$27,780)</mark>	<mark>\$1,994</mark>	<mark>(\$19,584)</mark>
<mark>Non-Winter</mark>	<mark>\$4,650</mark>	<mark>(\$18,741)</mark>		<mark>(\$14,091)</mark>
<mark>Winter</mark>	<mark>\$1,552</mark>	<mark>(\$9,039)</mark>	<mark>\$1,994</mark>	<mark>(\$5,493)</mark>
<mark>y2022</mark>	<mark>\$813</mark>	<mark>(\$5,305)</mark>	<mark>\$1,051</mark>	<mark>(\$3,441)</mark>
Non-Winter		<mark>(\$2)</mark>		<mark>(\$2)</mark>
<mark>Winter</mark>	<mark>\$813</mark>	<mark>(\$5,303)</mark>	<mark>\$1,051</mark>	<mark>(\$3,439)</mark>

Load Shape Changes

- Metric % of energy in every 15-minute increment above or below flat energy for given month.
- Objective of TOD is to shift energy out of yellow bands.
- □ Indoor Agriculture #2
 - Noticeable improvement in evening peak since 2021.
 - Improvement from 2021 to 2022
 - Shift to evening/early morning

Proportion of Load in 15-min incremement vs. Flat: IndAg_2

by Winter Month





Ind-Ag2 Bill Adjustments

Periods when opt-in highlighted Yellow

- 2021 Avg Monthly Consumption = 78 MWh
- □ Winter Peaking costs \$378
- □ Midday costs \$**1,461**
- Off-peak savings \$7,819
 2021 savings \$5,980

Bill Adjustments	TOD Period			
Year/Season	mid	off	peak	Grand Total
y2019	\$521	(\$2,603)	\$171	(\$1,910)
Non-Winter	\$386	(\$1,720)		(\$1,334)
Winter	\$135	(\$882)	\$171	(\$576)
y2020	\$1,129	(\$5,772)	\$389	(\$4,254)
Non-Winter	\$807	(\$3,642)		(\$2 <i>,</i> 835)
Winter	\$322	(\$2,130)	\$389	(\$1,419)
<mark>y2021</mark>	<mark>\$1,461</mark>	<mark>(\$7,819)</mark>	<mark>\$378</mark>	<mark>(\$5,980)</mark>
<mark>Non-Winter</mark>	<mark>\$1,143</mark>	<mark>(\$5,501)</mark>		<mark>(\$4,358)</mark>
<mark>Winter</mark>	<mark>\$317</mark>	<mark>(\$2,318)</mark>	<mark>\$378</mark>	<mark>(\$1,622)</mark>
<mark>y2022</mark>	<mark>\$154</mark>	<mark>(\$1,224)</mark>	<mark>\$180</mark>	<mark>(\$890)</mark>
<mark>Non-Winter</mark>		<mark>(\$0)</mark>		<mark>(\$0)</mark>
Winter	<mark>\$154</mark>	<mark>(\$1,223)</mark>	<mark>\$180</mark>	<mark>(\$890)</mark>

Load Shape Changes

- Metric % of energy in every 15-minute increment above or below flat energy for given month.
- Objective of TOD is to shift energy out of yellow bands.
- □ Transit Agency #1
 - Mixed shifting
 - Opt-in Jan 2021. Great initial performance.
 - Since 2022: morning peak reduction, evening peak has much higher proportion of load



by Winter Month





Load Shape Changes

- Metric % of energy in every 15-minute increment above or below flat energy for given month.
- Objective of TOD is to shift energy out of yellow bands.
- □ Waste Water #4
 - Great past performance previously part of the Winter peak load shifting pilot
 - Continued improvements in both peaks

Proportion of Load in 15-min incremement vs. Flat: WW_4

by Winter Month





What's Next

Future rate plans

Option to expanded enrollment into TOD

□ Exploring:

Critical Peak Pricing

Interruptible Rate

□ Time of Day Demand Charge

Tweaks to rate constructs (specific prices, mix of resources – hours/events per year, etc.)

Practicalities

□ Connect-up AMI Rollout will enable large scale enrollment

□ MySnoPUD - Enhanced customer data analytics and decision support

□ Enhanced Bill Design





QUESTIONS?

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