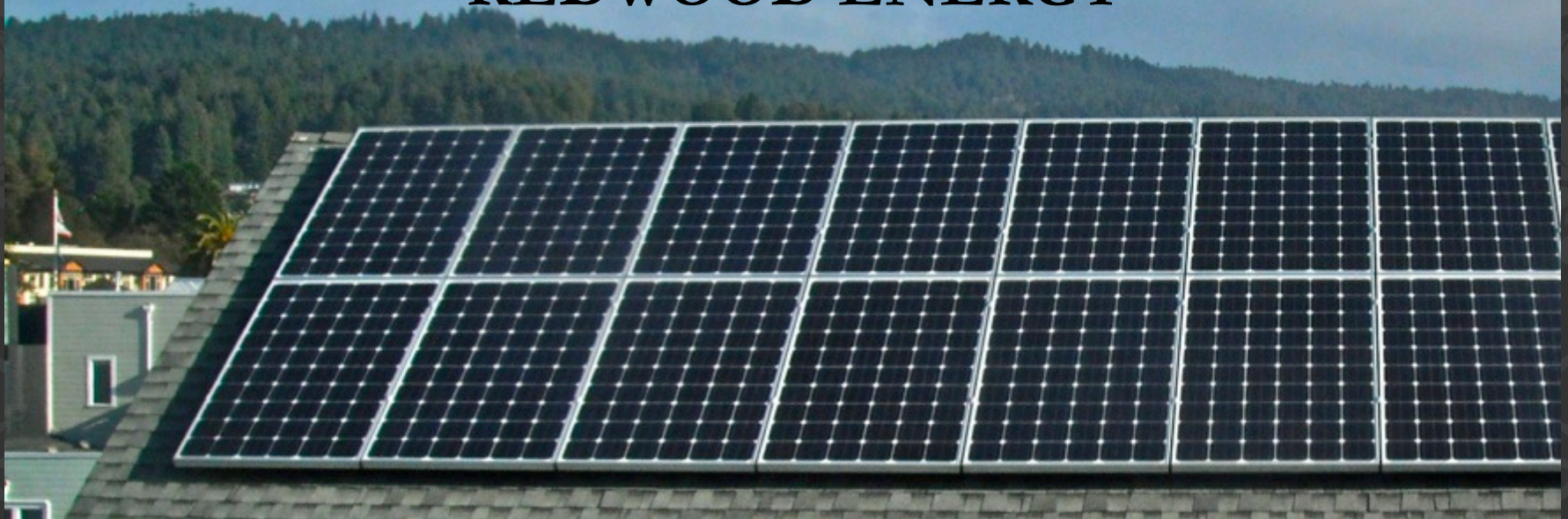


INNOVATIONS AND LESSONS FROM ZERO NET ENERGY HOUSING

**By SEAN ARMSTRONG, MICHAEL WINKLER
and GREG PHOTENHAUER of
REDWOOD ENERGY**



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707.826.1450

**PROJECT
MANAGER/BUILDING
SCIENTIST
SEAN ARMSTRONG**



- Volunteer and C-Director with a near-NZE demonstration home at Humboldt State 1995-2015 –solar and wind installations, pedal power, permaculture
- B.S. in Natural Resources Conservation ('00), Student Activist of the Year, and a short career as science teacher 2003-04
- Project Manager for entitling and designing market rate and affordable housing: 2005-2011
- Founded Redwood Energy in 2011 to help power affordable housing with renewable energy and edible, child friendly landscaping
- Co-Founded a CSA ranch specializing Kunekune pigs

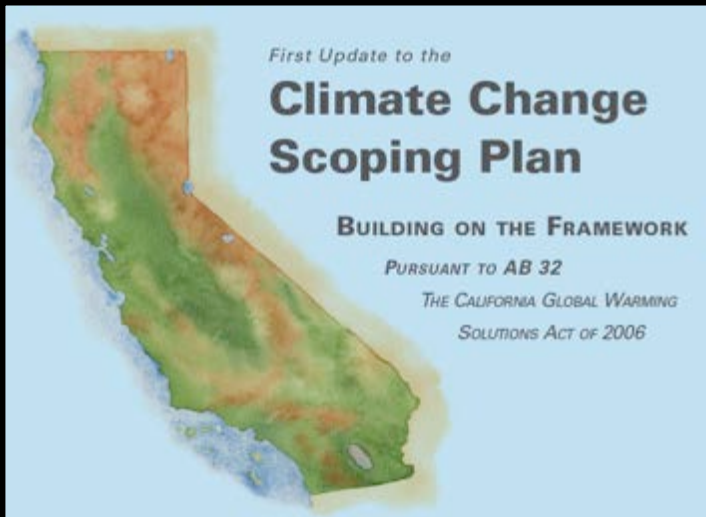
RENEWABLE ENERGY ENGINEER MICHAEL WINKLER



- B.S. in Environmental Resources Engineering and Physics
- Technical Lead for the world's first cell phone system by Motorola
- Telecommunication software engineer 1980s-1995
- Hydrogen Fuel Cell Engineer Engineer 1999-2009
- Redwood Energy: Renewable Energy Engineer, Certified Energy Analyst, HERS Rater and LEED Green Rater 2011-
- Arcata City Council from 2008- and Mayor



WHAT IS MEANT BY “ZERO NET ENERGY?”



- AB 32 necessitates “Net Zero Carbon” buildings to get 80% below 1990 GHG emissions. NZE is a proxy for NZC.
- Net Zero Energy residences produce 100% of energy used on-site each year with on-site renewables.
- All-electric with solar electric offsets: i.e. *no on-site combustion of dinosaur-era fossil fuels* per California’s Build It Green Program, the International Living Building Challenge, and President Obama’s Energy Initiatives of 2009 and 2013)
- DOE and CPUC currently include natural gas in their ZNE definitions.

FIRST 50% NZE EFFORTS USED GAS



2006: COURTYARDS OF
ARCATA II and III,
Arcata—36 apartments and
9 townhomes designed as
50% NZE. Danco
Communities



2007: SOLARA, Poway—56
family apartments designed as
50% NZE. Community Housing
Works

Lessons: VNM billing is
easier, people usually overstate
NZE when gas is used

WHY IS THE USDA A PLACE OF ZNE INNOVATION AND LESSONS?

- In 2009, President Obama issued his first Energy Initiative called for ZNE design in Federal Buildings
- Later in 2009 the USDA Rural Housing division modified their funding application in 2009 to award competitive points for their funding for projects committing to LEED Platinum, ZERH and Zero Net Energy
- In 2013 the USDA/EPA/CEC gave permission to Redwood Energy to modify the algorithms to reflect innovations if we monitored and shared the results
- In 2014 the USDA implemented the 2007 Energy Independence Act by awarding points for storing an additional 5% of energy

SECONDARY FUNDING COMES FROM TENANTS A CALIFORNIA UTILITY ALLOWANCE CALCULATOR (CUAC) BASED UTILITY ALLOWANCE

Allowances for Tenant-Furnished Utilities and Other Services

*Generated by TCAC Approved California
Utility Allowance Calculator (CUAC)*

Original Submittal

Software Version Date: 12/22/2010
Lookup Tables Version Date: 8/11/2011 2:31:00 PM
Print Timestamp: 2/25/2013 2:05:51 PM

Property Address: Farmers Central Road and Pioneer Avenue	Developer Signature: Qualified Consultant Signature: <i>Michael Winkler</i>	CUAC Project ID*: 4
Locality: Woodland	Unit Type: Affordable Housing	
	Date: 2/25/2013	

Utility or Service	Monthly Allowance					
	0 Bdrm	1 Bdrm	2 Bdrm	3 Bdrm	4 Bdrm	5 Bdrm 6 Bdrm
Heating						
Electric		\$0.17	\$0.38	\$0.55	\$0.67	
Natural Gas		\$0.00	\$0.00	\$0.00	\$0.00	
Cooking						
Electric		\$0.64	\$0.62	\$0.60	\$0.64	
Natural Gas		\$0.00	\$0.00	\$0.00	\$0.00	
Lighting						
Electric		\$0.40	\$0.41	\$0.43	\$0.49	
Other						
Electric		\$1.62	\$1.60	\$1.58	\$1.75	
Natural Gas		\$0.00	\$0.00	\$0.00	\$0.00	
Air Conditioning						
Electric		\$0.17	\$0.17	\$0.14	\$0.17	
Water Heating						
Electric		\$1.50	\$1.30	\$1.19	\$1.19	
Natural Gas		\$0.00	\$0.00	\$0.00	\$0.00	
Water						
Water	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00 \$0.00
Sewer						
Sewer						
Trash						
Trash	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00 \$0.00
Rental						
Microwave						
Refrigerator						

Tool Version: 12/22/2010
Lookup Table Verion: 8/11/2011 2:31:00 PM
Printed Timestamp: 2/25/2013 2:05:54 PM

Project Name: Woodland - Mutual Housing at Spring Lake Phase I
Site Address: Farmers Central Road and Pioneer Avenue, Woodland
Site Contact: Holly Wunder-Stiles
Electric Utility: PG&E Electric Territory: S - Electric
Gas Utility: No Gas Gas Territory: All
Tariff Type: Standard Affordable Housing ☒

Utility Allowance Calculator Results

Monthly Usage (\$/month)							
Apartment Type	Units		Electric	Gas	Water	Trash	Total
	Aff. Hous.	Mkt. Rate					
One Bedroom	12	0	\$4.50	\$0.00	\$0.00	\$0.00	\$4.50
Two Bedroom	20	0	\$4.50	\$0.00	\$0.00	\$0.00	\$4.50
Three Bedroom	22	0	\$4.50	\$0.00	\$0.00	\$0.00	\$4.50
Four Bedroom	8	0	\$4.91	\$0.00	\$0.00	\$0.00	\$4.91

I attest that the inputs to the Project Specific Utility Allowance Calculator are accurate.

	Energy Consultant	Project Owner
Signature	<i>Michael Winkler</i>	
Name	Michael Winkler	
Title	Energy Analyst	
Company	Redwood Energy	
Date	02/25/2013	

FINANCING NZE WITH CUAC UTILITY ALLOWANCES: \$1,300,000 LARGER PERMANENT LOAN BUILDS BETTER FARMWORKER HOUSING

Mutual Housing at Spring Lake, Woodland, CA 2013

100% NZE, DOE Challenge Home, LEED Platinum, NAHB Emerald, Green Communities
Farmworker Housing



Amount and Size of Units	Utility Allowances: HA vs. CUAC	Additional Rental Revenue with CUAC
12 units 1 Bed	\$90 vs. \$5	\$12,240
20 units 2 Beds	\$112 vs. \$5	\$25,680
22 units 3 Beds	\$146 vs. \$5	\$37,224
8 units 4 Beds	\$181 vs. \$5	\$16,896
\$92,040/year is equivalent to a \$1.3M loan at 3%.	Annual Total Revenue	\$92,040

LESSONS: ZERO NET ENERGY MAY “JUST” BREAK EVEN, BUT PROVIDE A STAND-OUT BETTER PROJECT

Danco Builders Cost Analysis for Net Zero Energy
Construction vs. 15% Above T24 Code:
\$12,582/unit, no net debt increase

Construction Items	Cost Change for NZE vs. 15% above Code
High Performance Heat Pumps	\$ 3,066
HERS Commissioning	\$ 259
NZE Solar (after rebates)	\$ 9,689
Plumbing (heat pump 50 gal tanks)	\$ (758)
Extra Insulation	\$ 326
Cost Per Unit	\$ 12,582
ZNE Project Cost (35 Units)	\$ 440,370
Increased Rents = Decreased Utility Bills Results in Increased Construction/Permanent Loan	\$ 430,560



2013: CHURCHILL TOWNHOMES,
Fortuna: 35 family apartments. Danco
Communities

Lesson: NZE was close to cost-
neutral, created best-in-the-
world housing

LESSONS: ZNE IS EQUALLY A WAY OF LIVING AS IT IS ENERGY TECHNOLOGIES SOLUTION

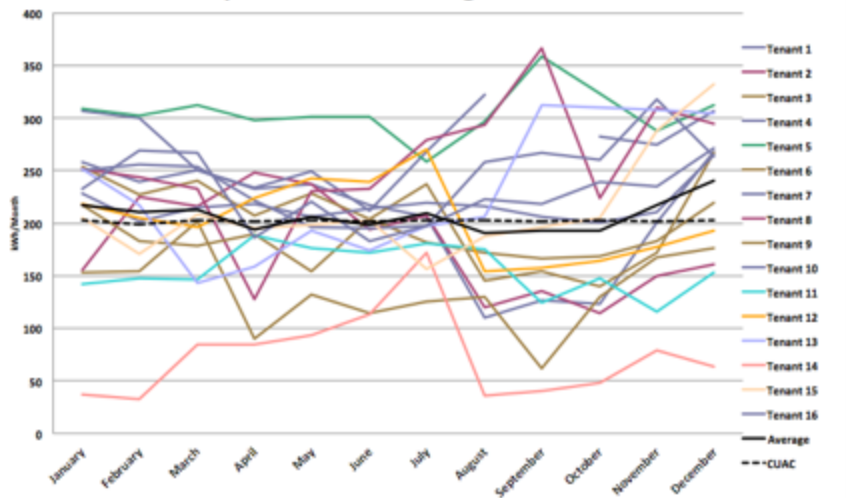


ASTER PLACE, Eureka, 2012: Forty family apartments. 52% Net Zero Energy by design, 6 households live “Net Positive,” 32 are Net Negative.



