

## MEMORANDUM

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Subject: **FURTHER REVIEW OF SOUTH COAST AQMD'S  
NET EMISSIONS ANALYSIS TOOL (NEAT)**

This memorandum includes observations Ramboll has made after further review of South Coast AQMD's Net Emissions Analysis Tool (NEAT). In particular, Ramboll reviewed assumptions/inputs used in NEAT for appliance usage characteristics, appliance costs, appliance installation costs, methane leakage rate, and greenhouse gas emission factors/global warming potential. Ramboll research indicates that NEAT assumptions/inputs may not be appropriate and should be reviewed/revise before the NEAT tool (or modules) are used for assessing policy options and/or control measures.

Ramboll appreciates South Coast AQMD staff taking the time to speak with us on December 15, 2020 regarding some model performance issues that Ramboll had identified and implementing bug fixes as needed. Ramboll looks forward to receiving a copy of the updated NEAT tool.

Ramboll further appreciates the South Coast AQMD's understanding of the importance of vetting the methodology and inputs to the NEAT tool with a group of diverse and qualified technical experts before using the tool to evaluate proposed control measures for residential buildings to support 2022 AQMP control measure development and presenting any results to the AQMP Advisory Group. As discussed during the first 2022 AQMP Residential and Commercial Buildings Working Group on December 17, 2020, South Coast AQMD staff have agreed to discuss their intended use of the NEAT tool, as well as specific model inputs and configurations to support AQMP control measure development at the upcoming Scientific, Technical & Modeling Peer Review (STMPR) Advisory Group meeting on January 27, 2021. We look forward continued discussions during the upcoming STMPR and Residential and Commercial Buildings Working Group meetings.

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## Outdated Inputs to the NEAT Model

We note that key inputs to the NEAT tool are out of date and have not been updated since the NEAT tool was initially developed in 2018. Ramboll strongly recommends that South Coast AQMD update these datasets to better represent current conditions in the South Coast Air Basin before using the NEAT tool to evaluate proposed control measures for residential buildings to support 2022 AQMP development process.

- Appliance usage characteristics in the NEAT tool are based on the 2009 Residential Appliance Saturation Study (RASS) which is more than a decade old.<sup>1</sup> The California Energy Commission (CEC) updated the RASS in 2019,<sup>2</sup> which provides more representative data for units of energy consumption and appliance penetration within the South Coast Air Basin.
- Vehicle units of energy consumption, penetration rates and emission factors in the NEAT tool are based on EMFAC2014,<sup>3</sup> whereas an updated version, EMFAC2017, was released in December 2017 and updated in March 2018. EMFAC2017 is the latest emissions inventory model that reflects the CARB's understanding of vehicle activity and emissions in California and was approved by United States Environmental Protection Agency (USEPA) for use in the development of the State Implementation Plan (SIP) and for conformity determination purposes effective August 15, 2019.<sup>4</sup> EMFAC2017 will also be used by the South Coast AQMD in the 2022 AQMP Mobile Source strategy development,<sup>5</sup> thus it is important that the NEAT tool maintain consistency in its evaluation of emission reductions relative to other AQMP efforts.
- Upstream well-to-pump GHG emission factors for transportation diesel and gasoline used in NEAT are based on CA-GREET 2.0.<sup>6</sup> However, CARB updated the CA-GREET model and replaced the older version with CA-GREET 3.0 in September 2018.<sup>7</sup> In particular, the new version CA-GREET 3.0 includes updates to tailpipe emission factors for vehicles and methane leakage rates from natural

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<sup>1</sup> SCAQMD NEAT Working Group #2. Available online at: <https://www.aqmd.gov/docs/default-source/clean-air-plans/air-quality-management-plans/2016-air-quality-management-plan/life-cycle-analysis-working-group/neat-pres-111617.pdf?sfvrsn=10>. Accessed: December 2020.

<sup>2</sup> CEC 2020. 2019 Residential Appliance Saturation Study, available online at: <https://www.energy.ca.gov/data-reports/surveys/2019-residential-appliance-saturation-study>. Accessed: December 2020.

<sup>3</sup> SCAQMD NEAT Working Group #2 and Working Group #5. Available online at: <https://www.aqmd.gov/docs/default-source/clean-air-plans/air-quality-management-plans/2016-air-quality-management-plan/life-cycle-analysis-working-group/neat-pres-111617.pdf?sfvrsn=10> and [https://www.aqmd.gov/docs/default-source/clean-air-plans/air-quality-management-plans/2016-air-quality-management-plan/life-cycle-analysis-working-group/neat\\_presentation-092818.pdf?sfvrsn=15](https://www.aqmd.gov/docs/default-source/clean-air-plans/air-quality-management-plans/2016-air-quality-management-plan/life-cycle-analysis-working-group/neat_presentation-092818.pdf?sfvrsn=15). Accessed: December 2020.

