Net Emissions Analysis Tool (NEAT) Working Group

Formally the Residential Commercial Appliance Life Cycle Analysis Working Group

Meeting #4
April 18, 2018

South Coast
Air Quality Management District

Summary of Submitted Comments, Responses, and Updates

Scott A. Epstein Ph.D.

Planning, Rule Development, and Area Sources Division

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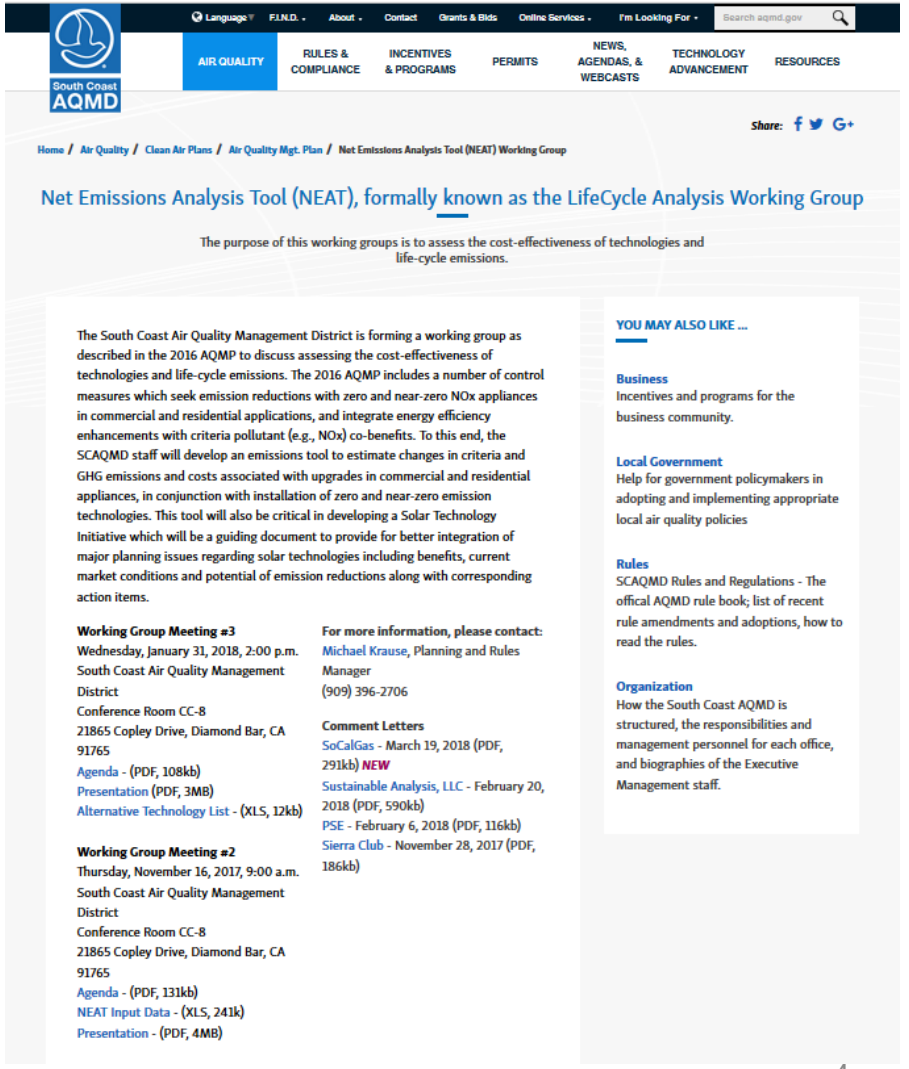
Air Quality Management District

Development Progress

Residential NEAT	Not Yet Started	In Progress	Draft Complete	WG meeting #
Building of tool framework (GUI, file I/O)			X	2
Collection of input data			X	2
Demand segment of tool			X	2, 3
Implementation of distributed solar			X	2
Implementation of distributed battery storage		X		Future
Electric Rate Calculator			X	3
Natural Gas Rate Calculator			X	4
Implementation of net metering			X	3
Solar and battery cost calculator			X	Future
Electric generation emission factors • Advanced EFs: Implementation of HiGRID		X	X	3, 4
Fugitive methane from Natural Gas Use			X	4
Electricity transportation loss			X	Future
Results analysis tools		X		Future

Summary of Submitted Comments

- Four comment letters submitted to date
- Staff appreciates the thoughtful feedback during the meetings and in the comment letters
- All comment letters posted to the NEAT website
  - http://www.aqmd.gov/home/air-quality/clean-air-plans/air-quality-mgt-plan/neat-working-group



Summary of Submitted Comments (continued)

Look into using WattTime to estimate marginal emissions

- *Currently pursuing a contract with APEP at UCI to integrate HiGRID into NEAT*
- *HiGRID will capture marginal emissions changes*

Add Gas Heat-Pump Water Heaters to alternative technology list

- *This technology was added to NEAT*

Add Micro Combined Heat and Power and Residential-Scale Fuel Cells to alternative technology list

- *These technologies will require a significant amount of development time to include in NEAT*
- *If technology becomes more widely implemented, inclusion will be considered for future updates. May require contracting outside experts to model fuel cells.*

Summary of Submitted Comments (continued)

Consider the costs of additional barriers to appliance retrofits

- *Barriers to appliance retrofits such as household infrastructure upgrades may pose additional costs*
- *Costs can be considered on a case-by-case basis and can be implemented in the "installation cost" field in the Demand module*
- *Modified the embedded documentation describing "Installation Cost"*

  "Install Cost: The average cost of installing the appliance in US dollars. This should include the cost of labor along with other major modifications that may be needed for installation such as wiring, plumbing, electric or gas upgrades, and/or asbestos removal. The NEAT software amortizes this installation cost based on the lifetime specified by the user."

Summary of Submitted Comments (continued)

Incorporate California Alternative Rates for Energy (CARE) into NEAT

- *NEAT was modified to include low income rates for every gas and electric utility with a low income rate option (utilities with fixed low income benefits were not treated as the low income benefit is the same in the base-case and scenario-case)*
- *We analyzed IPUMS harmonized American Community Survey data from 2016 to determine the percentage of homes in each gas/electric utility combination, Climate Zone, and housing category that are eligible based on the specific low income rate qualification criteria*
- *Eligibility percentages are modifiable in the Electric Rate and Gas Rate Selection tools*

Summary of Submitted Comments (continued)

Electricity emission factor options should reflect realistic or achievable scenarios

HOUSEHOLD

- Option to install rooftop PV
- Option to install residential battery

(costs and changes in electricity demand calculated)

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GRID

<u>Increased Electricity Use</u>

- Lower limit on Emissions
  - Ø All additional power from centralized PV
- Best-guess Emissions (default option)
  - Ø All additional power calculated with marginal Emissions Factor Analysis from CEMS data
- Upper limit on Emissions
  - Ø All additional power from peaker plants
- Rigorous Emissions Analysis
  - Ø Additional emissions calculated with HiGRID

<u>Reduced Electricity Use</u>

- Best-guess Emissions (default option)
  - Ø Emissions reductions calculated with marginal Emissions Factor Analysis from CEMS data
- Lower limit on Emissions
  - Ø Reductions arise from curtailing peaker plants
- Rigorous Emissions Analysis
  - Ø Additional emissions calculated with HiGRID

Fugitive Methane Emissions from Residential and Electric Generation Natural Gas Usage

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Fugitive Methane Emissions Considerations

- Methane emissions occur throughout lifecycle and must be considered for natural gas appliance usage and natural gas fired power generation
- Not aware of any estimates of fugitive methane resulting from marginal changes in natural gas use
- Until marginal studies/inventories are available, plan to use leakage rates based on average usage

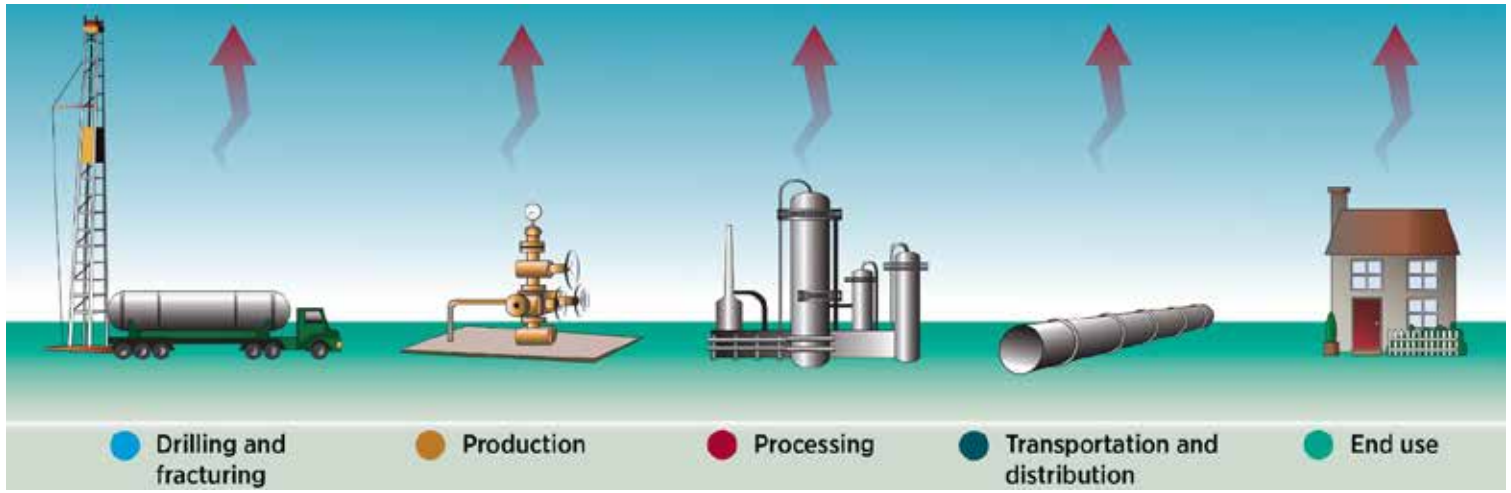

Image from: Stanford University School of Earth Sciences

Fugitive Methane Emissions Considerations

- Fugitive methane leak rates are modifiable parameters in NEAT
- NEAT separates into production, processing, transmission, distribution, and end use
- Four estimates are provided, but not presented as a comprehensive list; other recommendations are welcome.
- To date, we've reached out to CEC, CARB, Argonne National Lab (GREET), Environmental Defense Fund, and EPA for advice
- **What default numbers should NEAT use? What values should be options in NEAT? *Actual choice for policymaking should be addressed in other forums.***

Fugitive Natural Gas Leak Rates

	Title	Leak Rate	Source	Considerations
A	EPA GhG Emissions Inventory	1.27% (95% CI 1.08 to 1.48%)	2018 Draft Inventory of US GhG Emissions and Sinks: 1990-2016	• Bottom-up inventory updated every year • New inventory includes estimate from abandoned wells • Evidence that super-emitters are underestimated • Active stakeholder input in development of inventory • Behind-the-meter leakage not included • Used in CA-GREET & CA-LCFS
B	The 16 Study Series	1.7% *(95% CI 1.3 to 2.2%)*	Collaborative effort with 100 institutions spearheaded by Environmental Defense Fund. Synthesis Report Published in Littlefield et al. 2017*	• Inventory that includes site-level unassigned emissions • Top-down, bottom-up, & mobile measurement techniques • Summary of studies and references https://www.edf.org/sites/default/files/methane_studies_fact_sheet.pdf
C	Sierra Club comments	3.30%	EPA GhG emissions inventory, Marchese et al. 2015, Zimmerle et al. 2015, Lamb et al. 2015, conversations with experts at EDF	• Well-to-building leakage rate • Includes super-emitters • Does not include future voluntary reduction goals or higher leakage rates from growth in unconventional drilling
D	Sustainable Analysis, LLC comments	5.1%	13 Peer-reviewed publications and LBNL report	• Integrates studies of production-zone leakage, CA tower measurements, and residential leakage estimates • Weighted average of study results • California Specific

Comments on Fugitive Natural Gas

1. Allow user to use either a 20-year or 100 year global warming potential (GWP) value
2. Use a 20-year GWP

- *A 20-year GWP more accurately reflects the timeframe of climate change effects*
- *Atmospheric lifespan of methane is 12 years*
- *Both options are available in the tool, but 20-year timeframe is set as the default*

Comments on Fugitive Natural Gas (continued)

Methodology recommendations for considering methane leakage

- Consider fugitive methane along all stages of the lifecycle of natural gas: exploration, production, processing, storage, transmission, distribution, end use
  - *We consider fugitive methane from all stages for both in-home use and centralized energy generation*

- CEC report "A survey of Methane Emissions from the California Natural Gas System" by Fischer et al. 2017 contains in-home measurements of methane leakage
  - *This is a great reference for in-home measurements. Evaluated 10 homes is SF Bay Area. Current CEC project to measure 50-75 homes across all CA. Other in-home leak rate studies would be appreciated*

Comments on Fugitive Natural Gas (continued)

Methodology recommendations for considering methane leakage

- Bottom-up emission inventories such as the EPA Greenhouse Gas Inventory report lower emissions than in top-down studies
  - *We are aware of these discrepancies and will be mentioned in the documentation embedded within the tool.*
- Reference the broader body of scientific literature rather than relying on inventories alone when calculating methane leakage estimates
  - *Methane leakage rates are a modifiable parameter in NEAT, allowing the user to input results from specific studies if desired.*
- Use EPA Greenhouse Gas Inventory to be consistent with reporting at national and international levels

Future Inventory Development

- Yearly Improvements in EPA GHG Inventory
  - Behind-the-meter emissions incorporation is planned
- CARB is working with Stanford to update California specific methane leakage rate as part of the Oil Production Greenhouse Gas Emissions Estimator
  - Anticipated release in 2019
- Any other upcoming references we should be aware of?