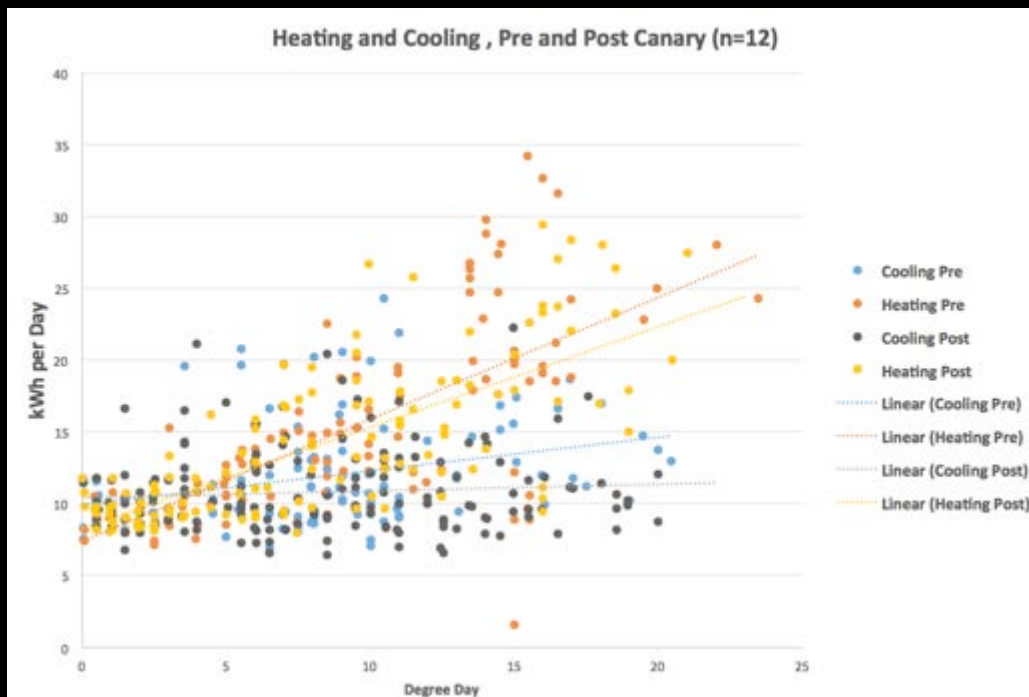
PLAZA POINT, Arcata, 2012: Twenty-nine senior apartments. 78% Zero Net Energy by design, 103% by performance. 14 households live Energy Positive, 15 are Net Negative.

Two Bedroom Electricity Use
Compared to CUAC Modeling at Brookfield Place



Canary Instruments teach tenants about their energy use while data-logging

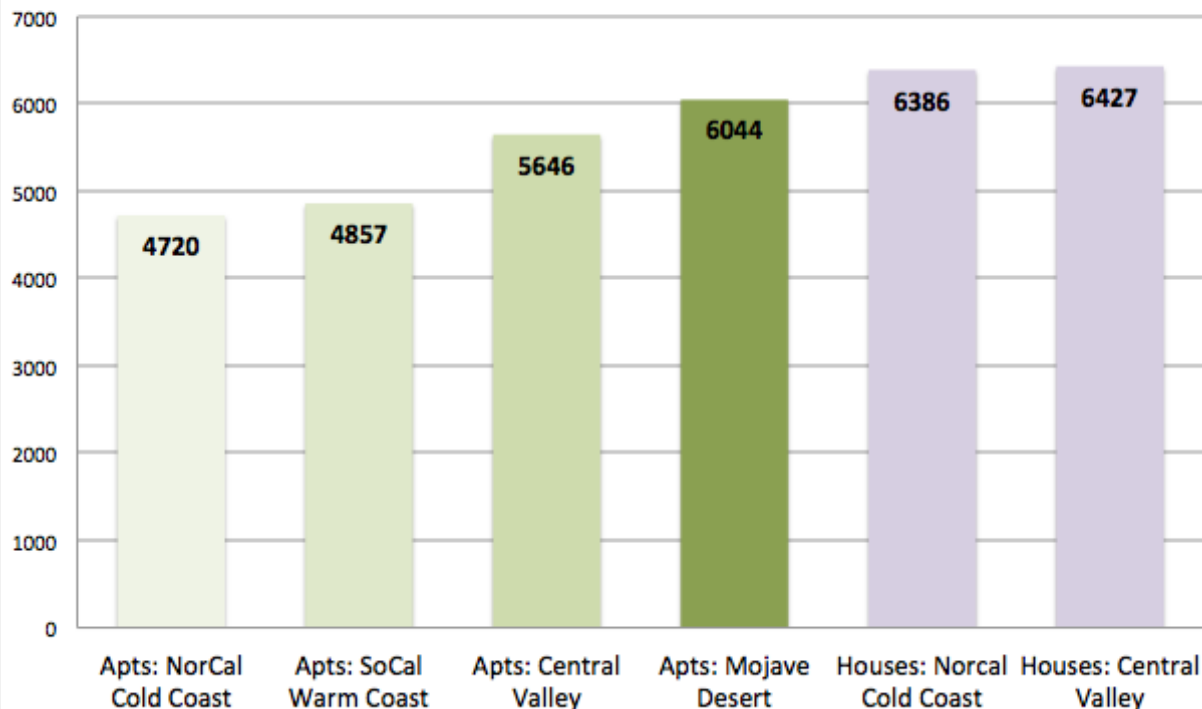
LESSONS: RESIDENT EDUCATION CAN CHANGE BEHAVIOR



- Huge variation seen in use demonstrates possibility of conservation
- Residents are taught their own installed solar energy budget with Canary Instruments
- A 5.6% reduction was seen in 2014 vs. 2015 Whole House loads, controlled for degree days

LESSONS: ZNE HOUSING CAN BE BUILT IN ALL CLIMATES, BUT HOUSES ALWAYS USE MORE ENERGY

**A Comparison of Modeled
Energy Use (kWh/year) in California Two Bedroom ZNE-
Designed Apartments vs. Single Family Houses**

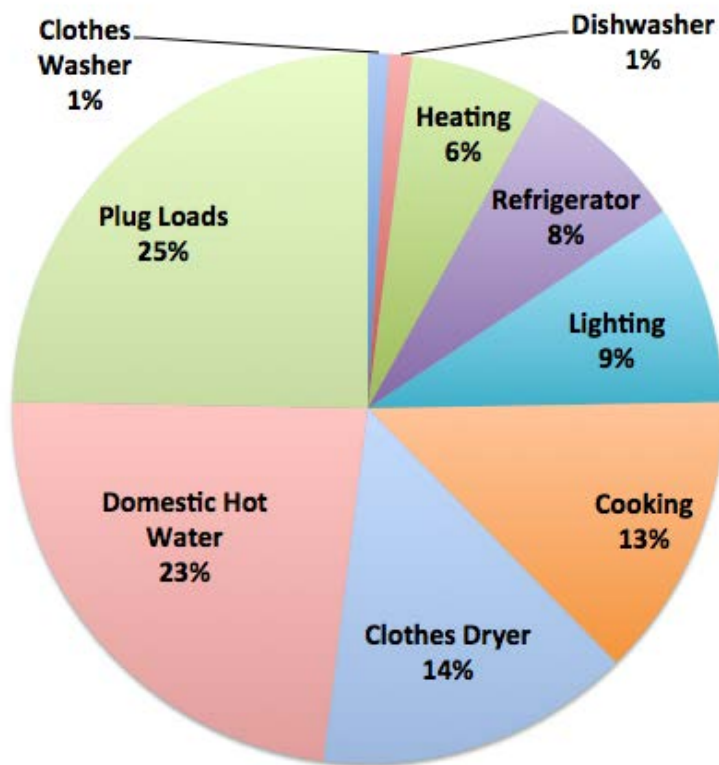


2014: COTTAGES AT CYPRESS, Fort Bragg: 25 houses that are 130%+ Net Positive after two years of operation. Danco Communities

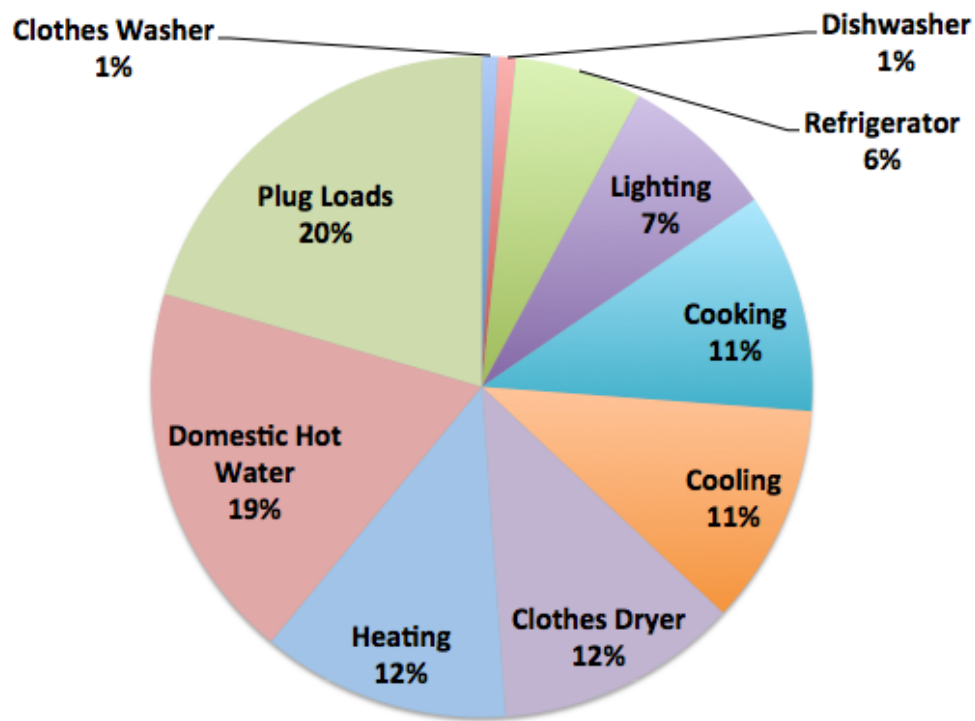
Lesson: Houses use ~20-40% more energy than same-sized Apartments in the same climate

LESSONS: PLUG LOADS, DHW AND BUILDING LAUNDROMATS ARE MORE IMPORTANT THAN HVAC IN EFFICIENT HOUSING

Warm Coast Apt Energy Use: 5732 kWh/year



Mojave Desert Apt Energy Use: 6921 kWh/year



LESSONS: THERMAL BATTERIES ARE THE LEAST COST BATTERIES

2015 and 2016: VALLEY VIEW AND GREEN VALLEY HOMES, in Selma and Williams—48 and 40 farmworker houses with $\sim 4\text{kW}$ /house (an in-house dryer would add 1.5kW). Solar thermal batteries with heat pumps are the least cost way to offset peak loads.



INNOVATIVE ENERGY GENERATION: ALL-ELECTRIC, COMBINED HVAC AND DOMESTIC HOT WATER



- Air conditioners can also efficiently create heat
- Daiken “Altherma” creates hot and cold water for HVAC and DHW
- As efficient as 50% solar hot water offset
- Recently installed in the Jolie-Pitt family residence in L.A.

LESSONS: CENTRAL HEAT PUMPS COST LESS TO BUILD, MORE TO USE






2015: CALISTOGA APTS,
Calistoga— 48 farmworker
apartments. Corporation for
Better Housing



Lesson: Central HVAC/DHW is a
least cost construction strategy,
saving space and
~\$2000/residence, but pump
energy and energy loss adds
2/3rds more total energy demand

INNOVATIVE LIGHTING: DIMMABLE SCREW-IN LEDS

	Watts	Lumens	Life (hrs)	Efficiency (lumens per watt)	Estimated Yearly Cost (3 hr/day at \$0.11/kWh)	Savings over life of the bulb (versus 60-watt incandescent)
GE energy smart* LED 	13	800	25,000	62	\$1.57	\$129.22
GE energy smart* CFL 	13	825	10,000	63	\$1.57	\$51.69
GE Bright from the Start™ CFL 	15	800	8,000	53	\$1.85	\$39.31

CREE brand 800 lumen, 3500 K
(white)

High Efficiency 84 lumen/watt
bulbs



VERY LOW IRRIGATION PLAYABLE, EDIBLE LANDSCAPING



Best Practice: Rolled gravel over soaker hose irrigated fruit trees

MUTUAL HOUSING AT SPRING LAKE: LESSONS IN WHO USES MORE ENERGY

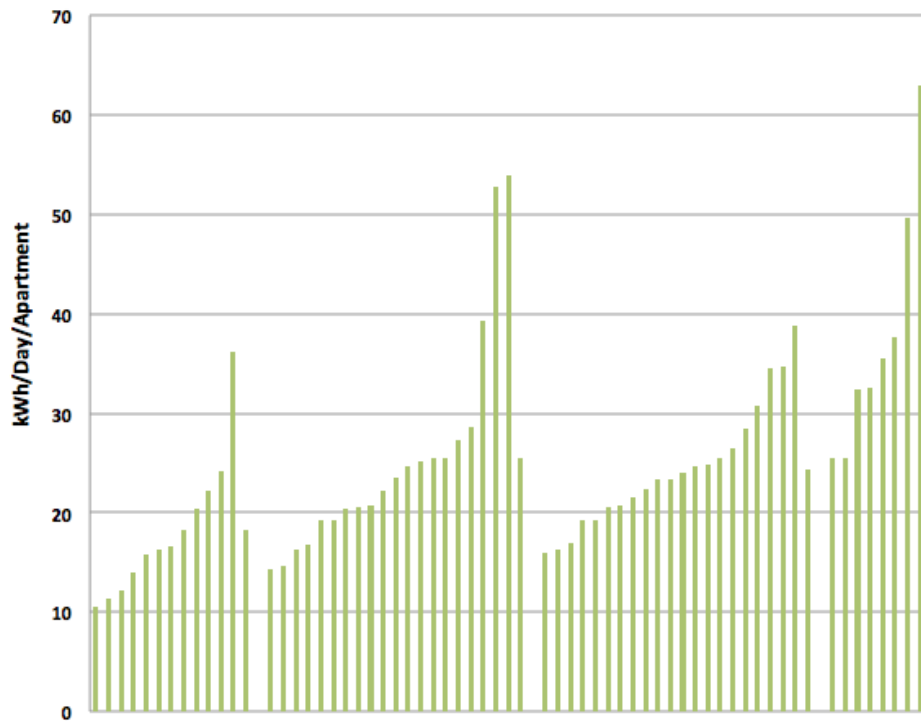


- Virtual Net Metering with PGE billing dept allocates PV credits to tenants
- Solar Cost : 3kw to 5 kW/residence PV array, Average of \$11k/apt after incentive
- Efficiency Cost: average of \$8k/apt