<sup>4</sup> USEPA Notice of Availability for the Official Release of EMFAC2017 Motor Vehicle Emission Factor Model for Use in the State of California. Available online at: <https://www.federalregister.gov/documents/2019/08/15/2019-17476/official-release-of-emfac2017-motor-vehicle-emission-factor-model-for-use-in-the-state-of-california>. Accessed: December 2020.

<sup>5</sup> South Coast AQMD 2022 AQMP Mobile Source Working Group Meeting #1, available online at: <http://www.aqmd.gov/docs/default-source/clean-air-plans/air-quality-management-plans/2022-air-quality-management-plan/presentation-2022-aqmp-mobile-sources-wg-final.pdf?sfvrsn=12>. Accessed: December 2020.

<sup>6</sup> SCAQMD NEAT Working Group #5. Available online at: [http://www.aqmd.gov/docs/default-source/clean-air-plans/air-quality-management-plans/2016-air-quality-management-plan/life-cycle-analysis-working-group/neat\\_presentation-092818.pdf?sfvrsn=15](http://www.aqmd.gov/docs/default-source/clean-air-plans/air-quality-management-plans/2016-air-quality-management-plan/life-cycle-analysis-working-group/neat_presentation-092818.pdf?sfvrsn=15). Accessed: August 2020.

<sup>7</sup> CARB LCFS Life Cycle Analysis Models and Documentation. Available online at: <https://ww2.arb.ca.gov/resources/documents/lcfs-life-cycle-analysis-models-and-documentation>. Accessed: December 2020

gas production.<sup>8</sup> The CA-GREET3.0 model is used to generate the carbon intensities (CIs) of all fuel pathways in California, including Lookup Table pathways and applicant-specific Tier 1 and Tier 2 pathways. Therefore, it is important that the NEAT tool be updated for South Coast AQMD's 2022 AQMP efforts to be consistent with CARB's efforts to manage GHG emissions from transportation.

- One of the default options for methane leakage rate provided in the NEAT tool is based on the USEPA's GHG Inventory. The default value is based on the USEPA's 2018 GHG Inventory,<sup>9</sup> whereas the USEPA updates their inventory annually, with the latest inventory released in 2020.<sup>10</sup> Per the USEPA's 2020 annual report, "Each year, some emission and sink estimates in the inventory are recalculated and revised to incorporate improved methods and/or data. The most common reason for recalculating U.S. greenhouse gas emission estimates is to update recent historical data."<sup>11</sup> Therefore, the South Coast AQMD should review the latest inventory to determine whether the current leakage rate in the NEAT tool, calculated based on the US EPA's 2018 GHG Inventory, is still valid. Ramboll also requests South Coast AQMD to share their derivation of methane leakage rate in NEAT that was derived using data in USEPA's 2018 GHG Inventory.

### Review of Appliance Purchase Cost Assumptions

- Purchase costs for appliances within the NEAT model were compared against publicly available data for Space Heaters, Water Heaters and Range Ovens. Significant differences were found for space heating and range oven purchase costs, as shown in **Table 1** below.
- Ramboll tabulated purchase costs for the top 10 best-selling appliances from the Home Depot and Lowes online retailers.
- Default costs in the NEAT model were obtained from various web sources such as Amazon.com, eBay.com, consumerreports.org, homeadvisor.com and homewyse.com.<sup>12</sup>

<sup>8</sup> CARB 2018. CA-GREET3.0 Supplemental Document and Tables of Changes. Available online at: [https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/ca-greet/cagreet\\_supp\\_doc\\_clean.pdf](https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/ca-greet/cagreet_supp_doc_clean.pdf). Accessed: December 2020.

<sup>9</sup> USEPA 2018. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2016. Available online at: <https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2016>. Accessed: December 2020.

<sup>10</sup> USEPA 2020. Inventory of U.S. Greenhouse Gas Emissions and Sinks. Available online at: <https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks>. Accessed: December 2020.

<sup>11</sup> USEPA 2020. Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990 – 2018. Available online at: <https://www.epa.gov/sites/production/files/2020-04/documents/us-ghg-inventory-2020-main-text.pdf>. Accessed: December 2020.

<sup>12</sup> SCAQMD NEAT Input Data, Working Group 2 Materials. Available online at: <http://www.aqmd.gov/docs/default-source/clean-air-plans/air-quality-management-plans/2016-air-quality-management-plan/life-cycle-analysis-working-group/neat-input-data-110317.xlsx?sfvrsn=10>. Accessed: August 2020.