Calculation of Natural Gas Rates and the Embedded Natural Gas Rate Structure Editor Tool

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Natural Gas Rate Structures

- Many gas utilities within the Basin
- Many different rate structures for each utility
- Analyzed census data and utility jurisdiction data to determine number of households in each utility, climate zone, category
- Analyzed IPUMS harmonized American Community Survey data to determine the percentage of homes in each gas/electric utility combination, Climate Zone, and housing category that are eligible based on the specific low income rate qualification criteria

http://www.energy.ca.gov/maps/serviceareas/natural_gas_service_areas.pdf

Natural Gas Rate Structure

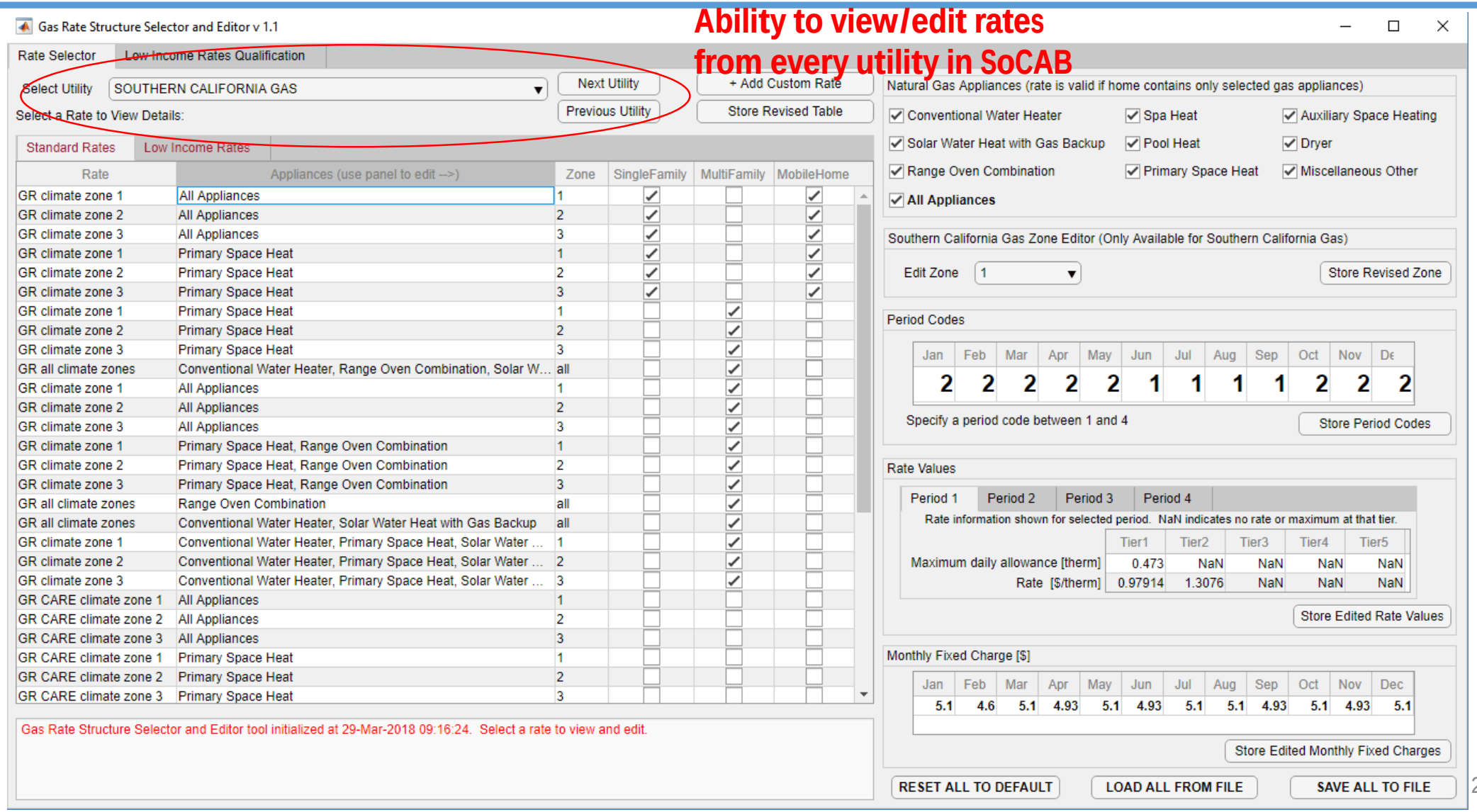
Number of Households for Climate Zone 9

	CZ = 9	CZ = 9	CZ = 9	All CZ
	SingleFamily	MultiFamily	MobileHome	TOTAL
City of Vernon Gas System	1012	958	11	12960
Long Beach Gas & Oil	0	0	0	186019
Southern California Gas Zone 1	991898	1002946	26552	5249715
Southwest Gas Corp.	0	0	0	23660
Southern California Gas Zone 2	0	0	0	40024
Southern California Gas Zone 3	0	0	0	34442

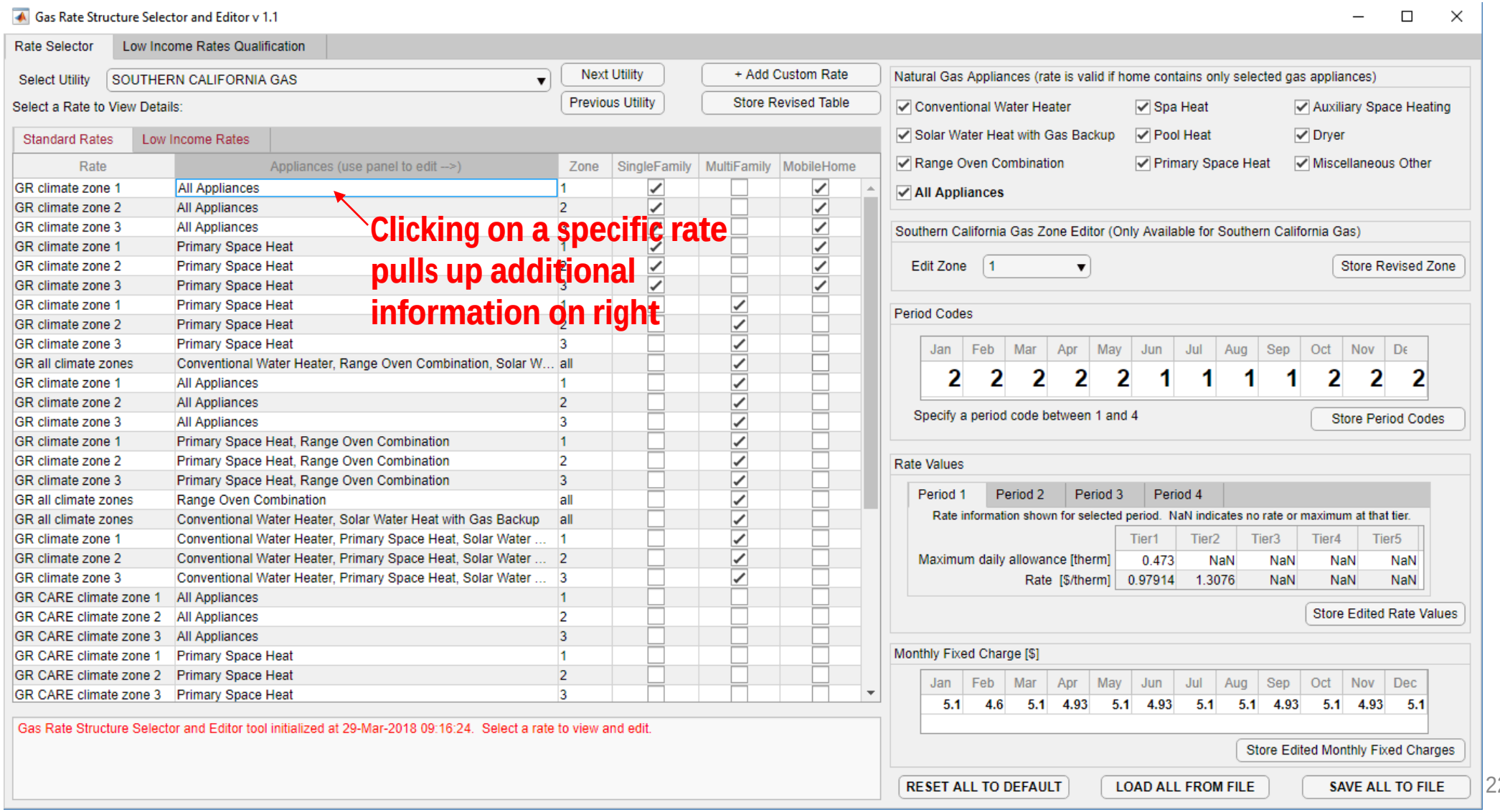
Natural Gas Rate Structure Editor Tool

- Separate tool linked from NEAT
- Allows “advanced” users to graphically view and edit natural gas rates
- Tool populated with default values but everything is editable
  - Choose rate to use for single family, multi family, mobile homes
  - Choose low income rate to use for single family, multi family, mobile homes
  - Modify fraction of homes in each gas/electric utility combination eligible for low income rates
- Utility rates obtained from each individual utility

Natural Gas Rate Structure Editor Tool



Natural Gas Rate Structure Editor Tool



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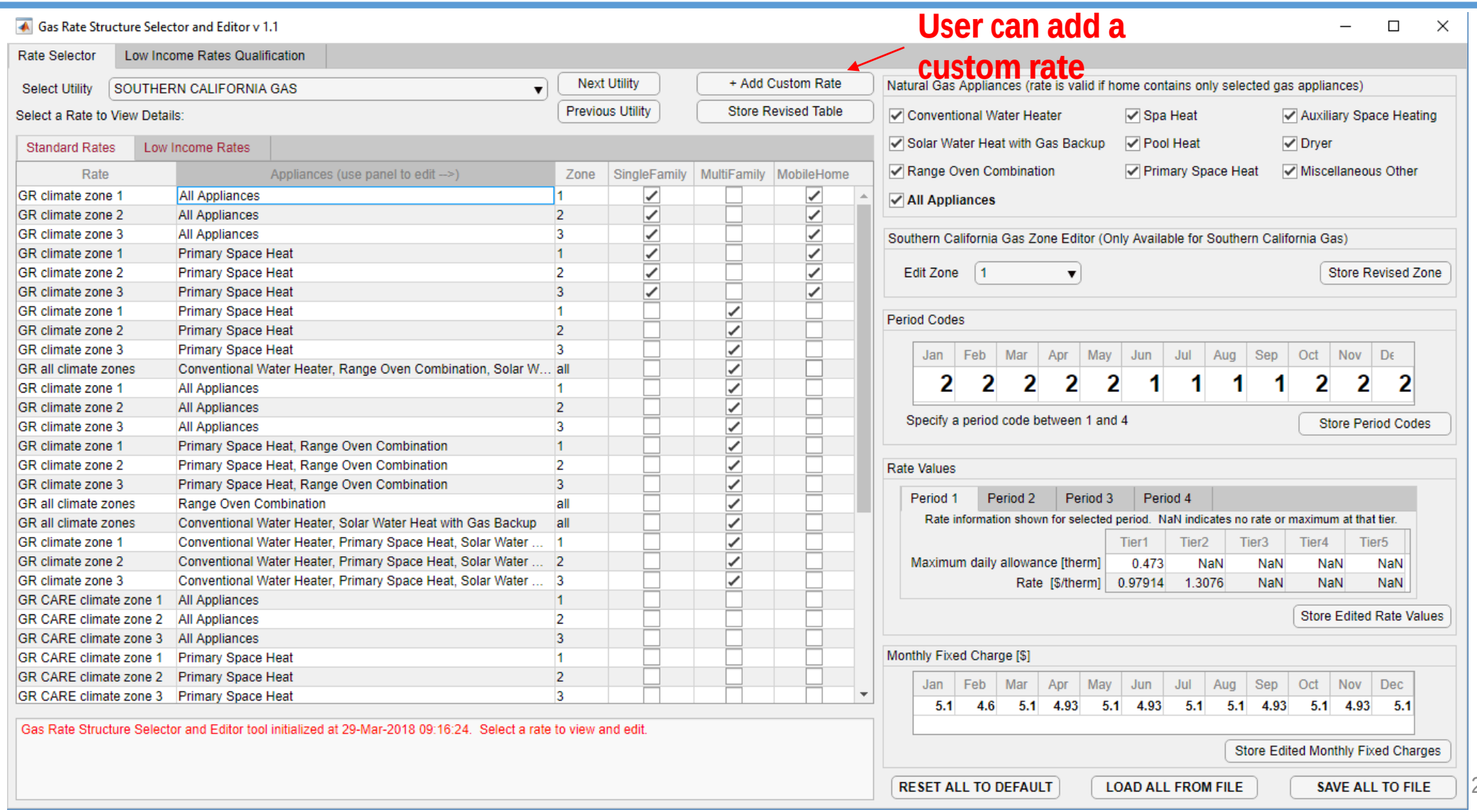