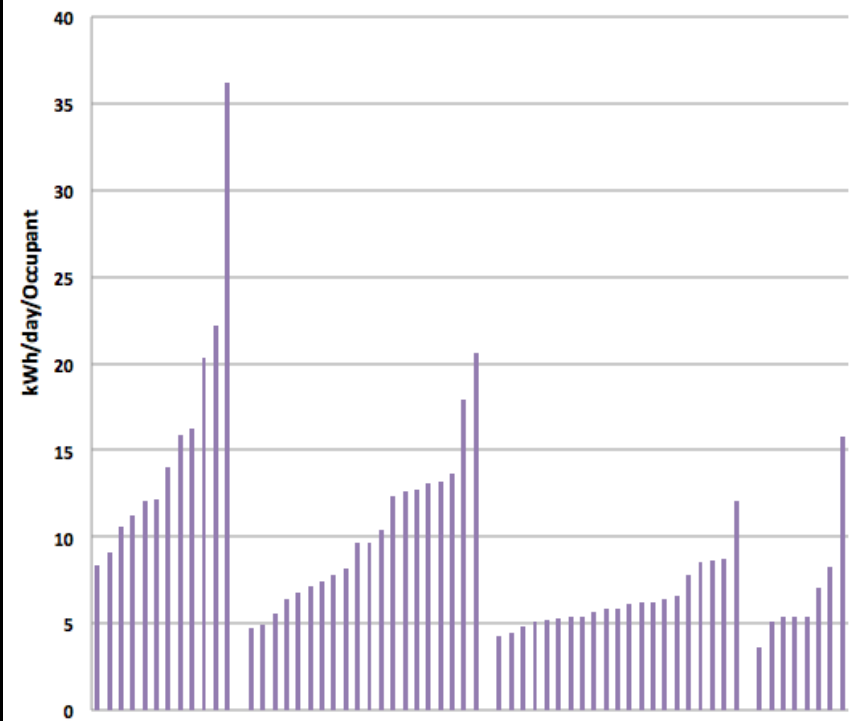


SMALLER HOUSEHOLDS USE LESS, BUT MORE PER PERSON

Energy Use/Apartment/Day Sorted by 1,2, 3 and 4 Bedroom
Apts at MH-Spring Lake



Energy Use/Person/Day Sorted by Apartment Size (1,2,3
and 4 Bedrooms) at MH-Spring Lake



INCOME VERSUS CONSUMPTION: MORE MONEY = MORE USE

**Houeshold Energy Use Per Day vs. Gross Annual Income at Mutual Housing at Spring Lake ZNE
Farmworker Housing**



A dark grey background with a repeating floral and vine pattern in a slightly lighter shade of grey.

SHOW ME THE DATA

STUDY SITES



STUDY SITES



Valley Glen
Apartments, Dixon



Belle Manor,
Lakeport



King Station, King
City



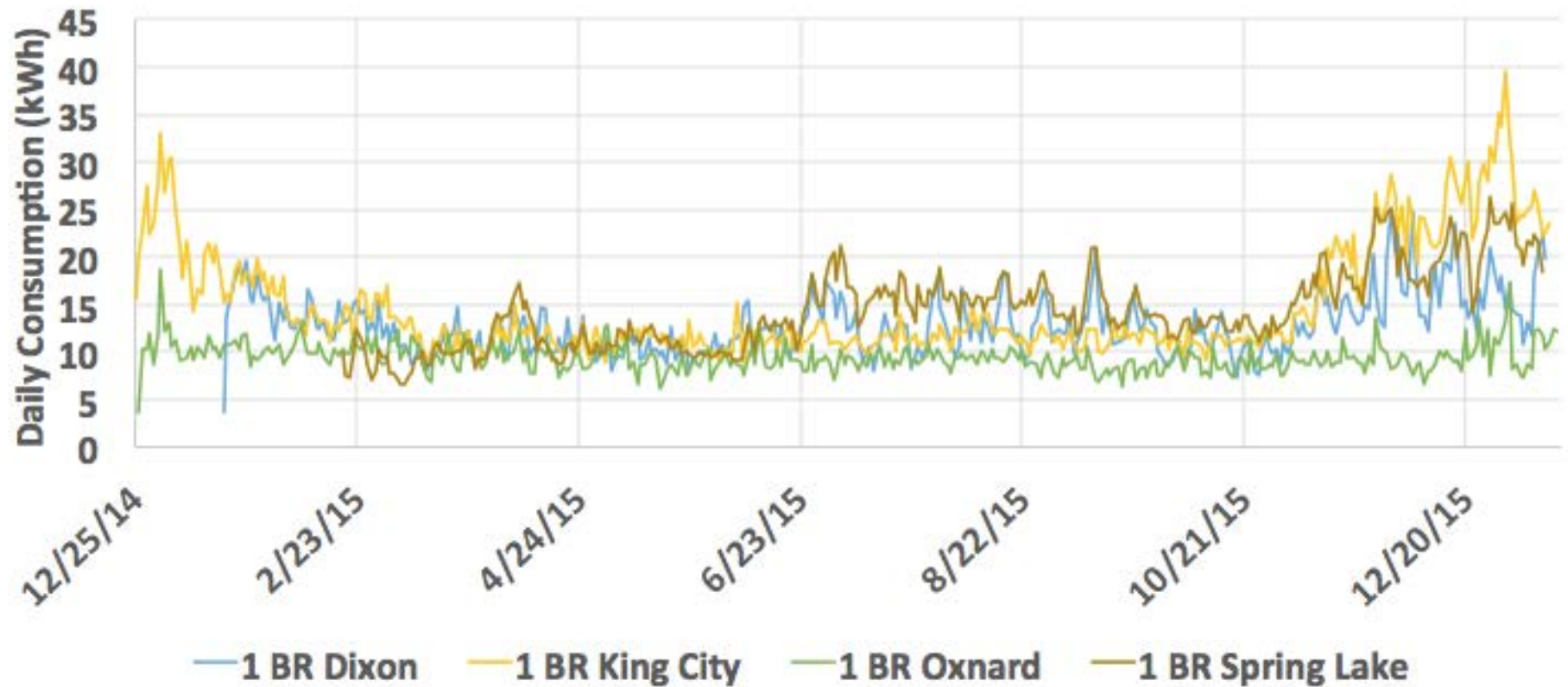
Mutual Housing at
Spring Lake, Woodland



Colonial House, Oxnard

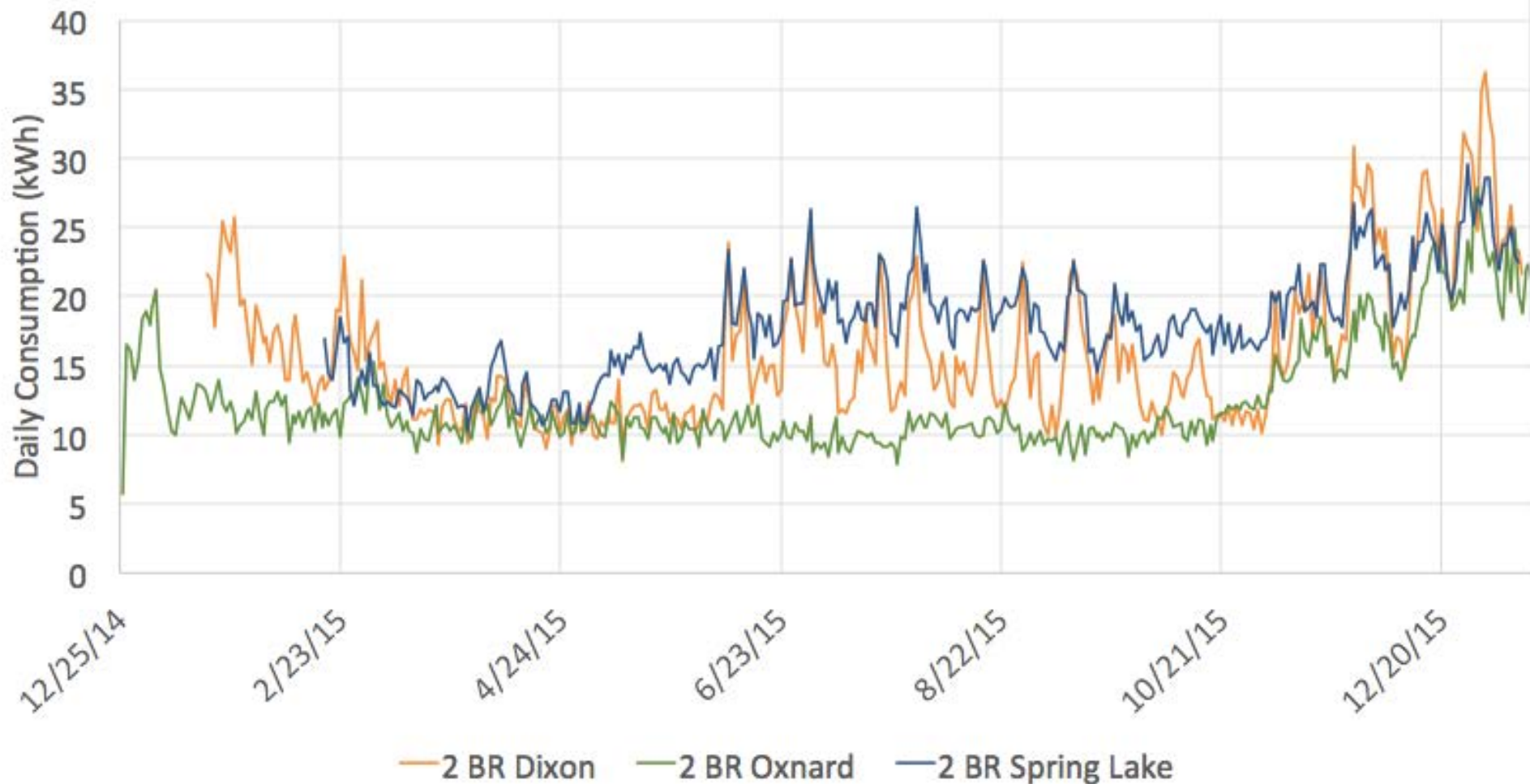
1 BEDROOM APARTMENTS

Daily Electricity Consumption Averages for 1 BR Apartments



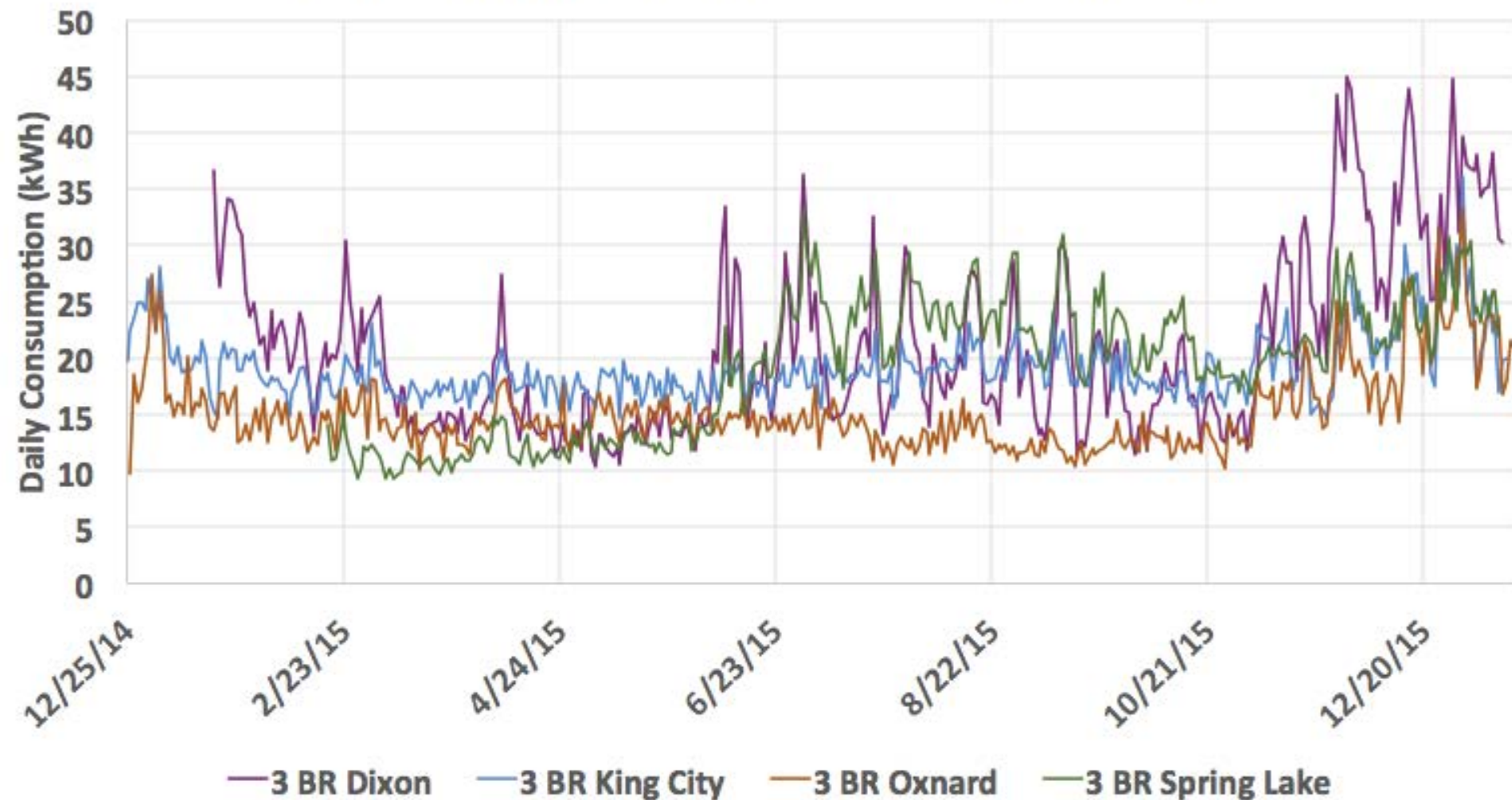
2 BEDROOM APARTMENTS

Daily Electricity Consumption for 2 BR Apartments



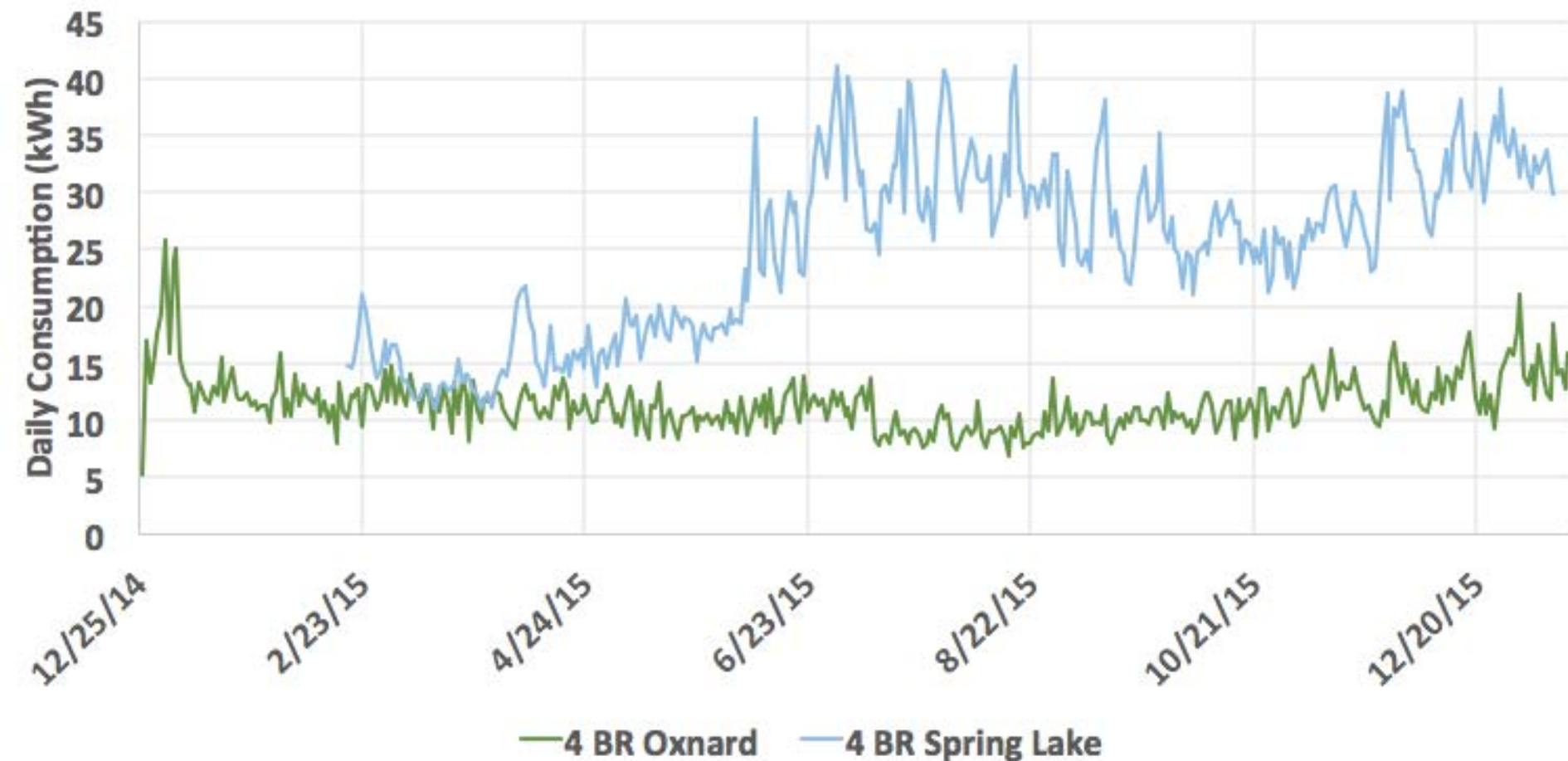
3 BEDROOM APARTMENTS

Daily Electricity Consumption for 3 BR Apartments



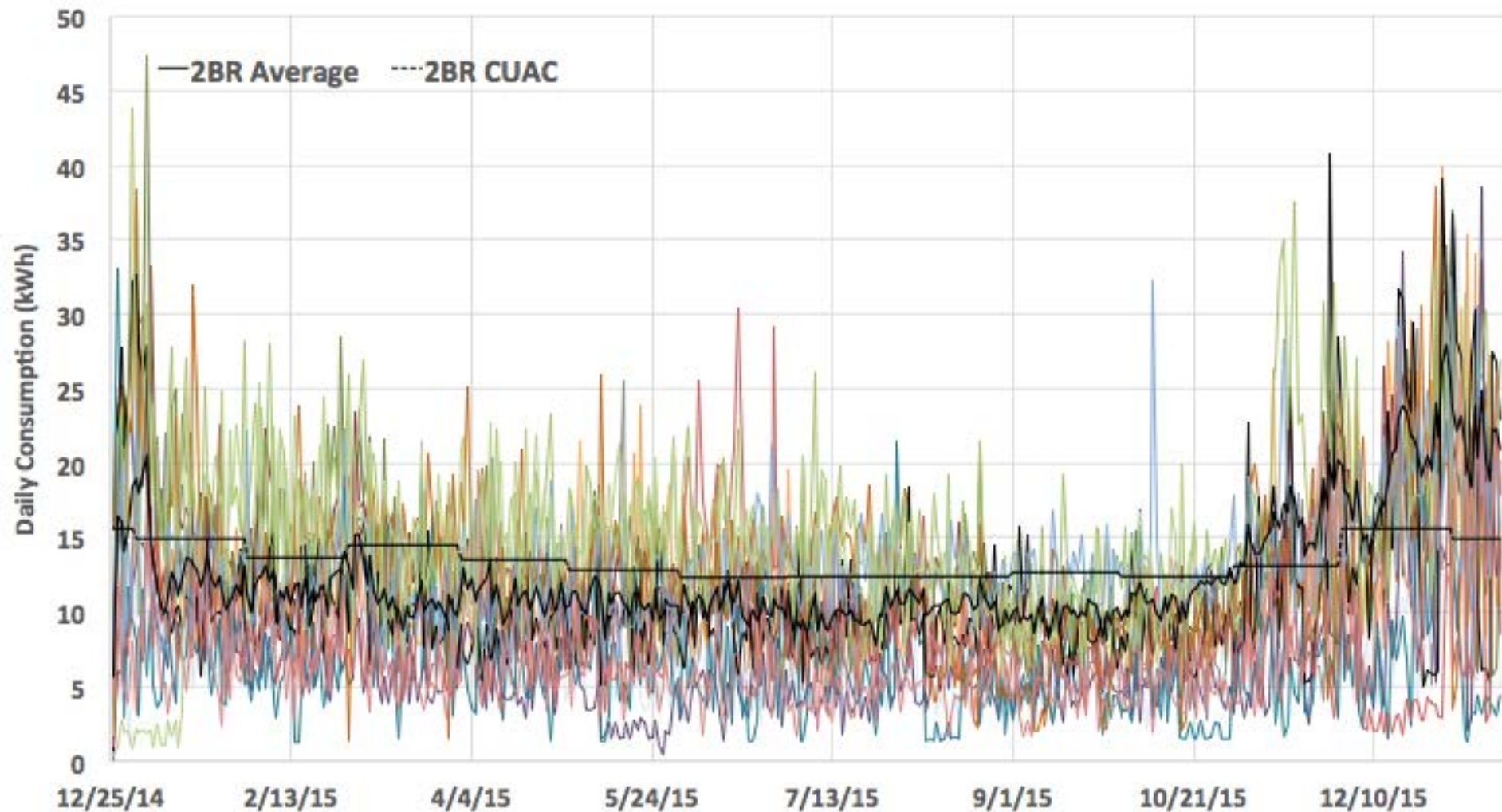
4 BEDROOM APARTMENTS

Daily Electricity Consumption for 4 BR Apartments



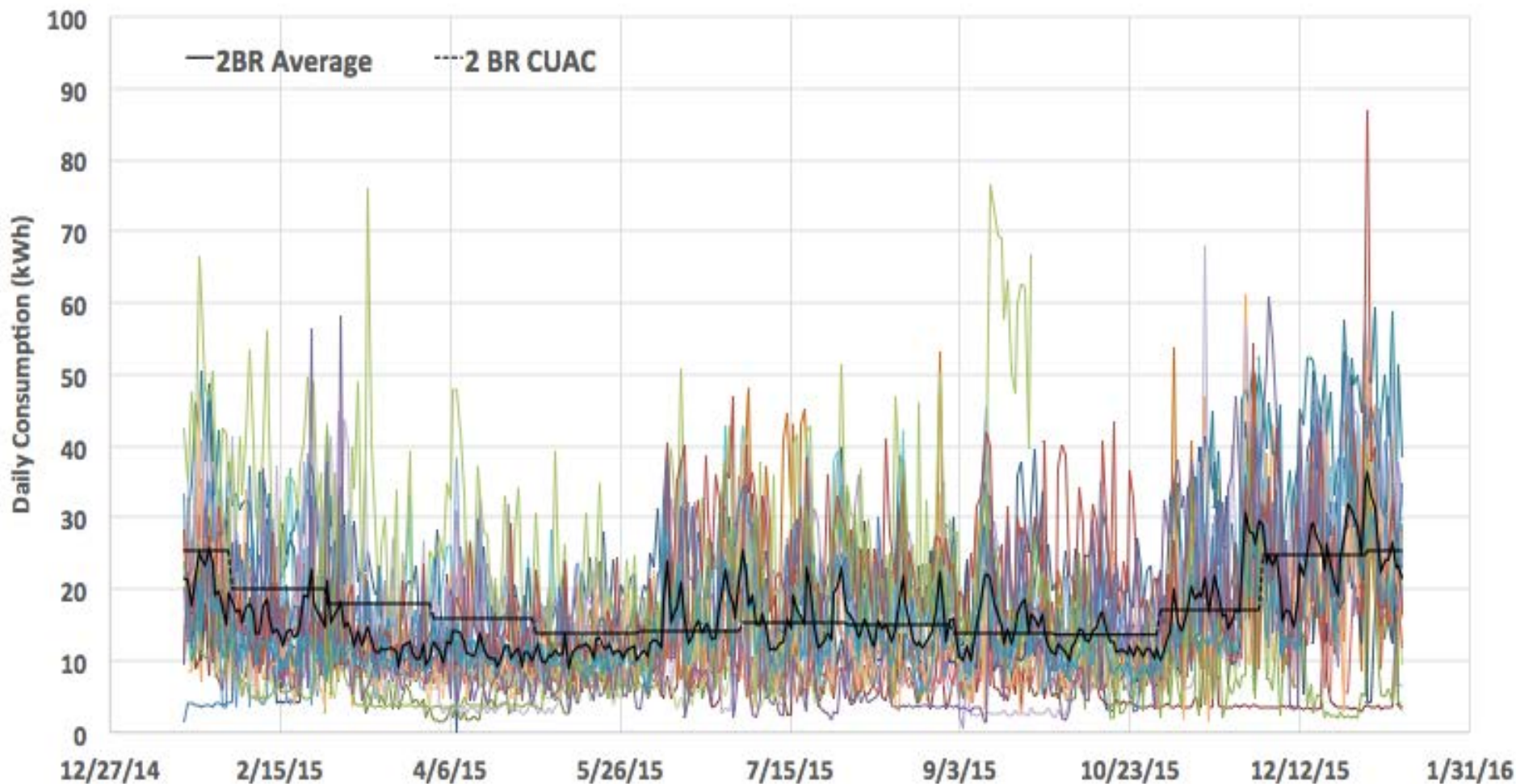
OXNARD 2 BEDROOM COMPARED TO WHOLE HOUSE MODEL

Daily Electricity Consumption in 2-Bedroom Apartments at Oxnard, CA



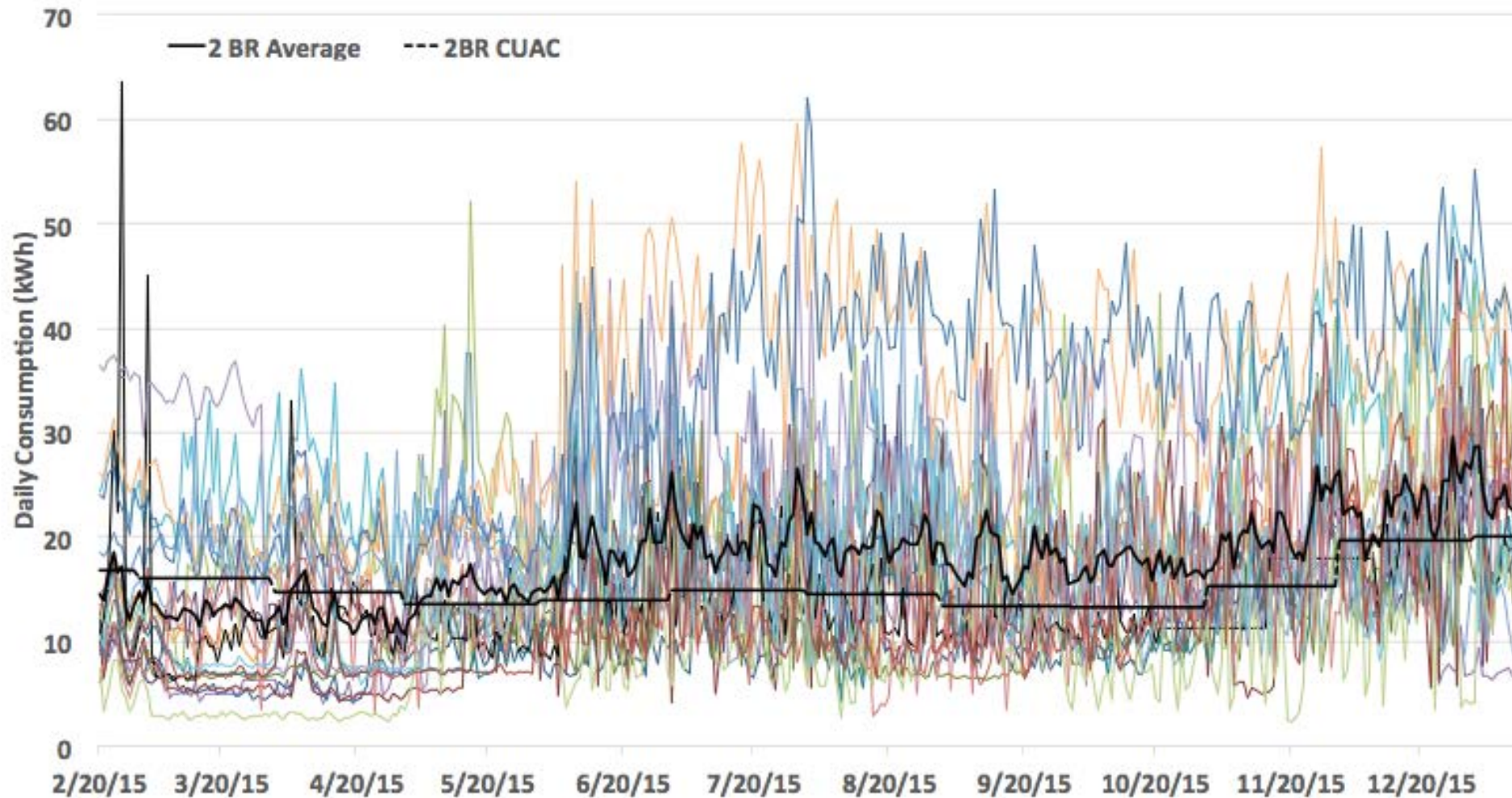
DIXON 2 BEDROOM COMPARED TO WHOLE HOUSE MODEL