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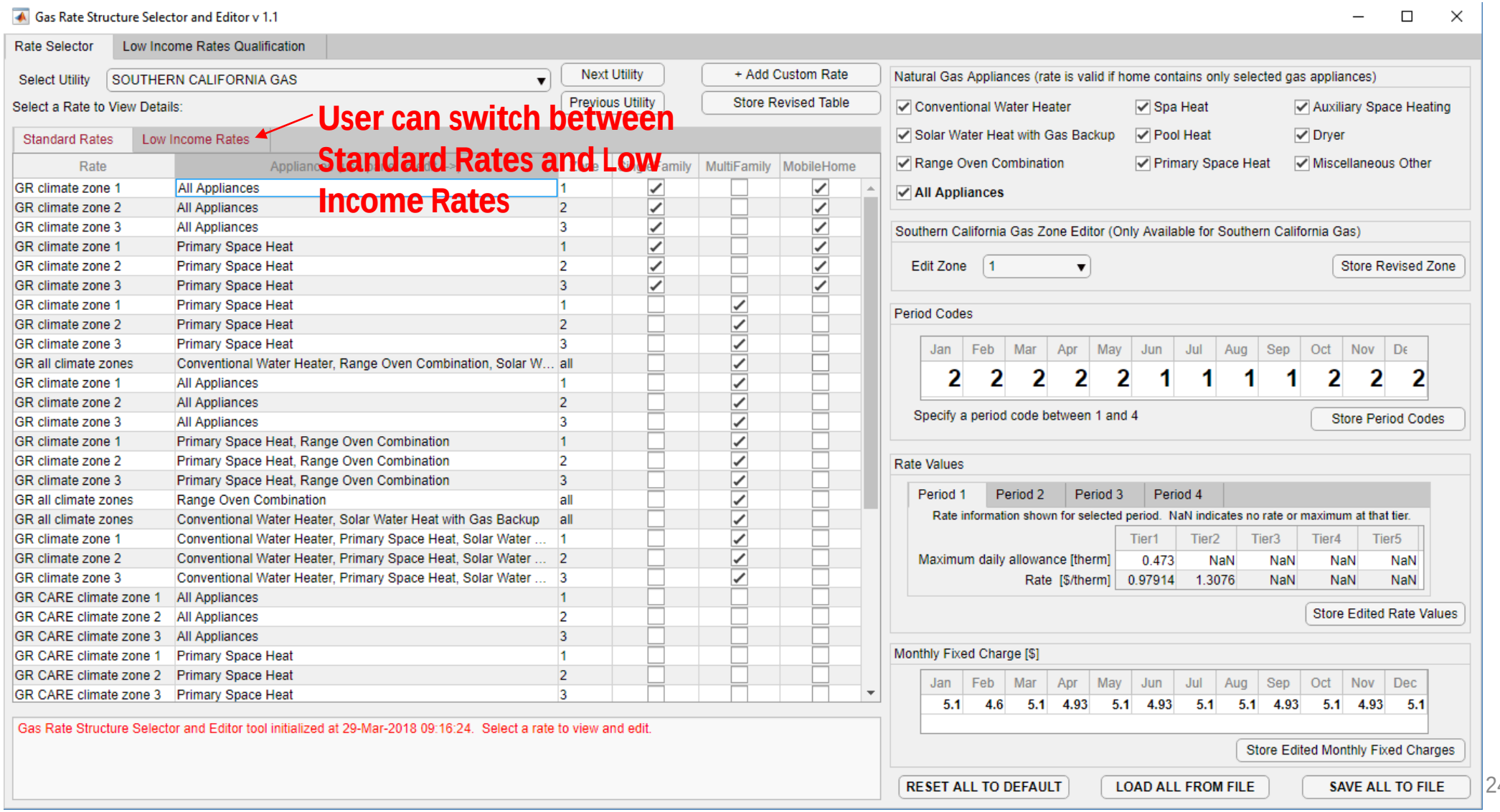

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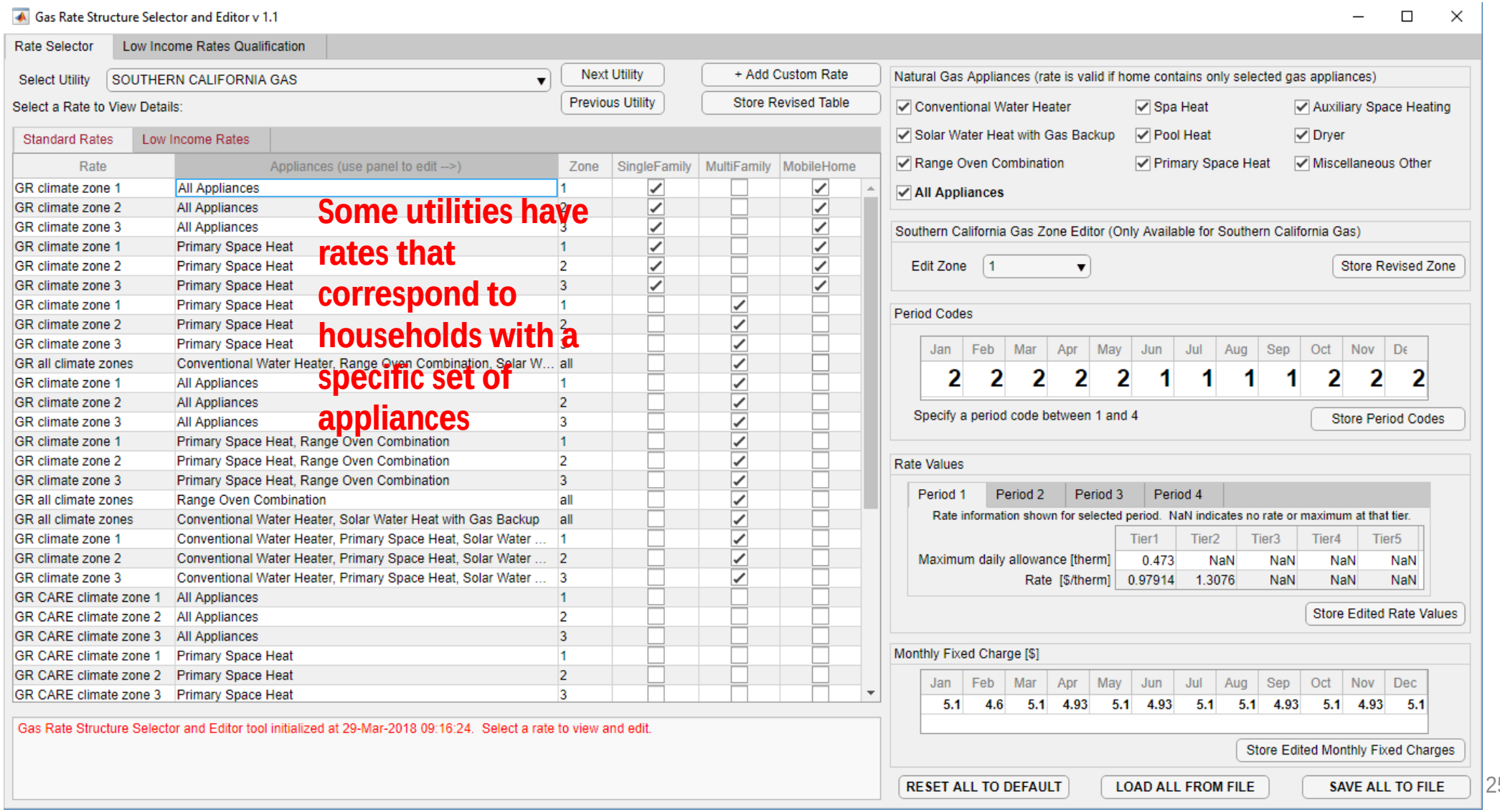

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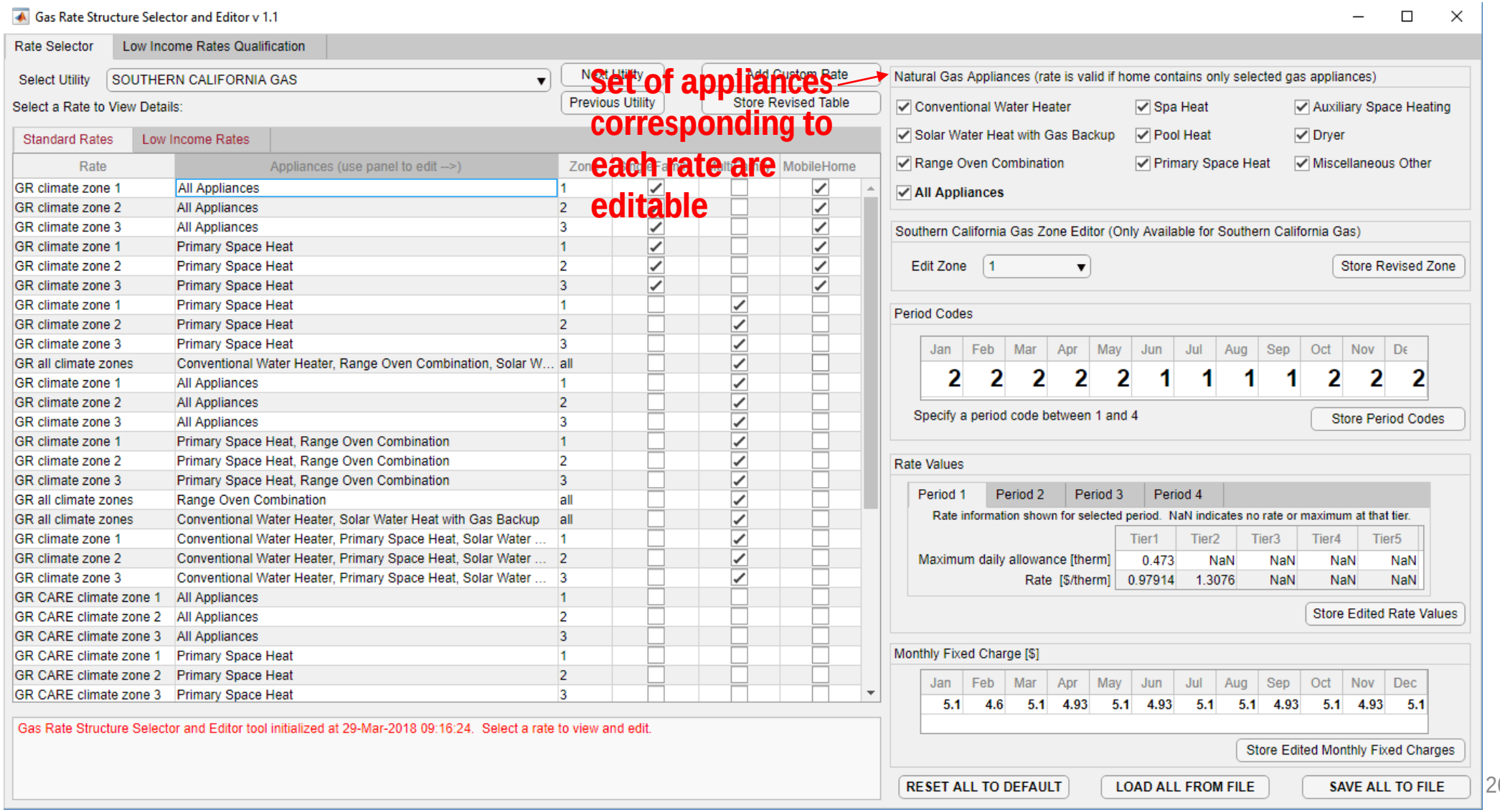

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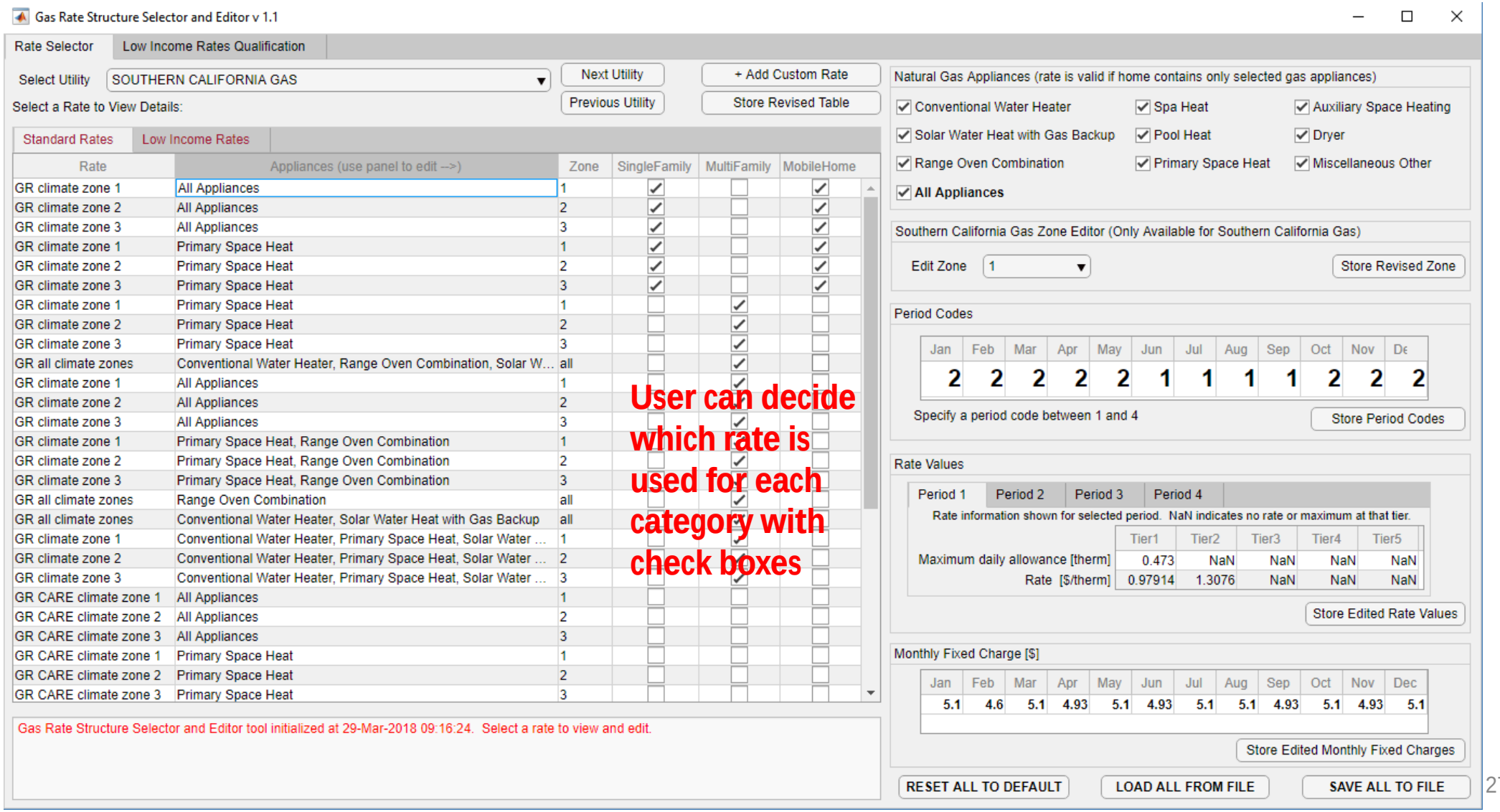

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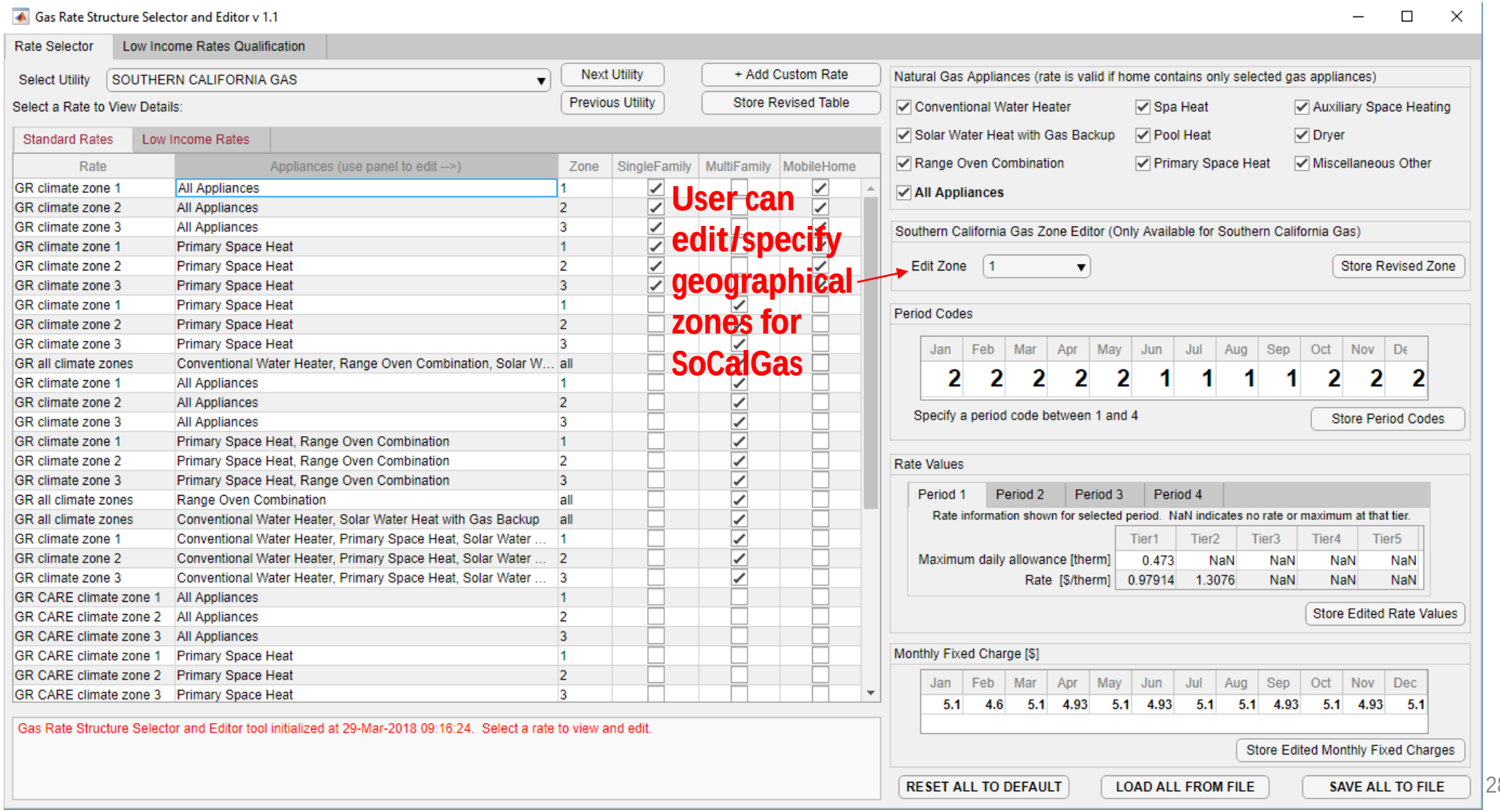

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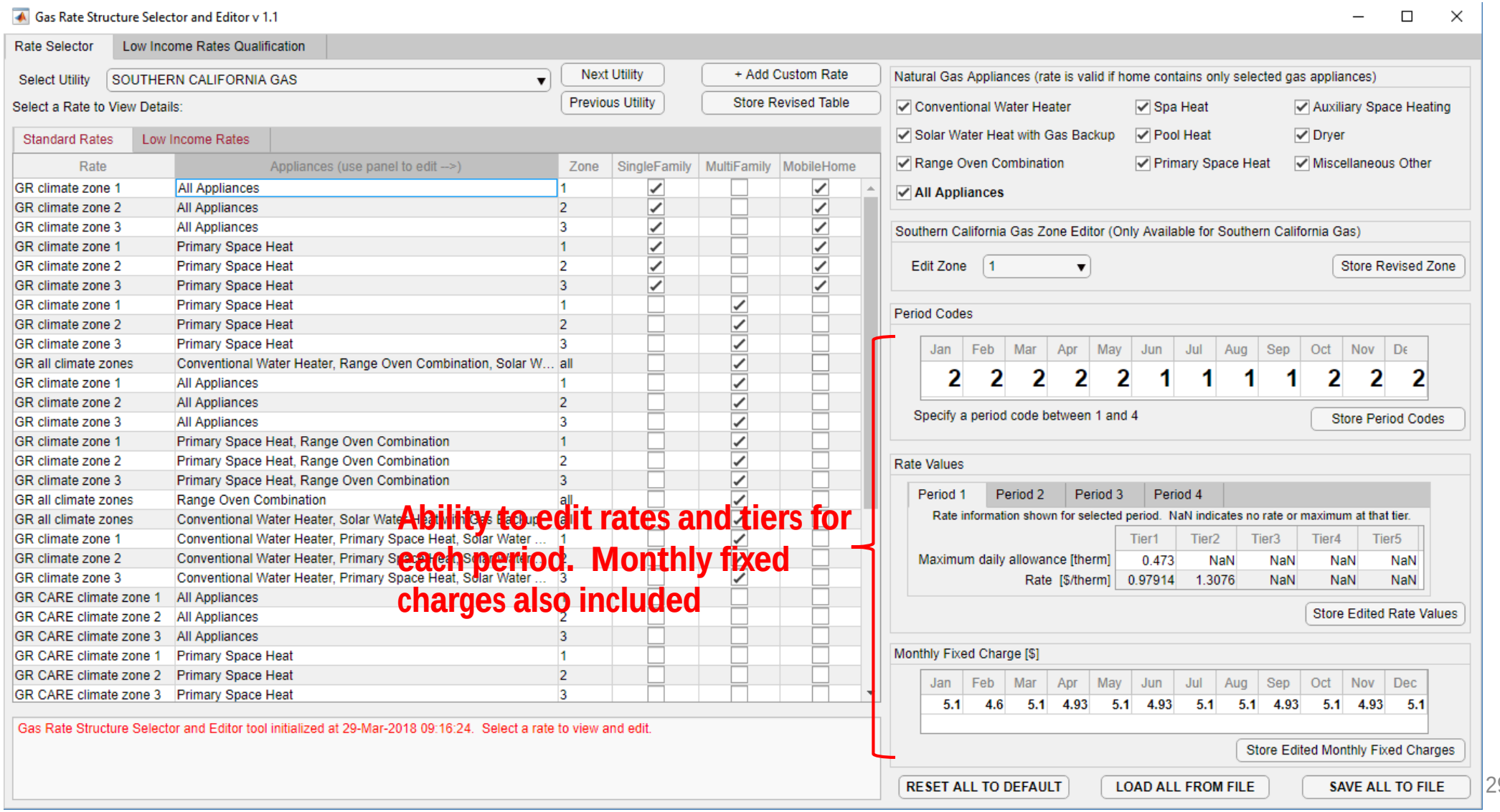