Daily Electricity Consumption in 2-Bedroom Apartments at Dixon, CA



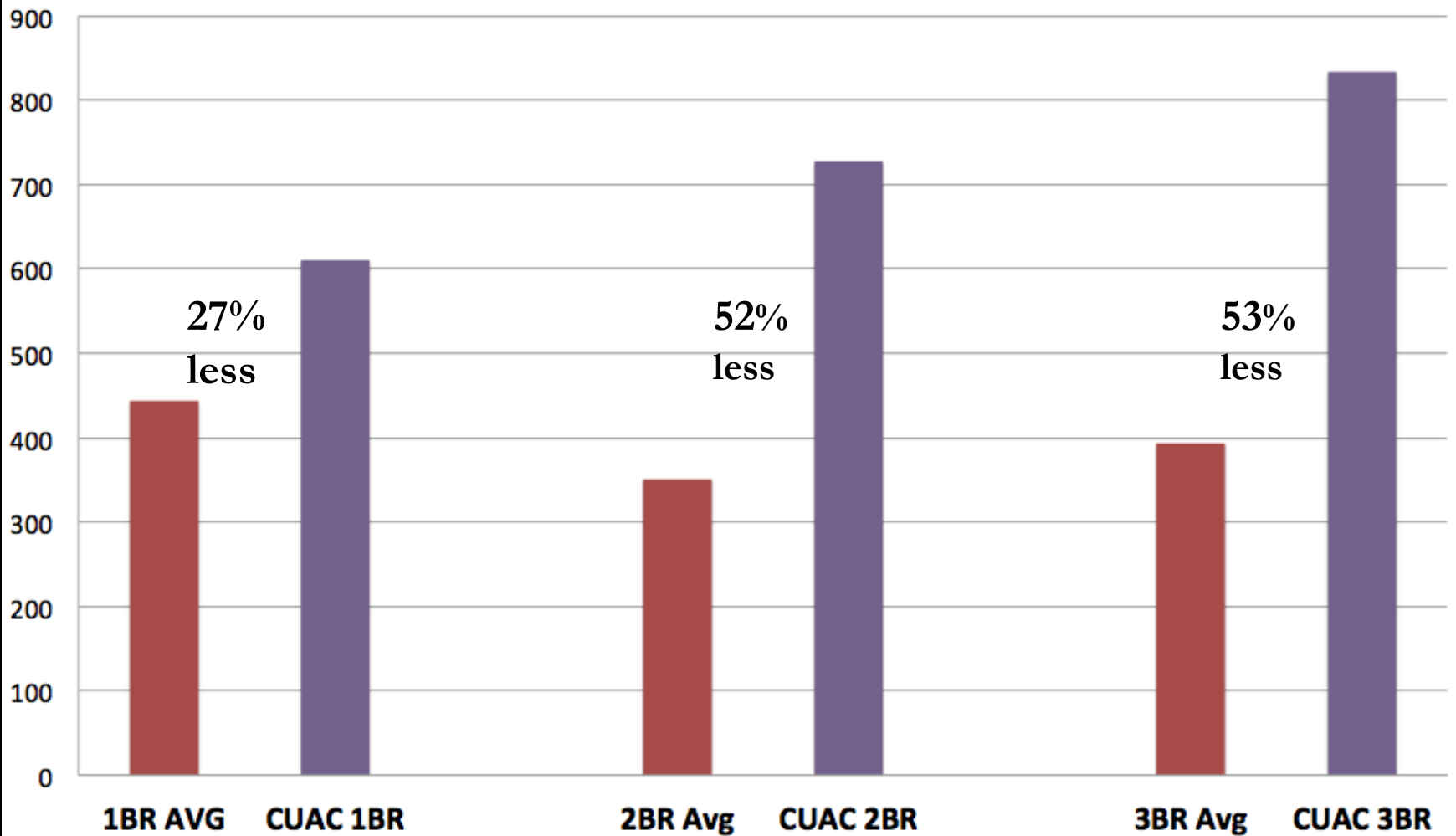
SPRING LAKE 2 BEDROOM COMPARED TO WHOLE HOUSE MODEL

Electricity Consumption in 2-Bedroom Homes in Spring Lake, CA



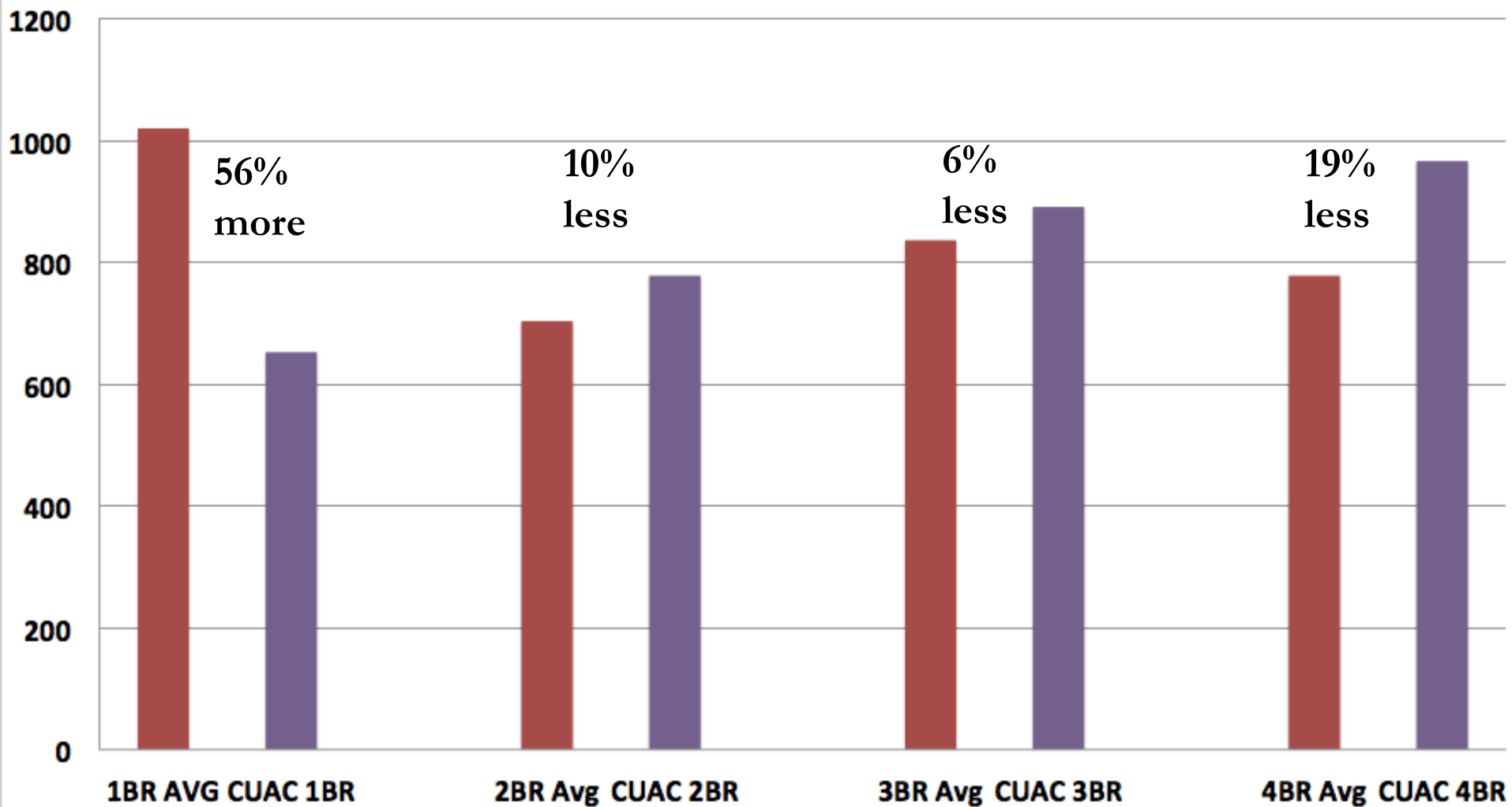
**DIXON COOKING ENERGY:
MODELED VS. ACTUAL**

Dixon Cooking Energy Use (kWh/year)



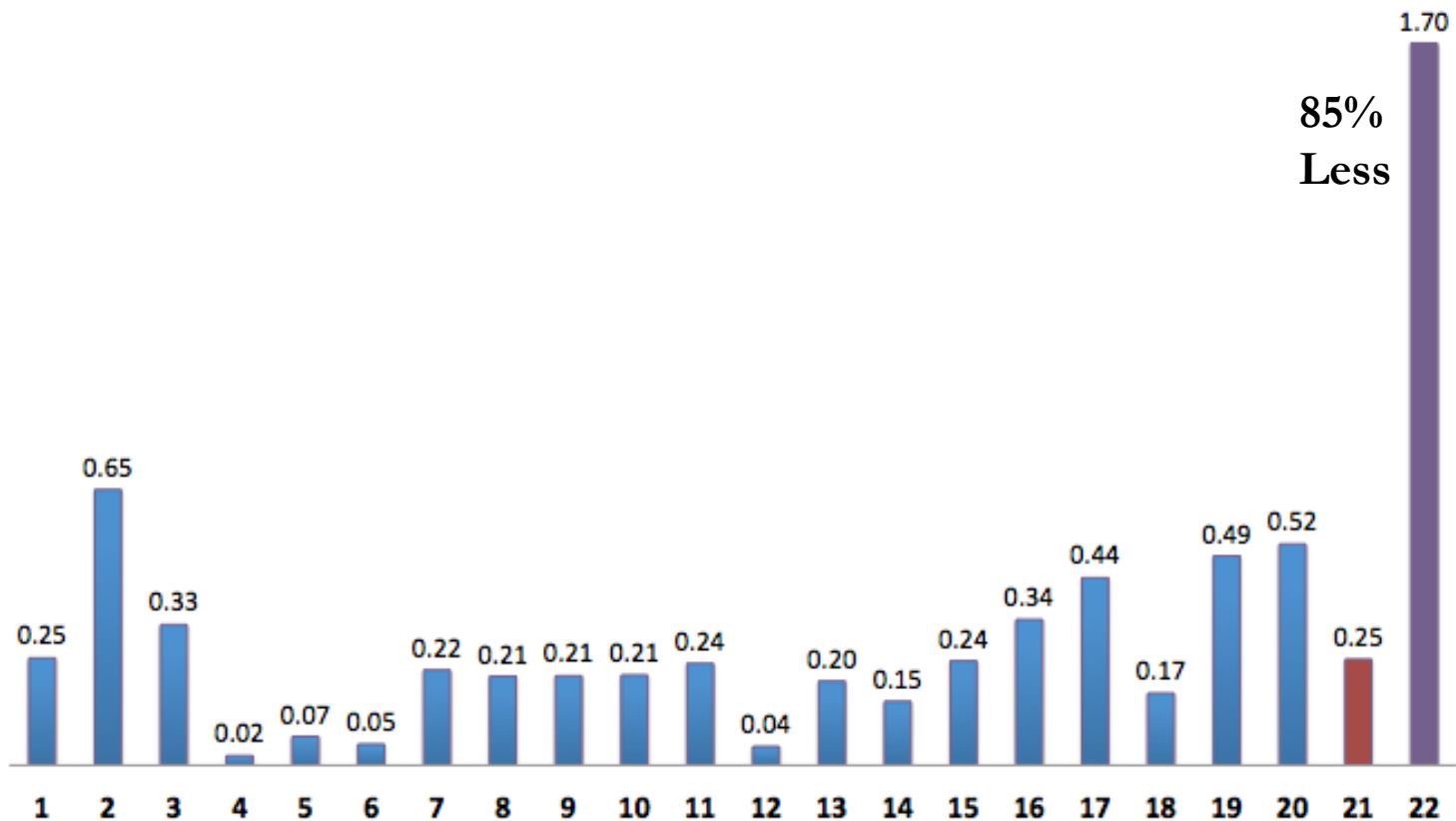
**OXNARD COOKING ENERGY:
ACTUAL VS. MODELED**