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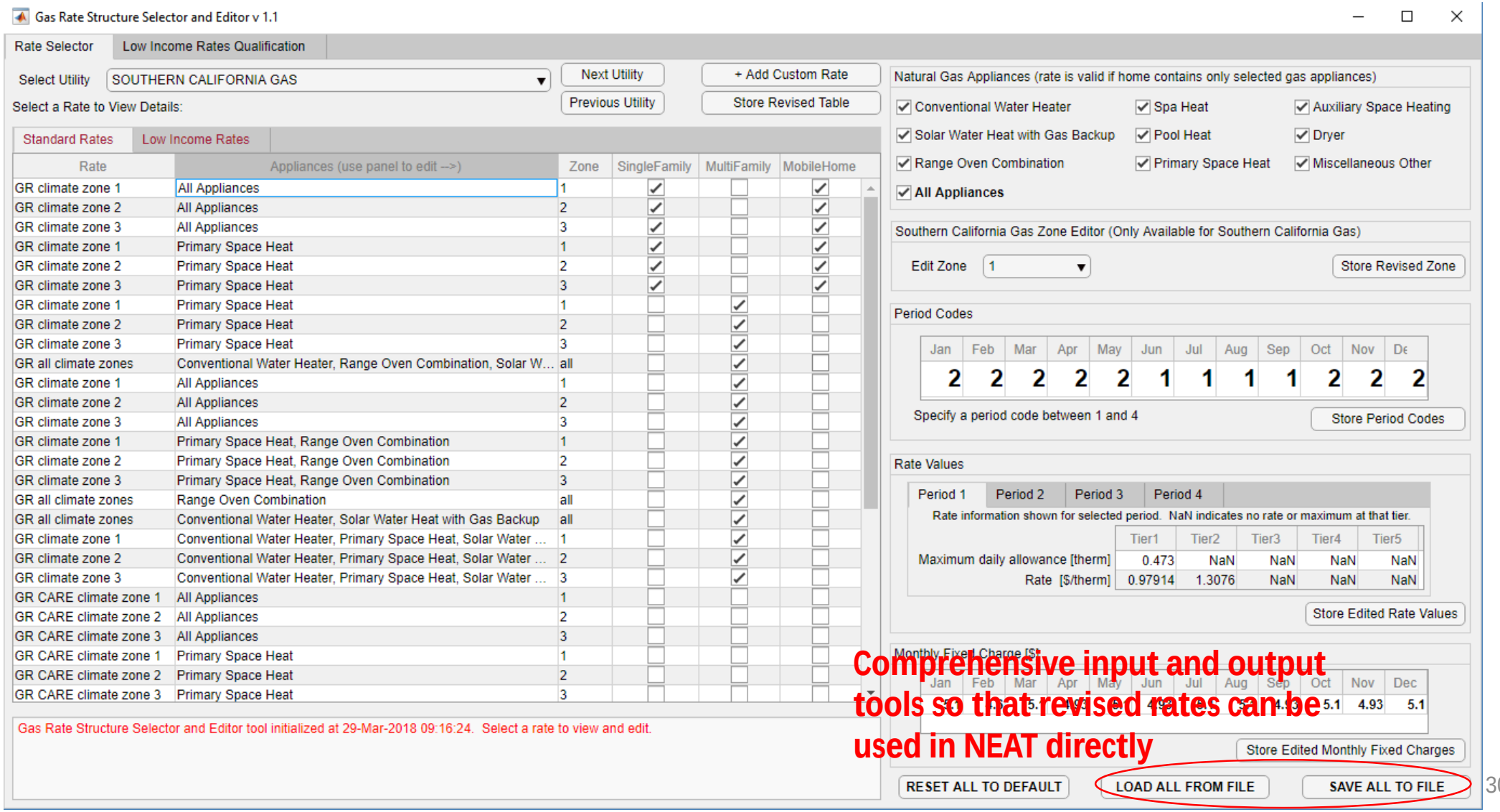
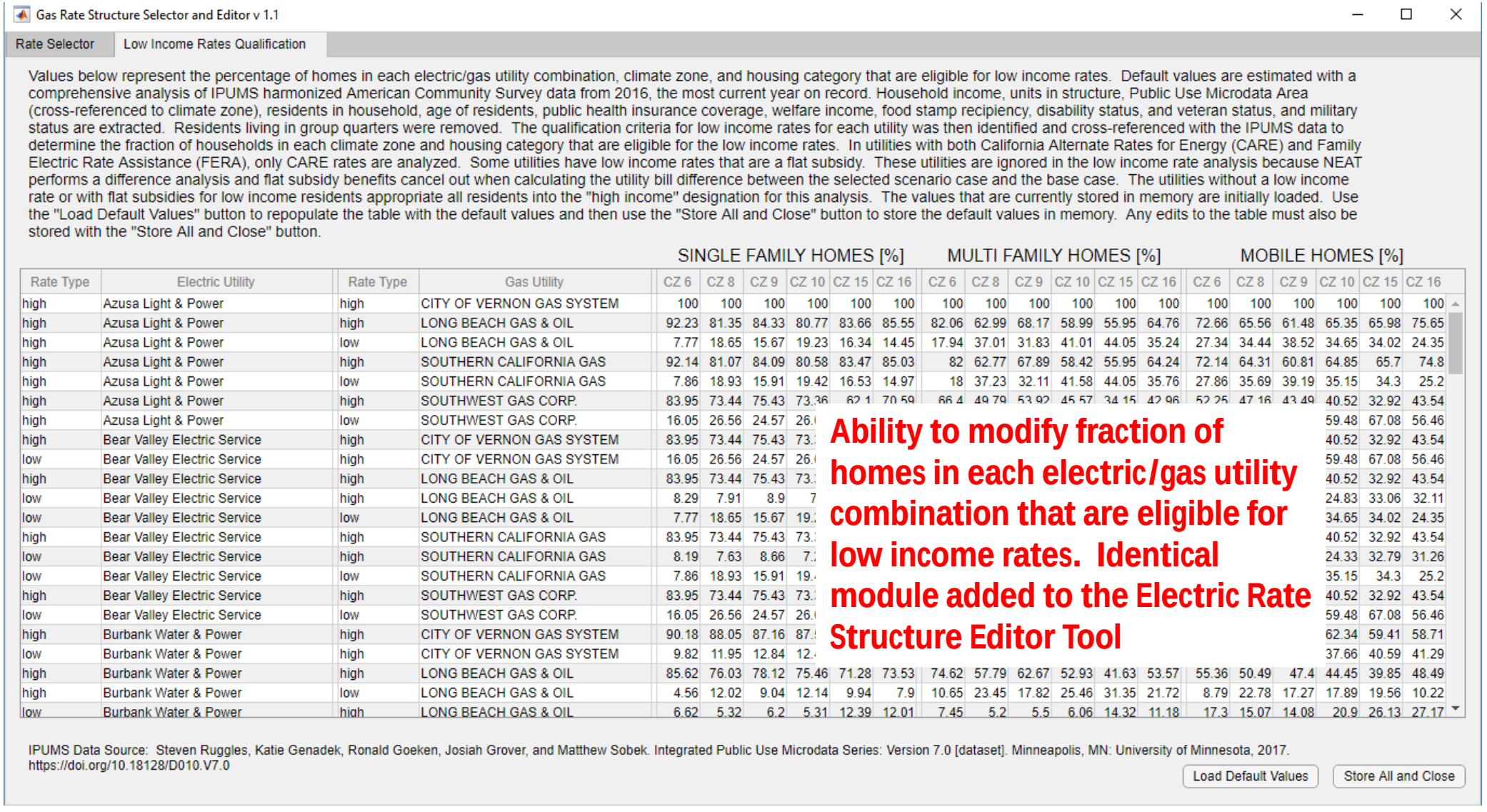


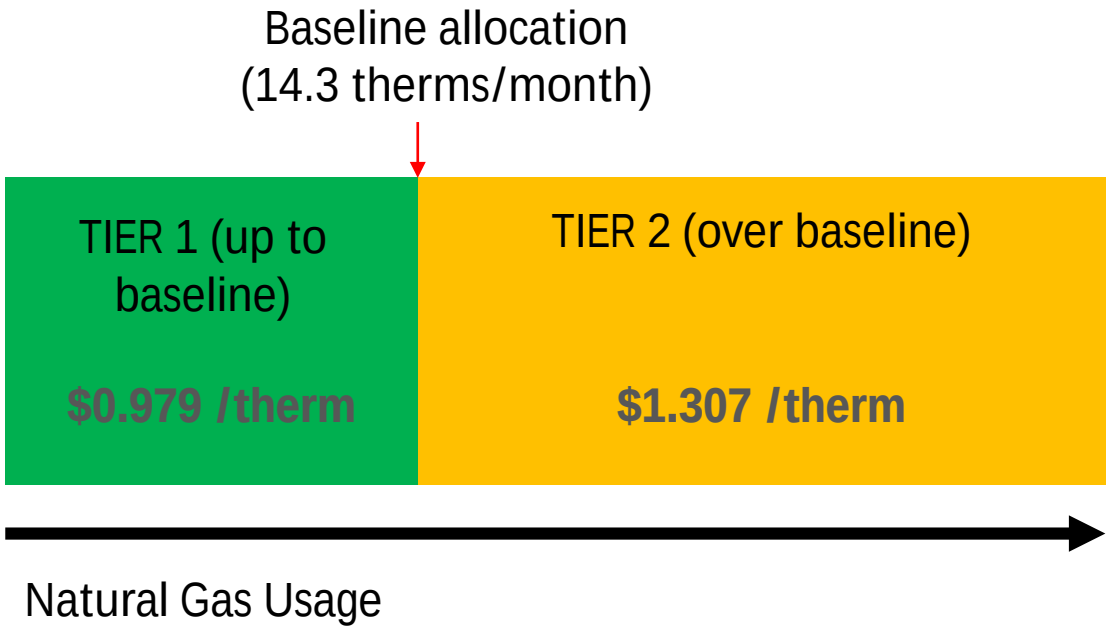
Comprehensive input and output tools so that revised rates can be used in NEAT directly

Natural Gas Rate Structure Editor Tool



Calculation of Natural Gas Rates

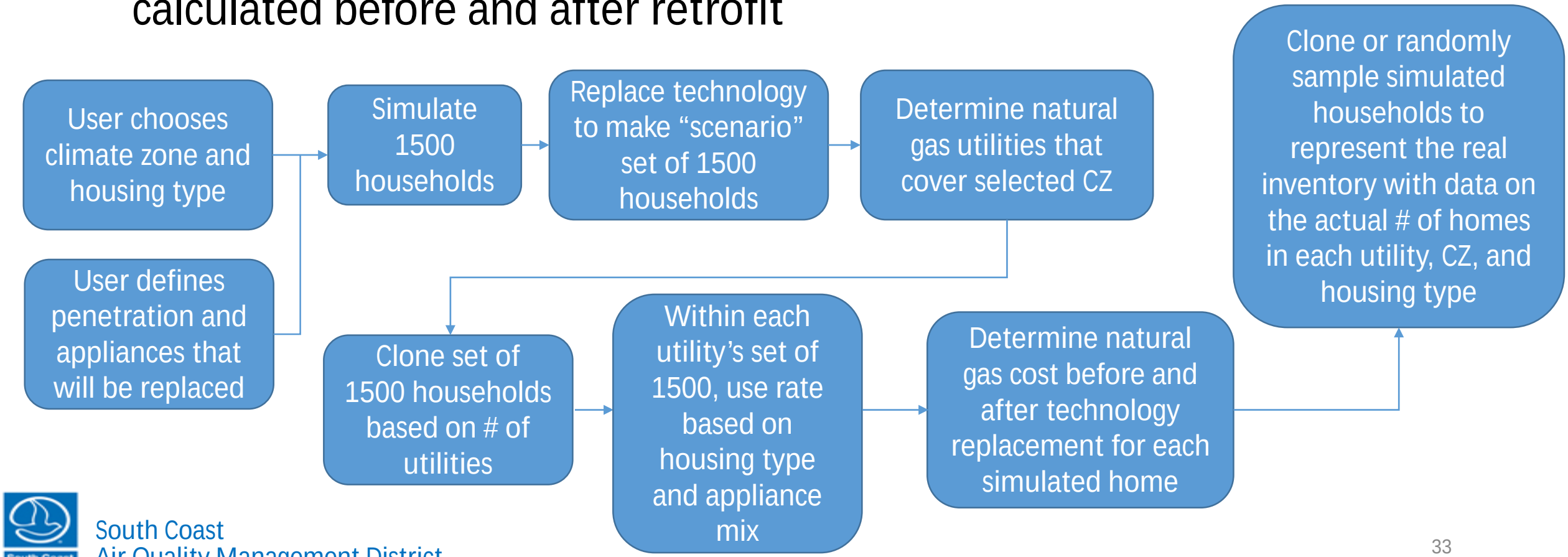
Each period code (assigned monthly) has a set of tiers with a Maximum monthly usage and a corresponding rate:



- Monthly usage is allocated between the tiers and multiplied by the rate of each tier to generate a monthly variable natural gas charge
- Monthly fixed charges are added

Calculation of Natural Gas Rates

- For each of the 1500 simulated homes, natural gas costs must be calculated before and after retrofit



Updates to Electricity Generation Emissions

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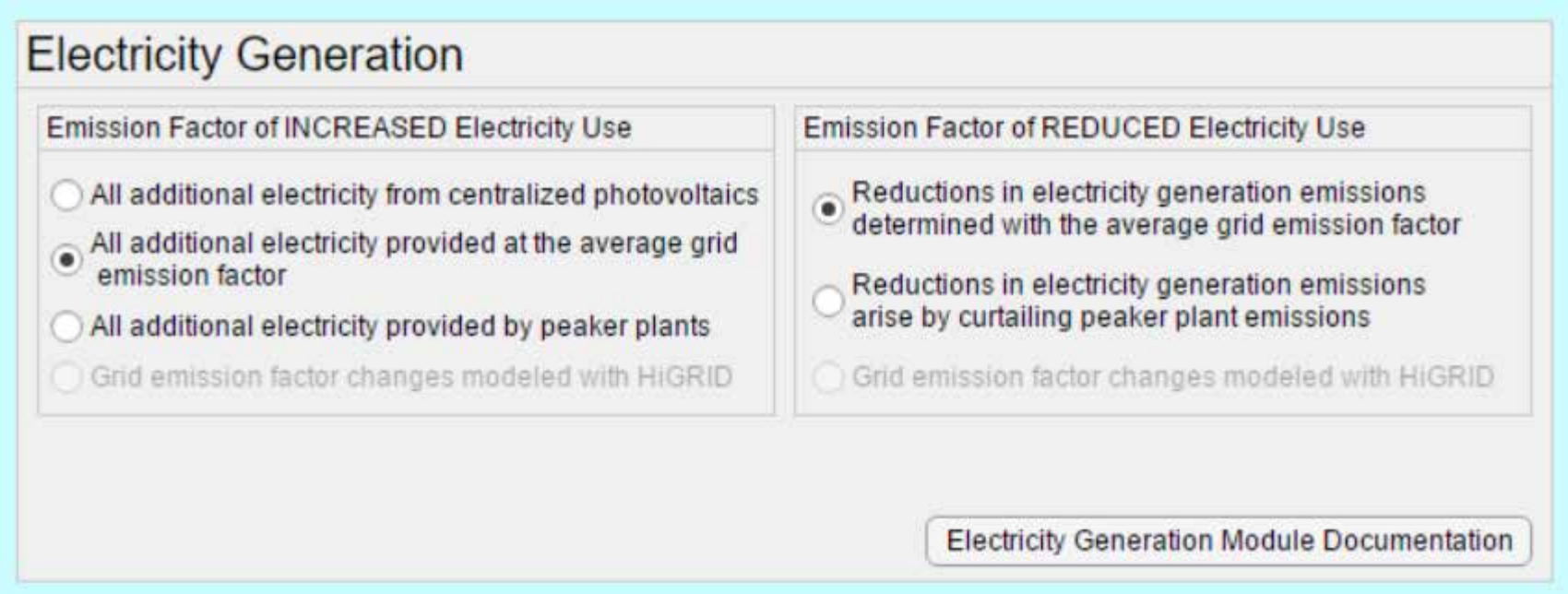
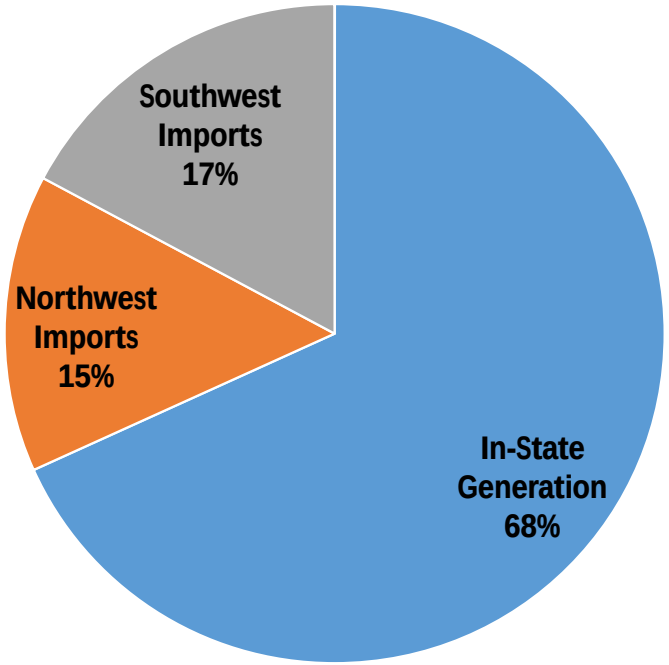
Electricity Generation Emission Factor Options