Oxnard Cooking Energy (kWh/year) Actual vs. Model N=17



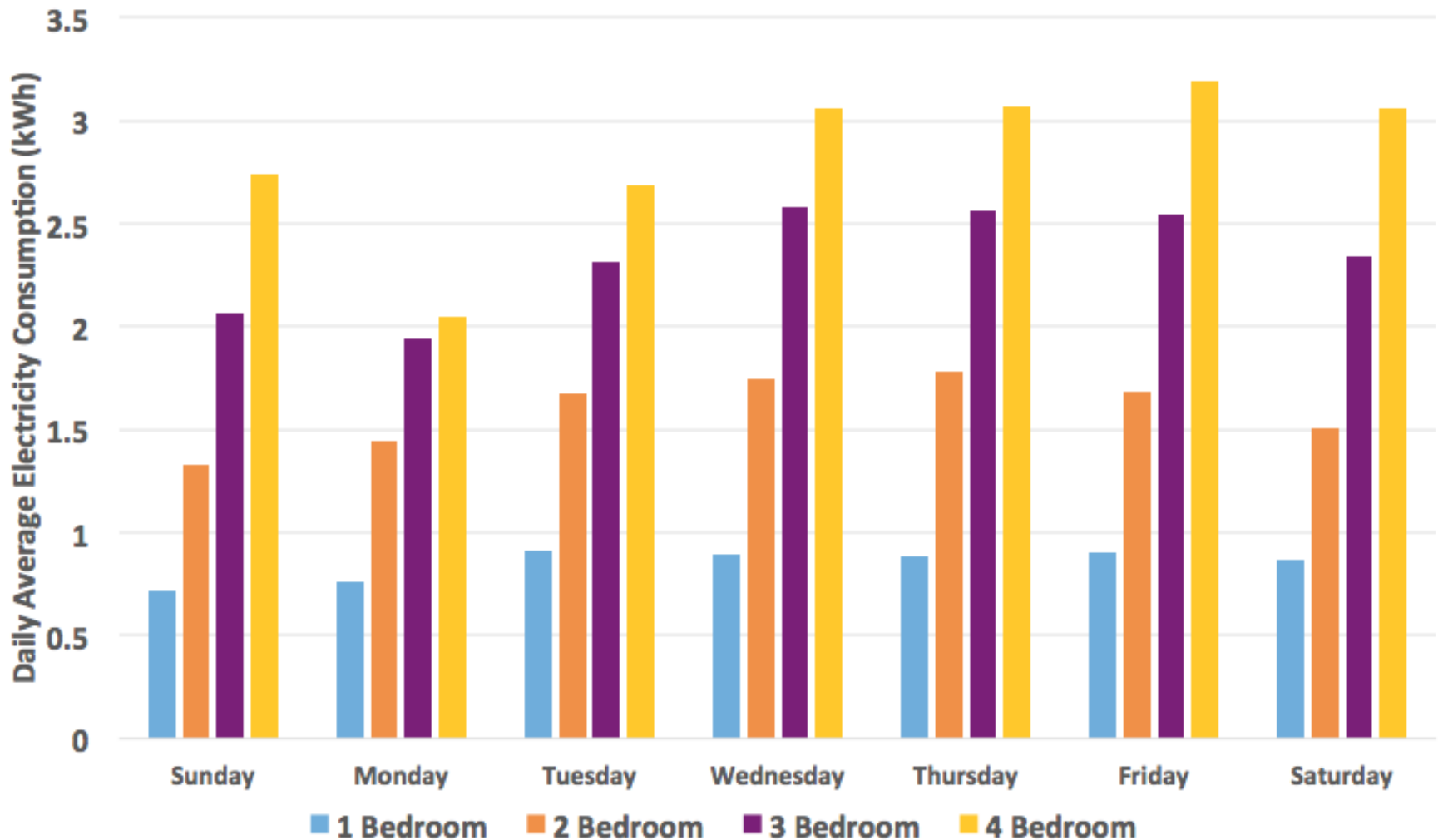
LAKEPORT COOKING ENERGY: MODELED VS. ACTUAL

**Daily Cooking Energy (kWh/day) for One Person
Occupancy 1 Bed Apartments in Lakeport, CA**
Average Compared to Modeled



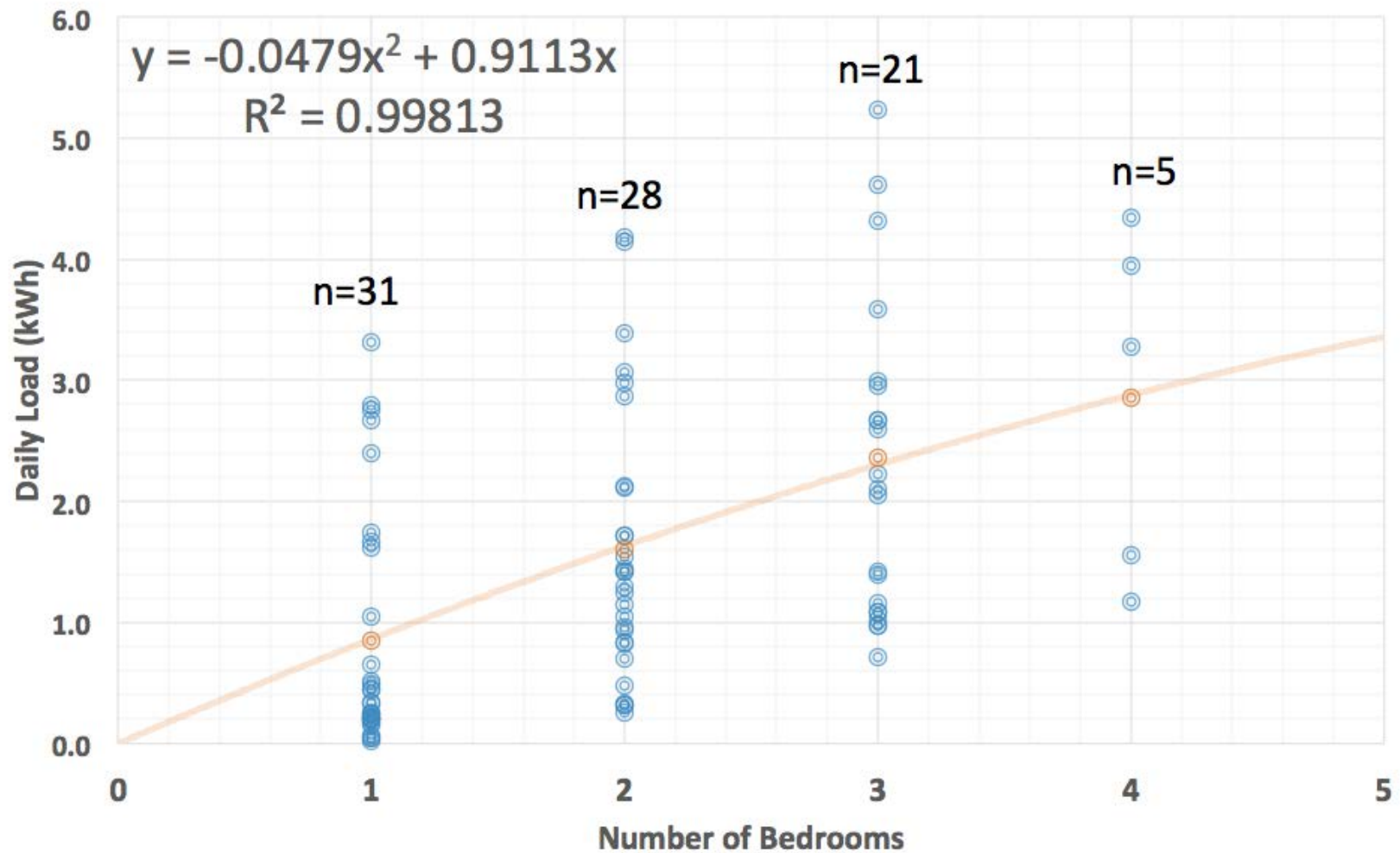
DAILY COOKING LOADS

Cooking Load by Time of Week and Apartment Size



PROPOSED TITLE 24 COOKING ALGORITHM

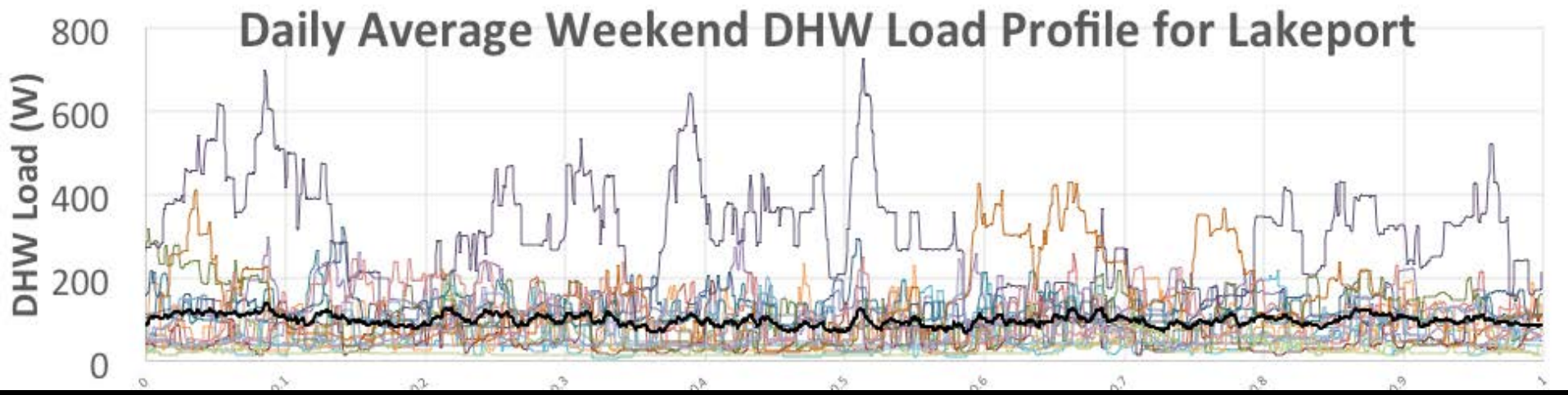
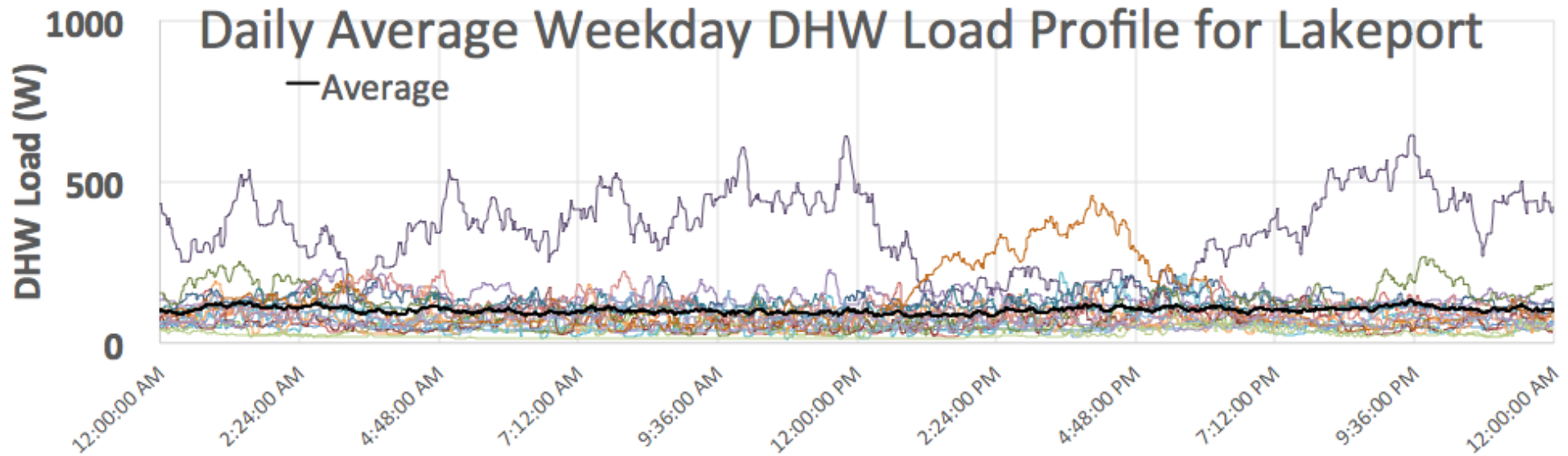
Bedroom Count vs. Daily Cooking Loads



A decorative floral pattern in a dark gray color, featuring stylized leaves and scrolls, runs horizontally across the top of the slide.