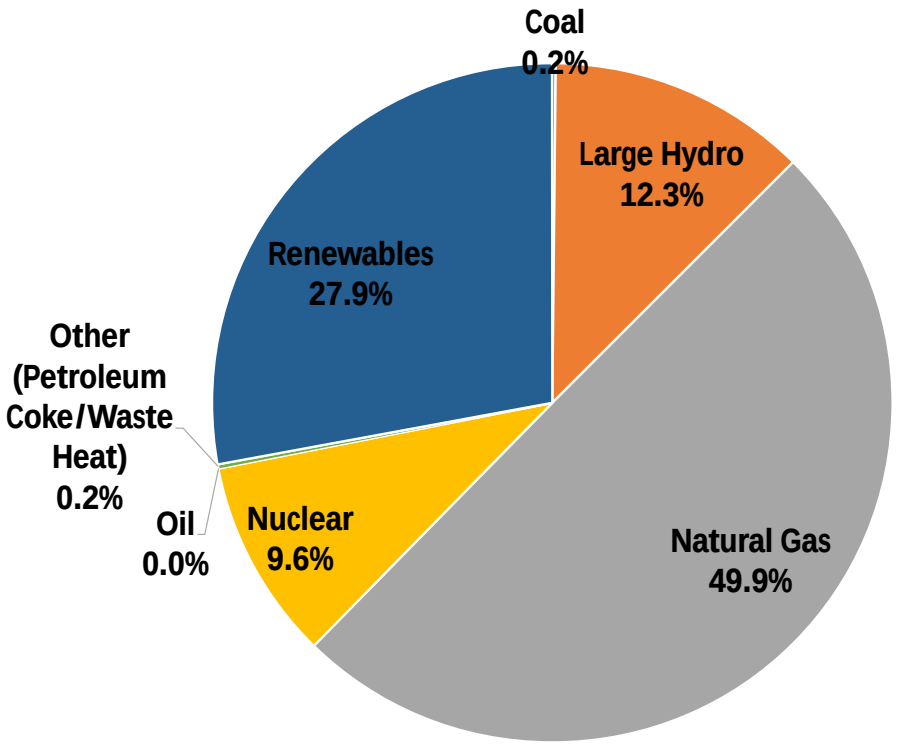


Electricity Generation in California

Imports of Electricity

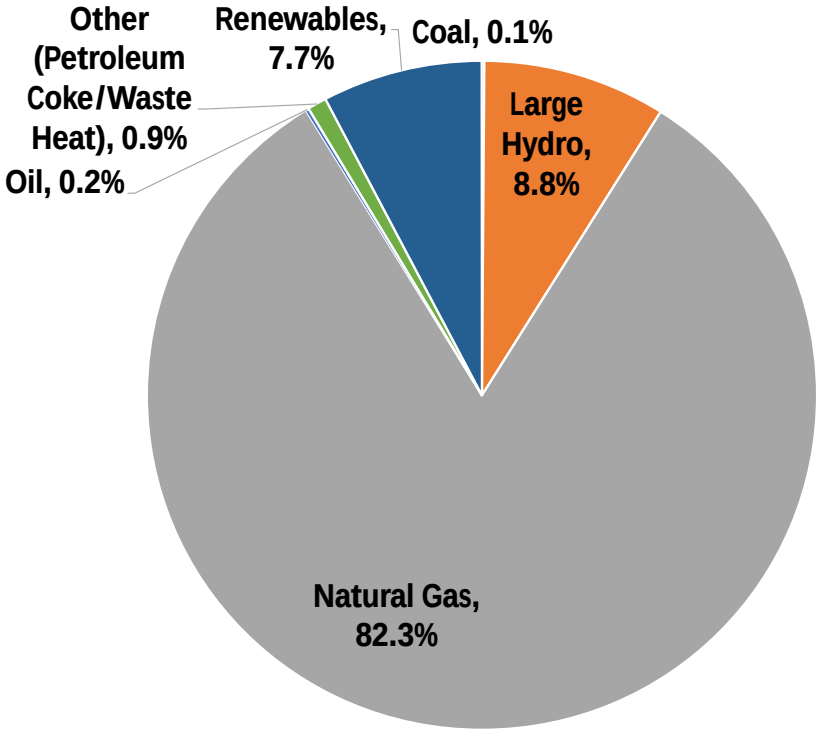


In-state Electricity Generation



From CEC, 2016 Total System Electric Generation

Electricity Generation within SCAQMD



From eGRID 2014

Emissions from Average Grid

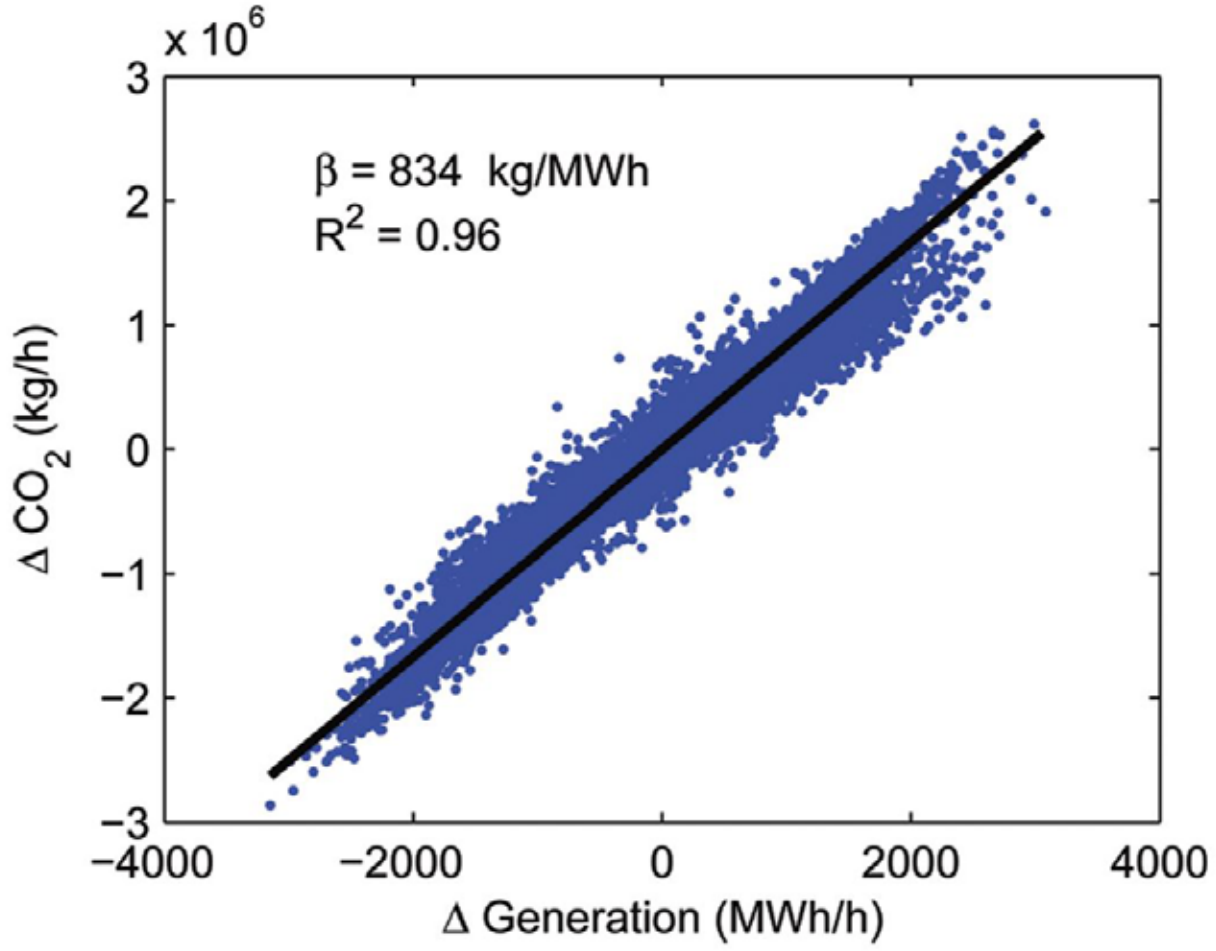
- We assume changes in electricity will be met by the marginal grid
- For California, we assume marginal electricity is generated from dispatchable units, which are NG units
- Hourly load and emissions are obtained from the Continuous Emissions Monitoring system (Air Markets Program Data, https://ampd.epa.gov/ampd/)

Power Plant Data Availability

- Data availability for hourly emissions and throughput data:
  - Used hourly data from 2011 to 2017
  - NO_X and CO_2 emissions are used to calculate marginal emissions
  - Hourly marginal values are calculated for four representative days:
    - Winter weekday, winter weekend day, summer weekday and summer weekend day

Methodology for Marginal Emissions

Methodology based on peer-reviewed work (Siler-Evans et al., 2012)



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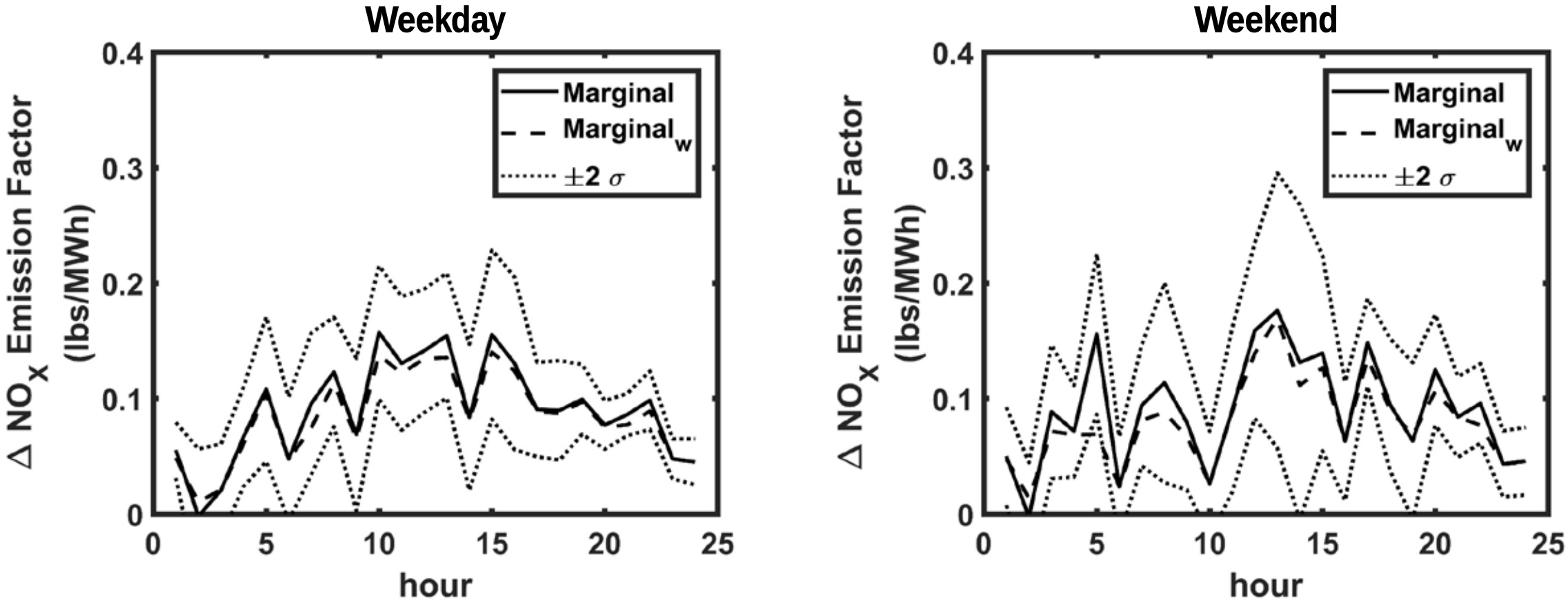
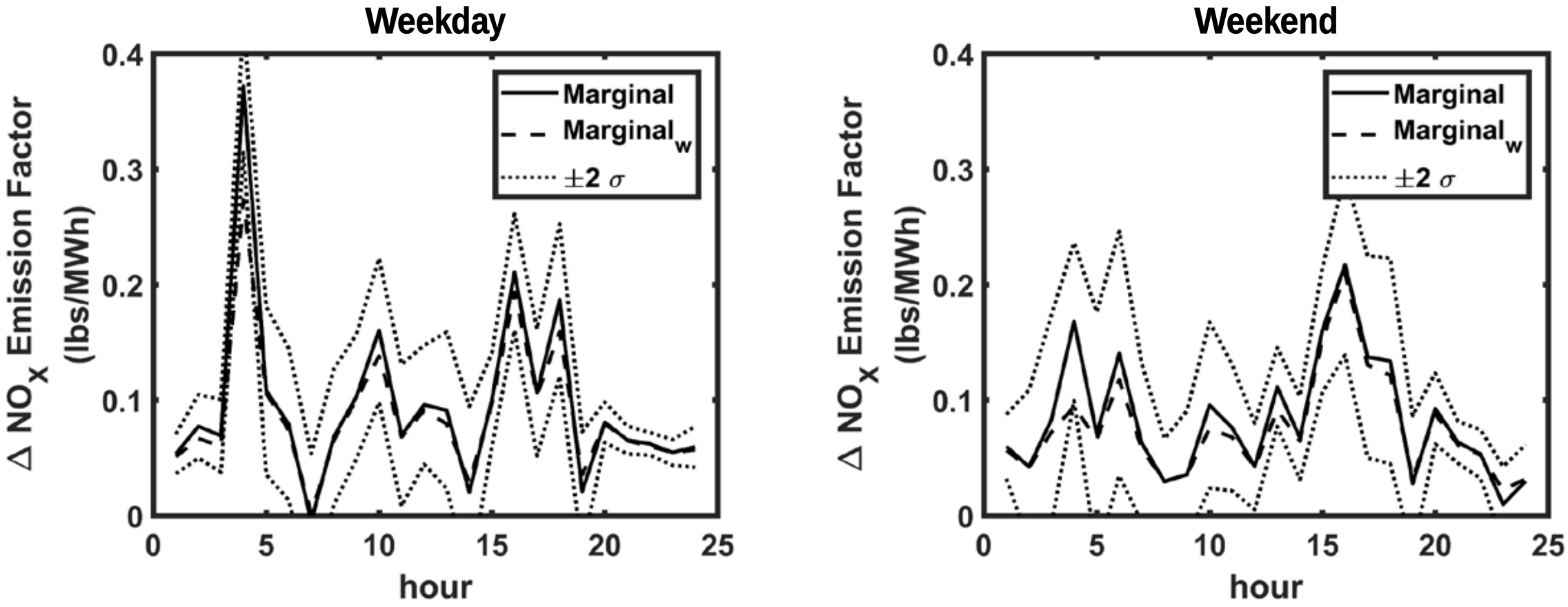
Summer Marginal Emission Factors for NO_X



For NOX, we calculated marginal emissions using a linear regression (Marginal) and a weighted linear regression ($Marginal_w$) to trim out outliers

Winter Marginal Emission Factors for NO_X



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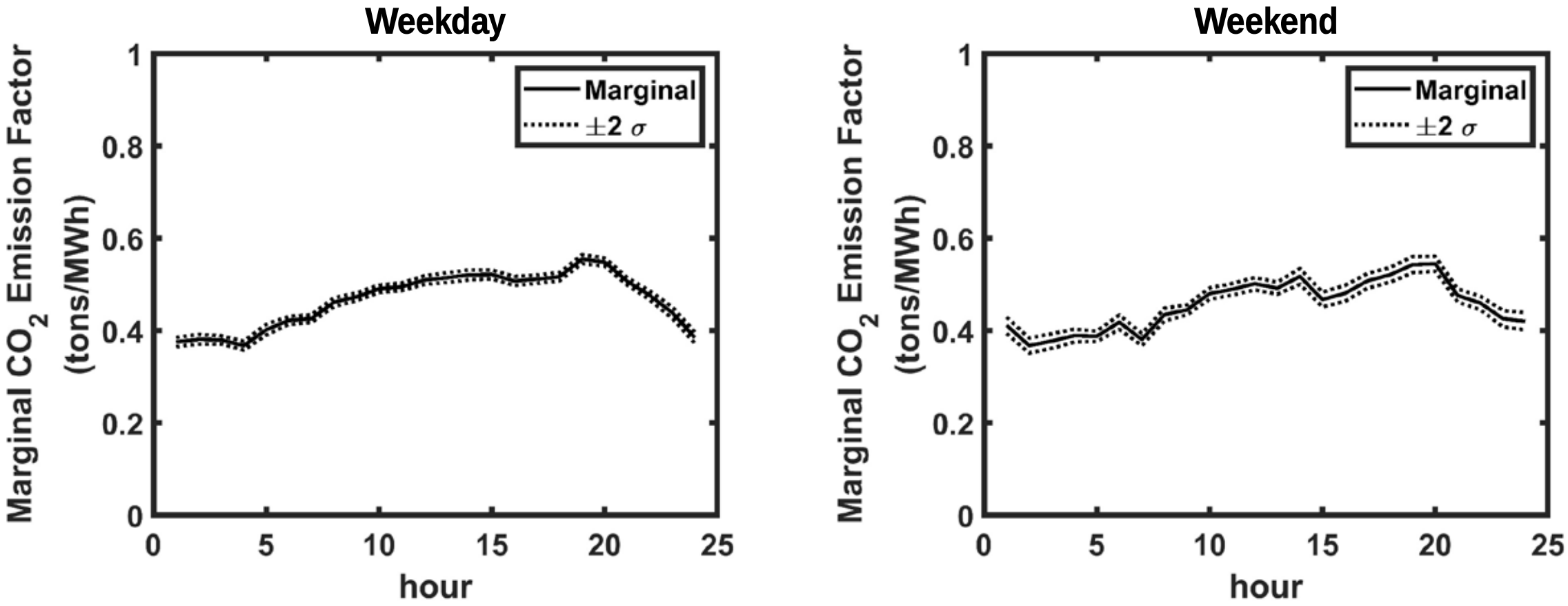
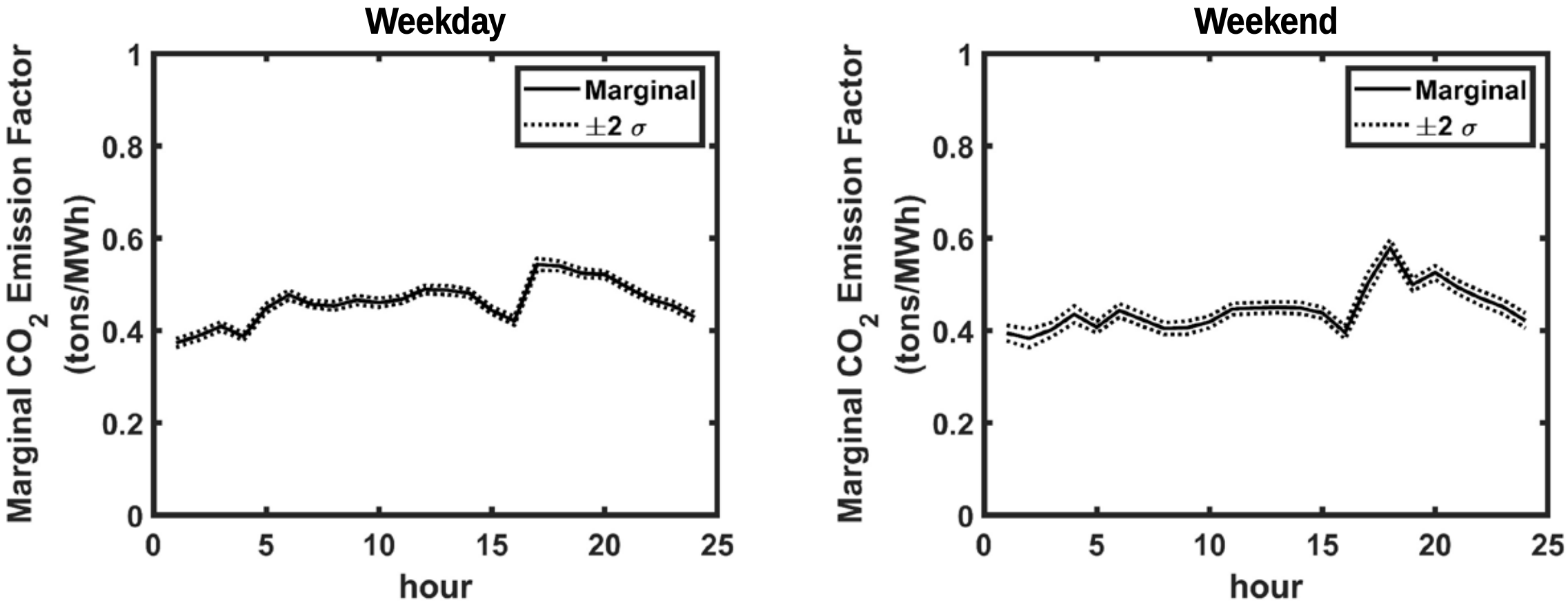
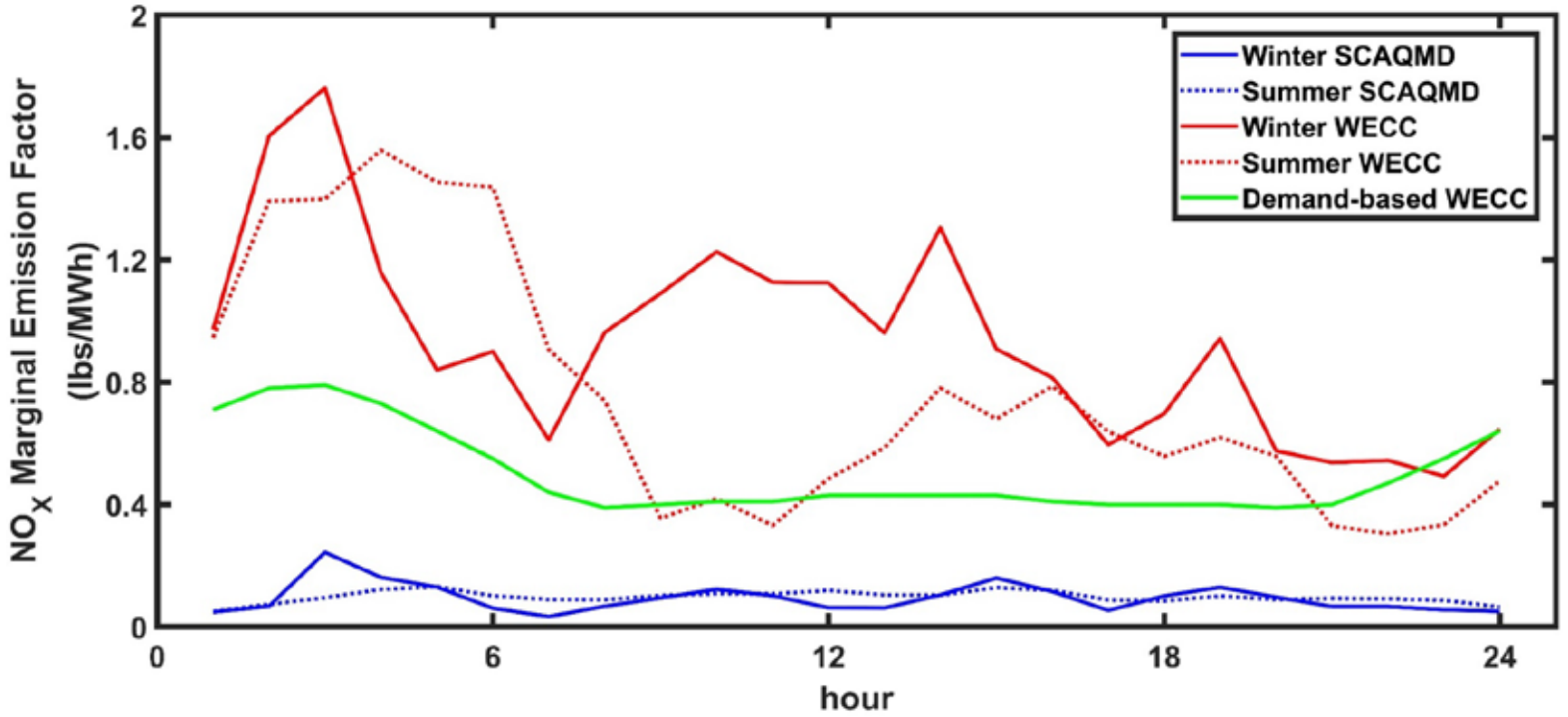
Summer Marginal Emission Factors for CO_2