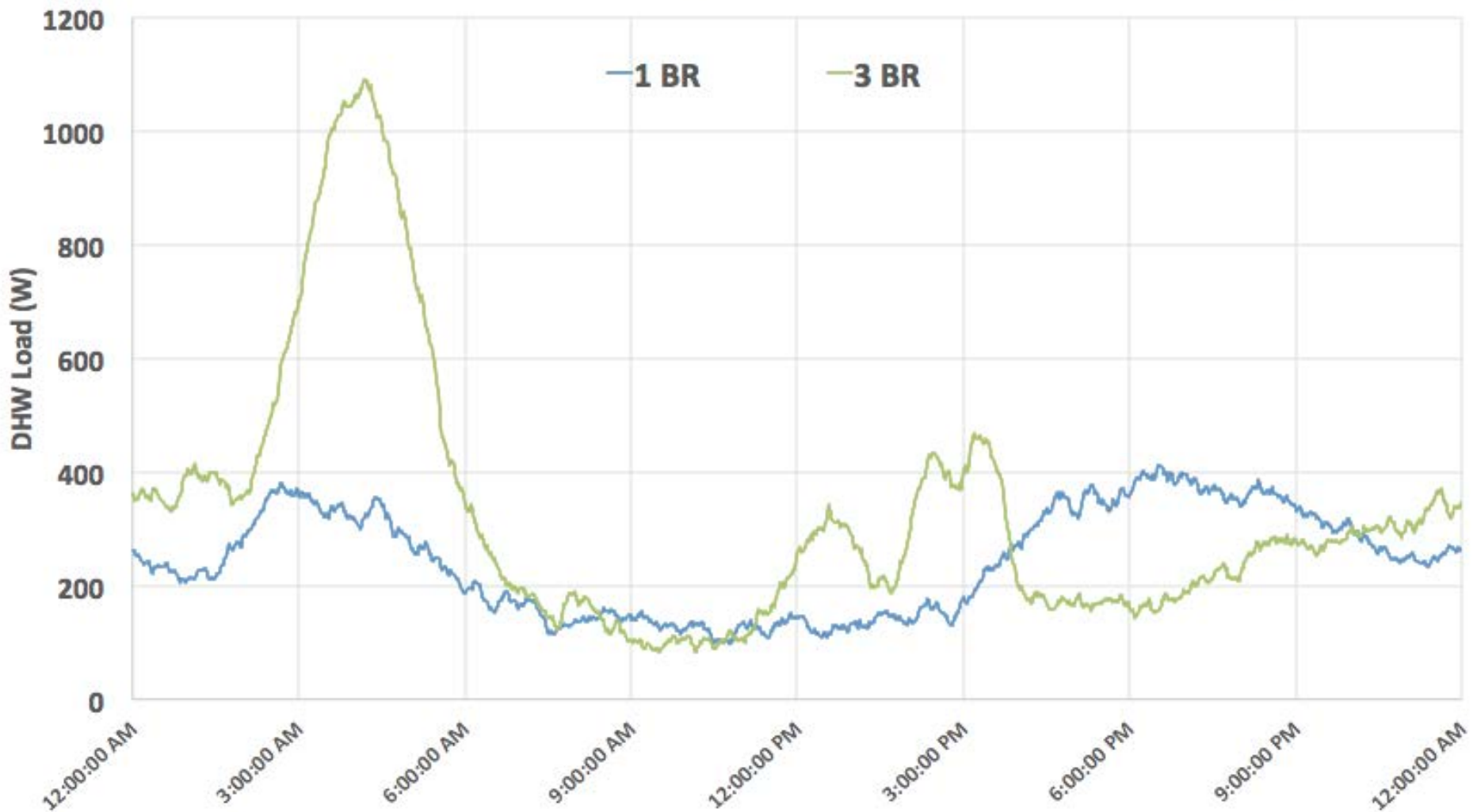
DOMESTIC HOT WATER DATA

LAKEPORT SENIOR HOUSING: FLAT DHW DEMAND EACH HOUR



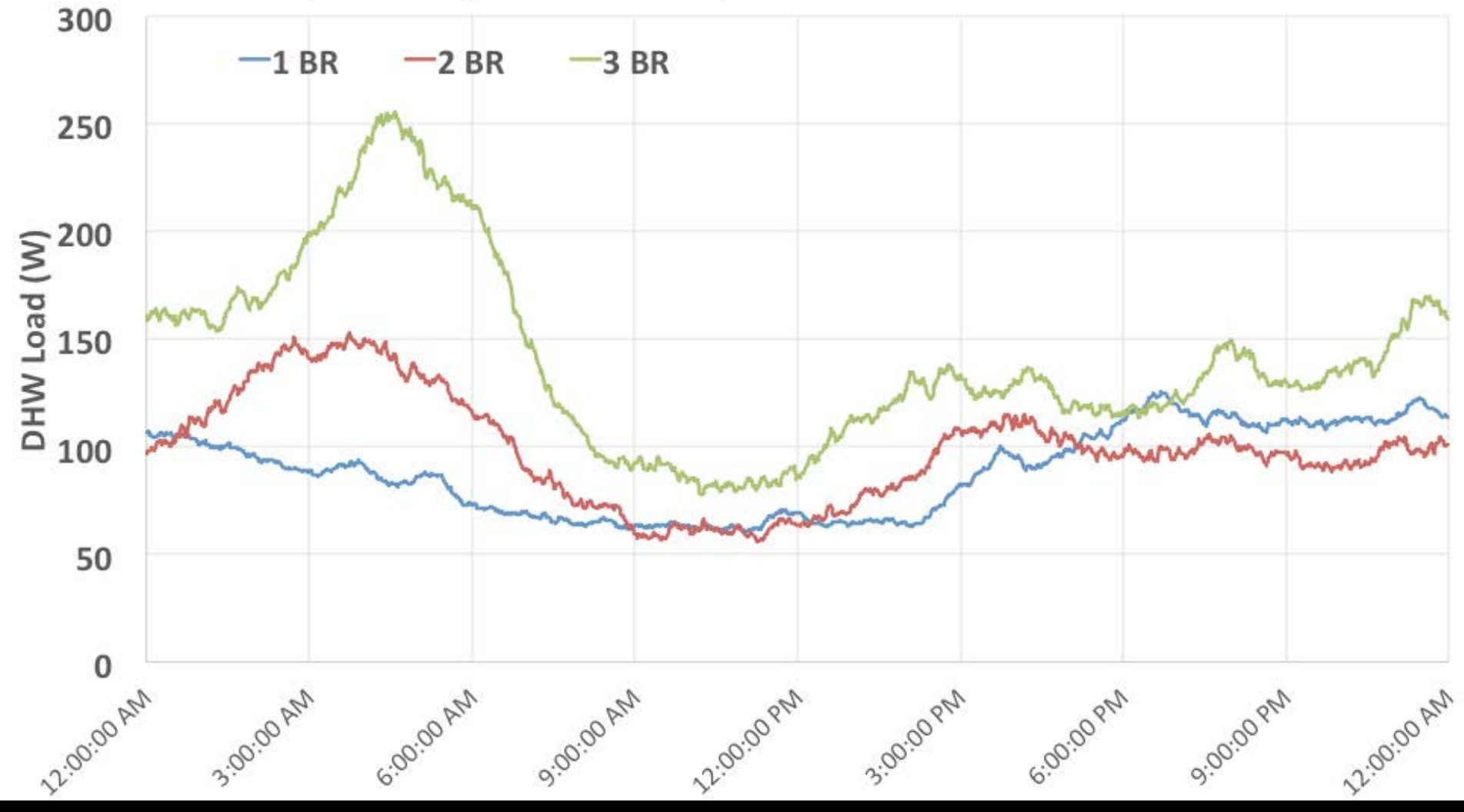
KING CITY DAILY USE: SIGNIFICANT DIFFERENCES BETWEEN HOUSEHOLD SIZES

Daily Average Weekday DHW Load Profile for King City



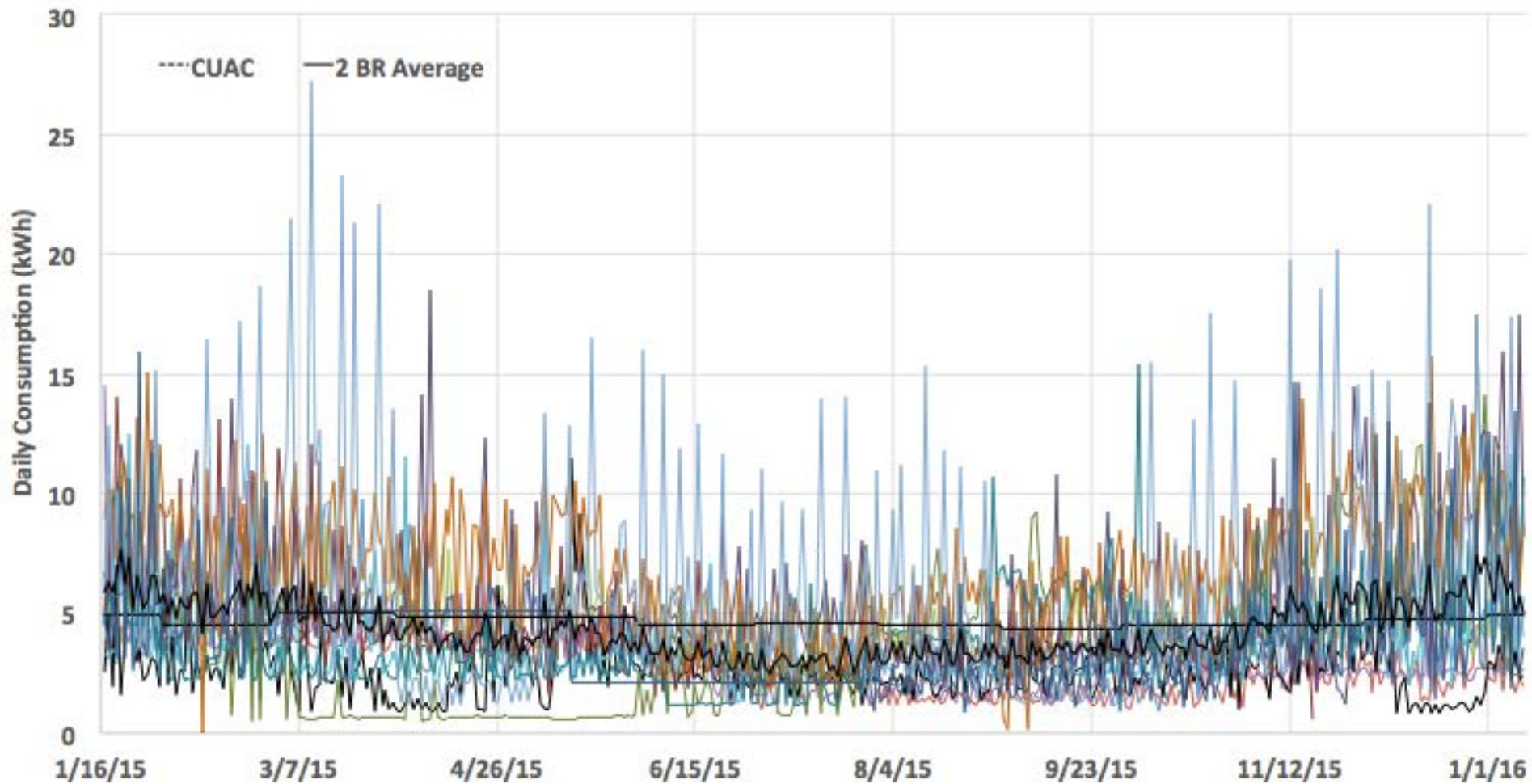
DIXON DAILY USE: DIFFERENT FOR EACH HOUSEHOLD SIZE

Daily Average Weekday DHW Load Profile for Dixon



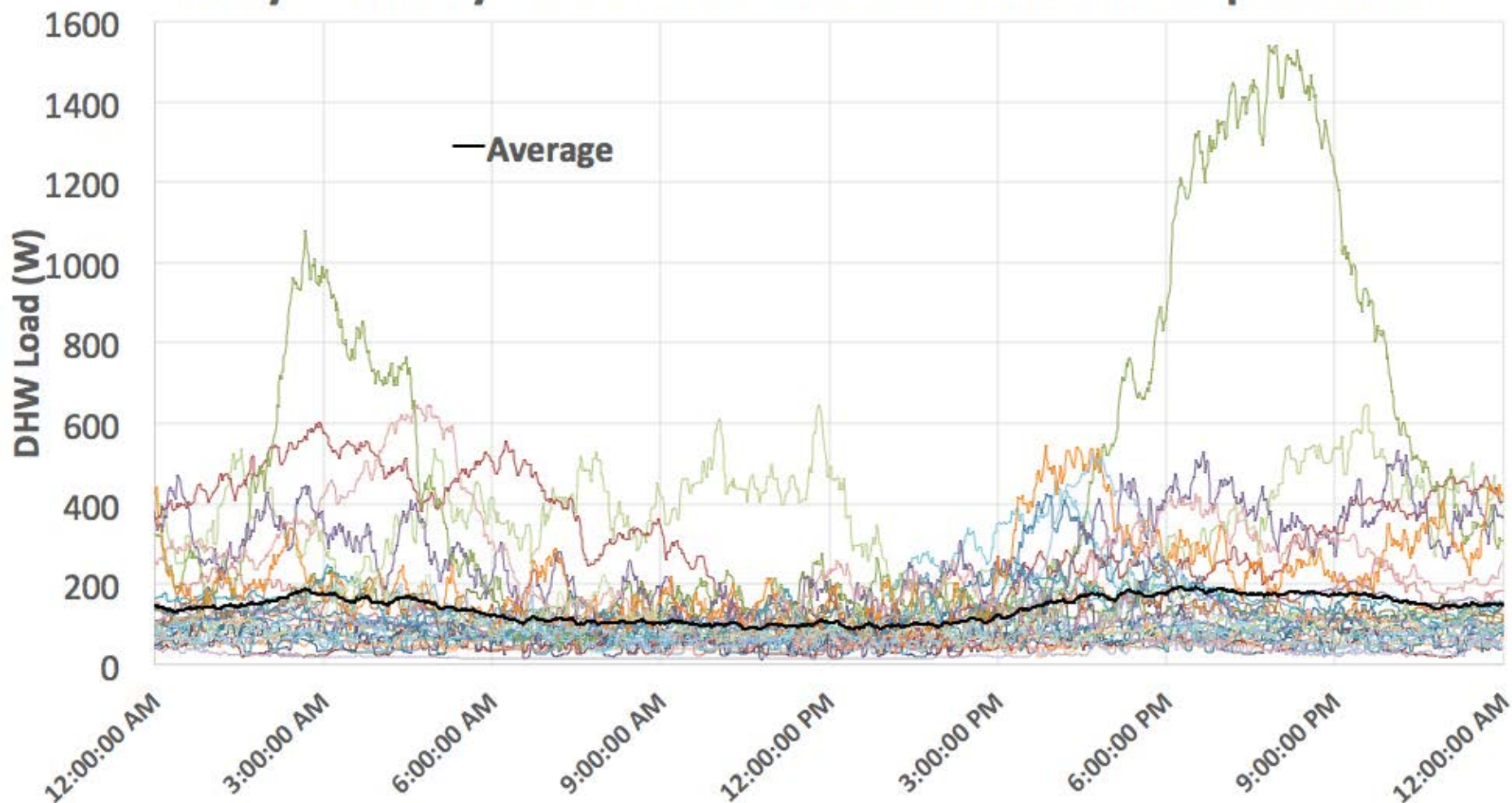
COMPARING TWO BEDROOM USE OF DHW TO THE MODEL