Winter Marginal Emission Factors for CO_2



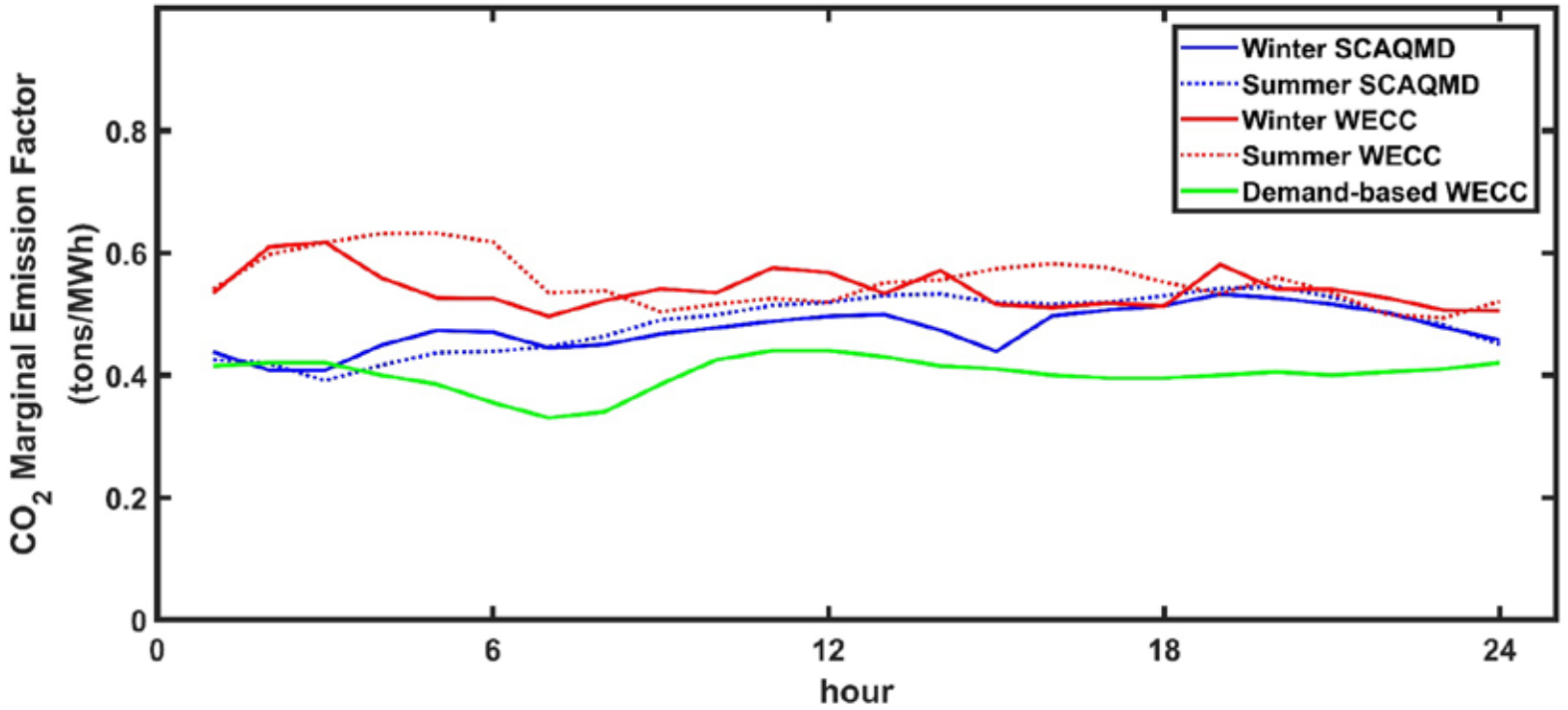
Comparison of Marginal EFs with Other Studies



Other analyses found higher emission values for the grid mix, because they considered the entire western interconnect (WECC), which includes coal generation and less restrictive emission limits:

- Siler-Evans et al., (2012) calculated EF based on hourly power generation in WECC
- Watt-time calculated EF based on hourly demand in WECC, which implicitly includes renewables

Comparison of Marginal EFs with Other Studies

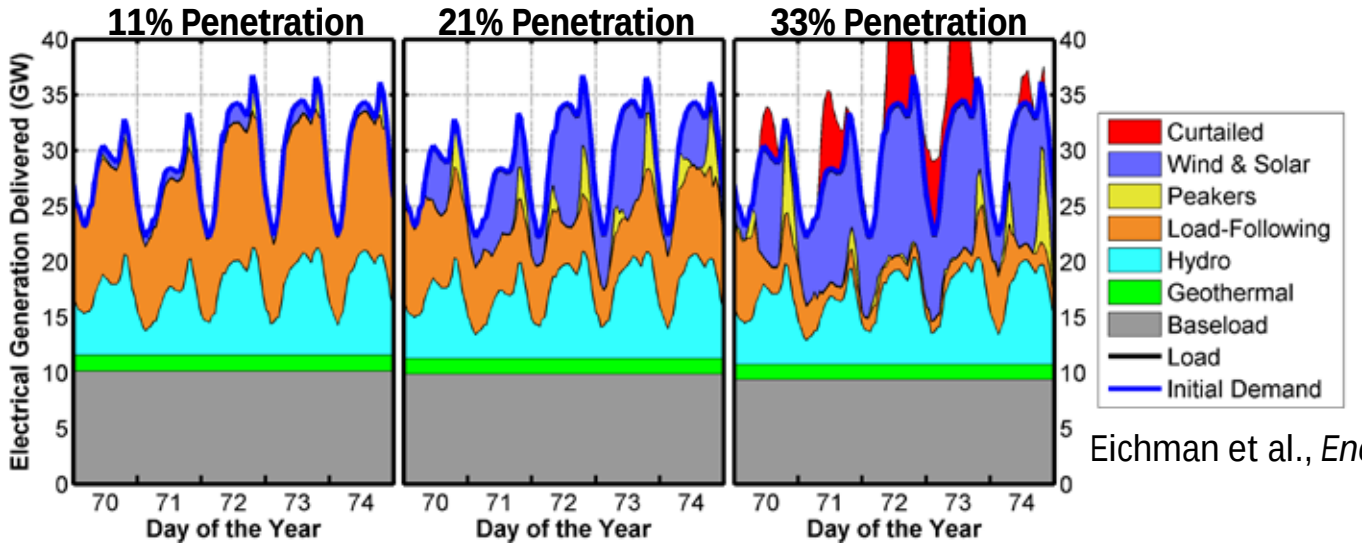


Differences in CO_2 estimates among studies are narrower:

- WECC CO2 marginal emissions based on power generation are generally higher than in California due to coal
- Watt-time calculated EF tend to be lower than for California, because demand-based marginal emissions intrinsically include renewables

Advanced Grid Emissions Modeling

- UC Irvine developing the Holistic Grid Resource Integration and Deployment (HiGRID) Model, to be integrated with NEAT
  - Used originally to analyze the impacts of renewable integration



Eichman et al., *Energy*, 50, 353-363, 2013.

- HiGRID is a comprehensive model
  - Uses algorithms that mimic the electric market
  - Determines temporal profile of load-following and peaking power plants
  - Accounts for limitations due to ramping rates, spinning reserves and frequency regulation on a capacity basis

Natural Gas Consumption from Electricity Generation

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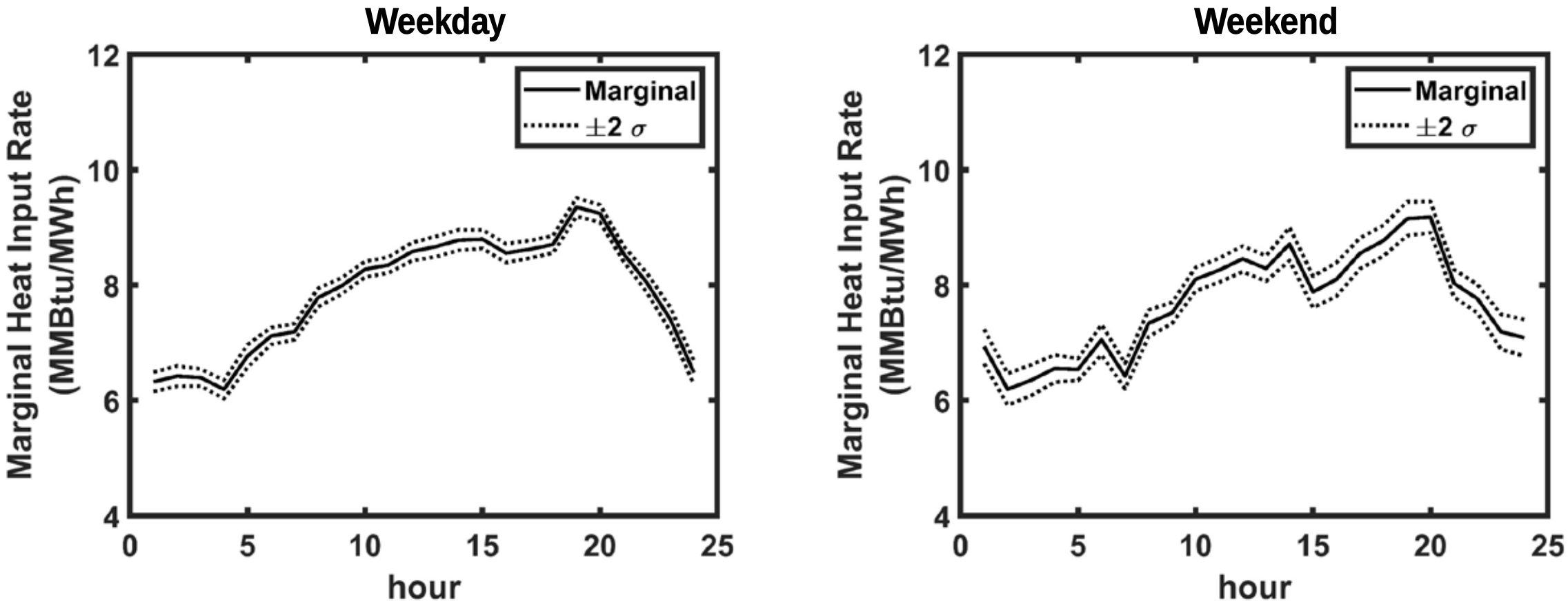
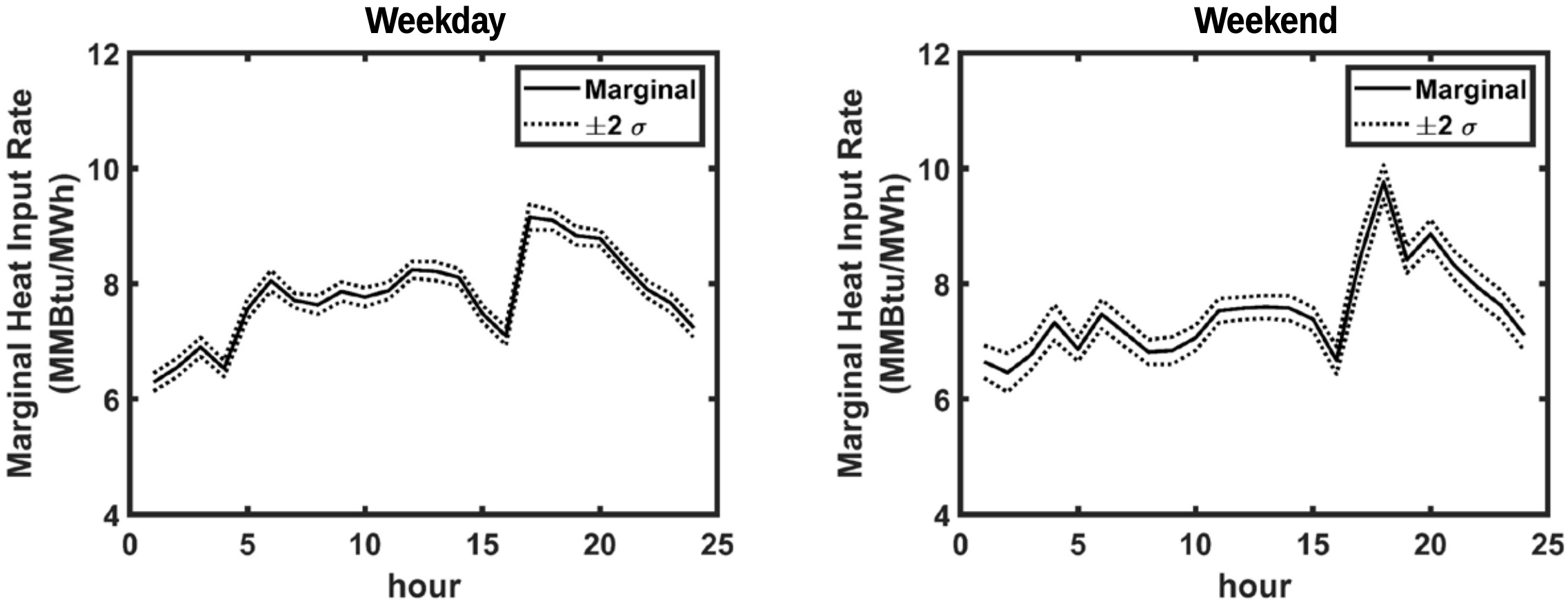
Power Plant Data Availability

- Data availability for hourly heat input rate and throughput data:
  - Heat input rate represents natural gas consumption used for electricity generation
  - Used hourly data from 2011 to 2017
  - Heat input rate is used to calculate marginal natural gas consumption
  - Hourly marginal values are calculated for four representative days:
    - Winter weekday, winter weekend day, summer weekday and summer weekend day

Summer Marginal Heat Input Rate



Winter Marginal Heat Input Rate



Marginal heat input rate will be used to calculate changes in NG consumption due to changes in electricity demand, which may affect total NG leaks

Public Comment

blog.cleanenergy.org

Next Steps

Residential NEAT	Not Yet Started	In Progress	Draft Complete	WG meeting #
Building of tool framework (GUI, file I/O)			X	2
Collection of input data			X	2
Demand segment of tool			X	2, 3
Implementation of distributed solar			X	2
Implementation of distributed battery storage		X		Future
Electric Rate Calculator			X	3
Natural Gas Rate Calculator			X	4
Implementation of net metering			X	3
Solar and battery cost calculator			X	Future
Electric generation emission factors • Advanced EFs: Implementation of HiGRID		X	X	3, 4
Fugitive methane from Natural Gas Use			X	4
Electricity transportation loss			X	Future
Results analysis tools		X		Future