Daily DHW Electricity Consumption in 2-Bedroom Apartments at Dixon, CA



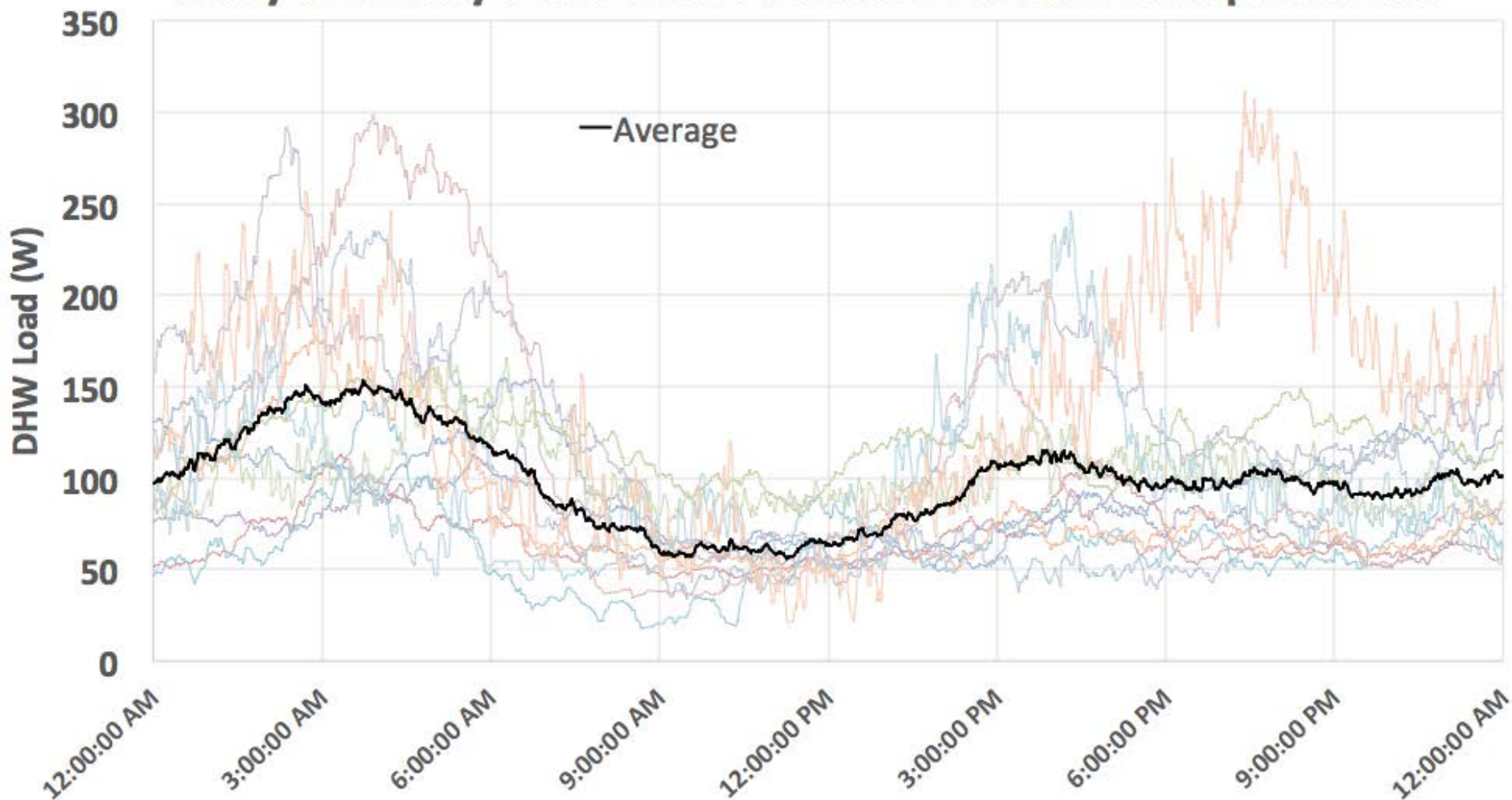
ONE BEDROOM LOAD SHAPE: FLAT

Daily Weekday DHW Load Profile for 1-Bedroom Apartments



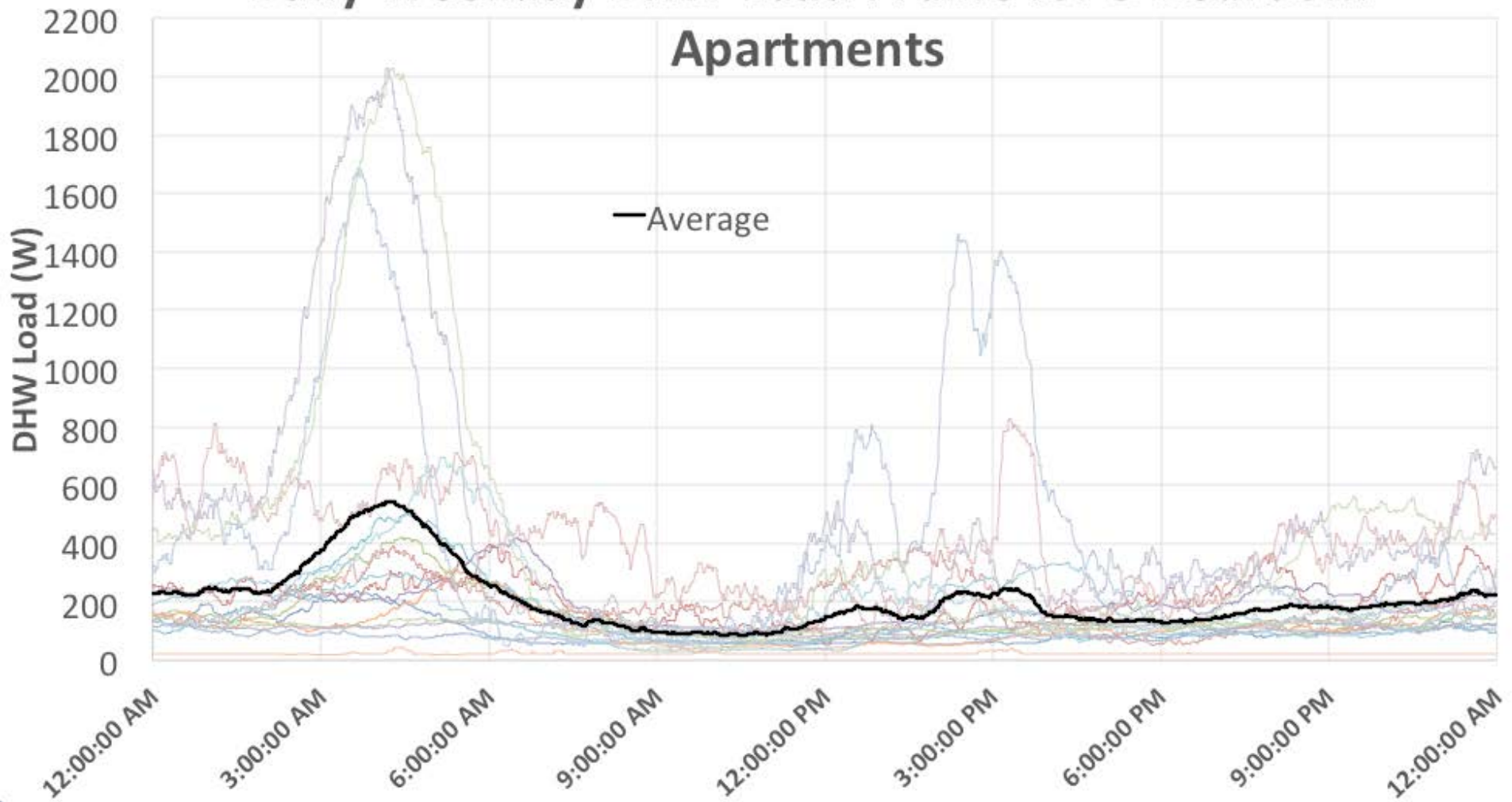
TWO BEDROOM LOAD SHAPE: BIMODAL

Daily Weekday DHW Load Profile for 2-Bedroom Apartments



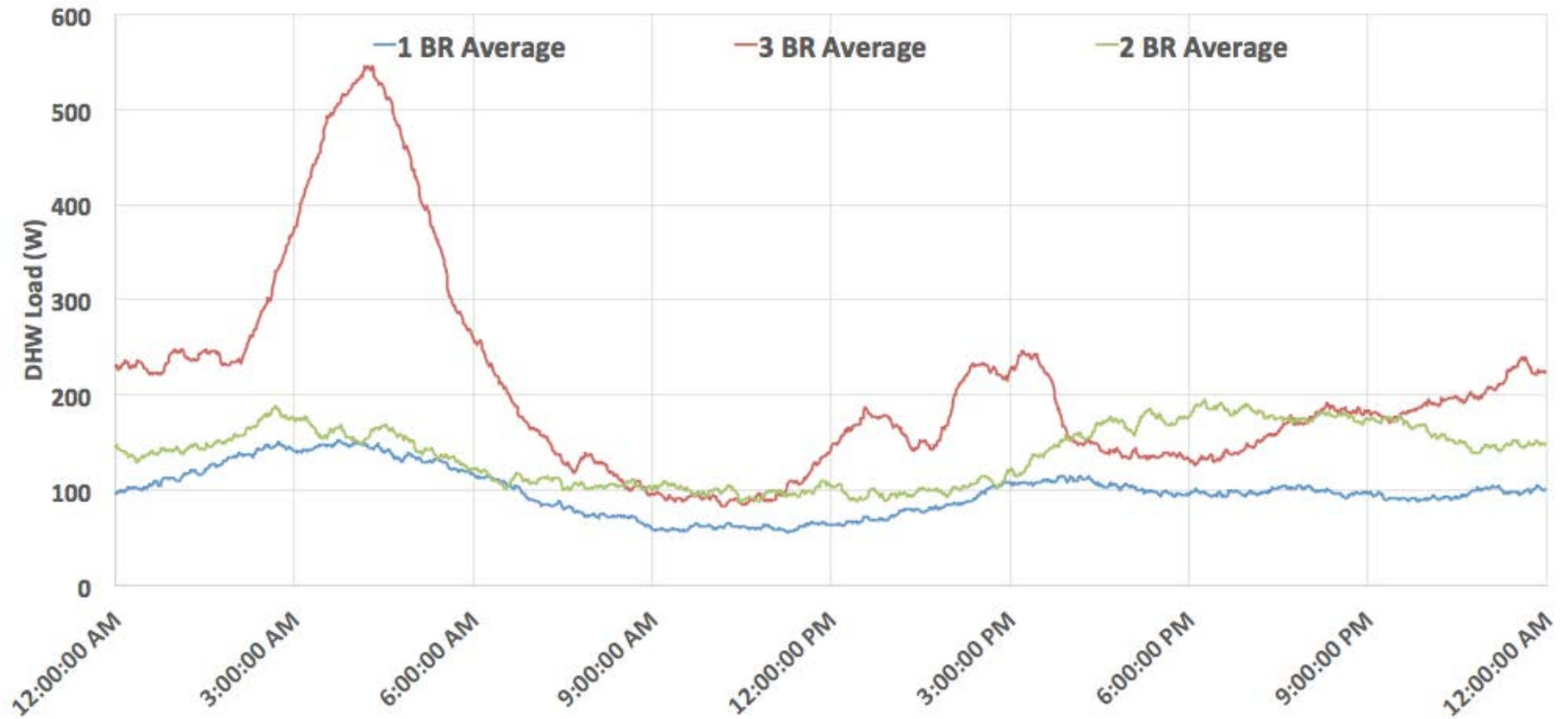
THREE BEDROOM LOAD SHAPE: STRONGLY BIMODAL

Daily Weekday DHW Load Profile for 3-Bedroom Apartments



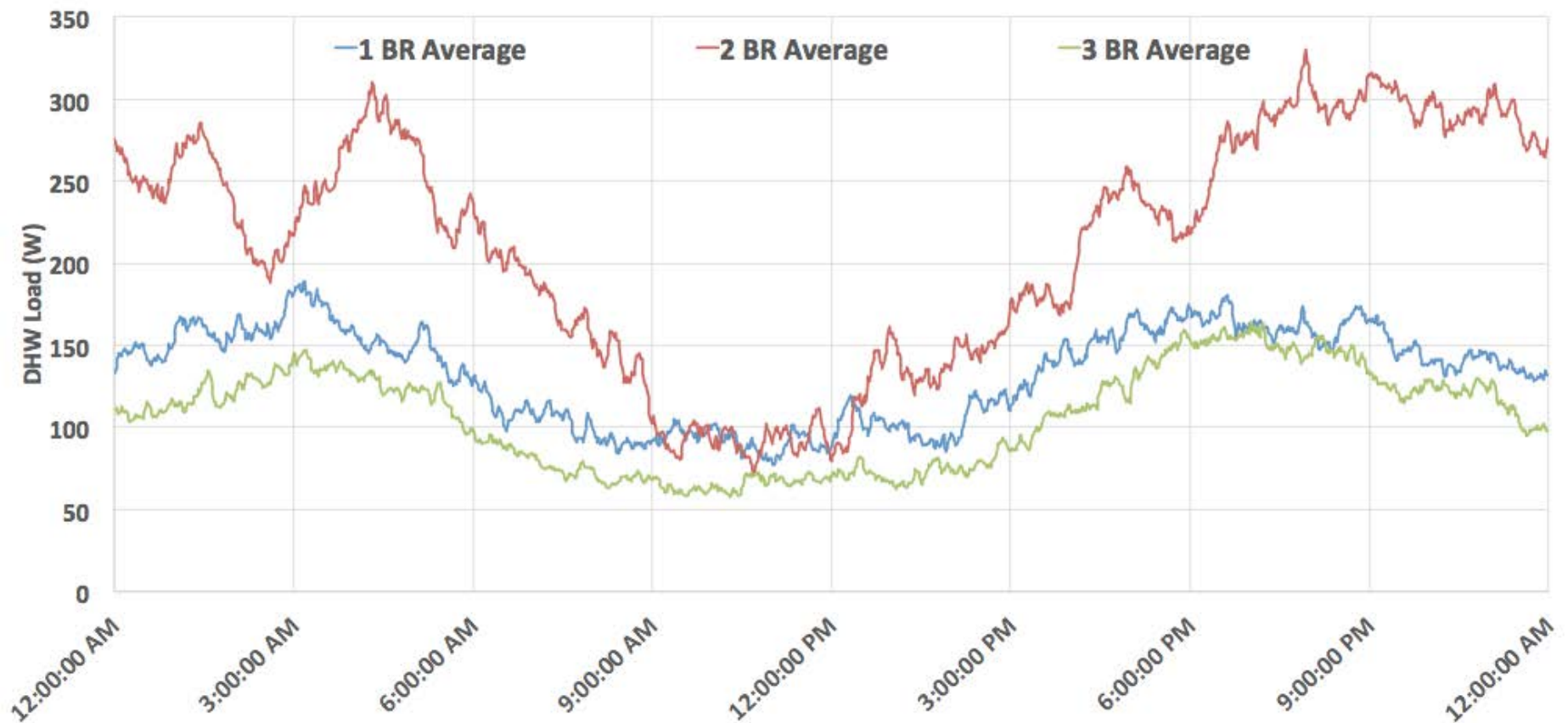
WEEKDAY LOAD SHAPE FOR EACH HOUSEHOLD SIZE

Daily Average Weekday DHW Load Profile for Lakeport, Dixon, and King City Apartments



WEEKEND LOAD SHAPE FOR EACH HOUSEHOLD SIZE

Daily Average Weekend DHW Load Profile for Lakeport, Dixon, and King City Apartments



MORE QUESTIONS?