<b>Table 1: Comparison of Appliance Purchase Prices</b>						
	<b>Space Heating</b>		<b>Range Oven</b>		<b>Water Heating</b>	
	<b>NG Heaters<sup>3</sup></b>	<b>Electric Heat Pumps<sup>4</sup></b>	<b>NG Range</b>	<b>Electric Range</b>	<b>NG Water Heater</b>	<b>Electric Water Heater</b>
<b>Appliance Prices</b>						
<b>Ramboll Online Research<sup>1</sup></b>	\$1,282	\$2,648	\$944	\$686	\$561	\$409
<b>NEAT Default<sup>2</sup></b>	\$3,040	\$1,977	\$1,890	\$1,000	\$653	\$368
<b>Percent Difference (NEAT vs. Ramboll)</b>	+137%	-25%	+100%	+46%	+16%	-10%
<b>Appliance Price Differentials (Electric - Natural Gas)</b>						
<b>Ramboll Online Research<sup>1</sup></b>	\$1,367		-\$258		-\$152	
<b>NEAT Default<sup>2</sup></b>	-\$1,063		-\$890		-\$285	
<b>Notes:</b>						
<sup>1</sup> Based on the median price of the top 10 best-selling appliances in zip code 90028 located in Southern California from Lowes and Home Depot online retailers. <sup>2</sup> Default purchase prices provided in the NEAT model for All Housing Types and All Climate Zones. <sup>3</sup> Costs for natural gas space heaters were obtained for only those units that are compliant with South Coast AQMD Rule 1111. <sup>4</sup> Costs are for electric heat pumps sold in the South Coast Air Basin.						
<b>Abbreviations:</b>						
NG – Natural Gas						

**Appliance Installation Cost Assumptions**

- Installation costs for appliances within the NEAT model were compared against publicly available data for Space Heaters, Water Heaters and Range Ovens. The comparison is shown in **Table 2** below.
  - Ramboll tabulated installation costs from limited online vendor quotes.
  - Default costs in the NEAT model were obtained from various web sources such as Amazon.com, eBay.com, consumerreports.org, homeadvisor.com and homewyse.com.<sup>16</sup>
- In some cases, the installation costs from Ramboll’s research were found to be significantly higher than the default values in the NEAT model.
- Furthermore, it is no clear whether installation costs in NEAT account for infrastructure upgrades that may be necessary to support increased electrical loads from electric appliances.

- For example, HomeAdvisor<sup>13</sup> estimates the average cost to upgrade an electrical panel as \$1,133, with increased costs for higher amperages or rewiring. Further, research by the California Energy Commission (CEC) on Cost of Residential Electrification<sup>14</sup> indicates that “many homes are not wired to handle the electric load from having all-electric stoves, space heaters, and water heaters in addition to their usual electric appliances” and that “homeowners would need to pay roughly \$4,600 to upgrade their wiring and electric panel” to support electrification of appliances.
- Recent research by University of California Los Angeles (UCLA) Institute of the Environment and Sustainability<sup>15</sup> indicates that diurnal patterns of hourly natural gas use largely coincide with the timing of daily peak electricity loads. This suggests that electrification of residential appliances has the potential to place additional electrical loads during peak residential electricity usage and that most homeowners who chose to switch natural gas appliances to their electric counterparts would require electrical panel upgrades. It is therefore important that costs associated with these panel upgrades are appropriately accounted for within the NEAT tool.

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<sup>13</sup> Available online at: <https://www.homeadvisor.com/cost/electrical/upgrade-an-electrical-panel/>. Accessed: December 2020.

<sup>14</sup> California Energy Commission, “Cost of Residential Electrification” (Navigant Research on behalf of the California Building Industry Association). Available online at: <https://efiling.energy.ca.gov/GetDocument.aspx?tn=224498&DocumentContentId=55045>. Accessed: December 2020.

<sup>15</sup> Fournier et al (2020). “Implications of the timing of residential natural gas use for appliance electrification efforts”. Environ. Res. Lett. 15 124008.

**Table 2: Comparison of Appliance Installation Costs**

	Space Heating		Range Oven		Water Heating	
	NG Heaters	Electric Heaters	NG Range	Electric Range	NG Water Heater	Electric Water Heater
<b>Appliance Installation Costs</b>						
<b>Ramboll Online Research<sup>1</sup></b>	\$4,296	\$3,588	\$175	\$175	\$1,136	\$942
<b>NEAT Default<sup>2</sup></b>	\$1,696	\$3,233	\$150	\$140	\$1,900	\$1,700
<b>Percent Difference (NEAT vs. Ramboll)</b>	-61%	-10%	-14%	-20%	+67%	+80%
<b>Appliance Installation Cost Differentials (Electric - Natural Gas)</b>						
<b>Ramboll Online Research<sup>1</sup></b>	-\$708		\$0		-\$194	
<b>NEAT Default<sup>2</sup></b>	\$1,537		-\$10		-\$200	
<p><b>Notes:</b></p> <p><sup>1</sup> Installation cost quotes based on the following sources:            Space Heater (NG): <a href="https://modernize.com/hvac/heating-repair-installation/furnace/gas">https://modernize.com/hvac/heating-repair-installation/furnace/gas</a> (Accessed: August 2020).            Space Heater (Electric): <a href="https://modernize.com/hvac/heating-repair-installation/furnace/electric">https://modernize.com/hvac/heating-repair-installation/furnace/electric</a> (Accessed: August 2020).            Range (NG and Electric): <a href="https://www.thumbtack.com/p/appliance-installation-cost">https://www.thumbtack.com/p/appliance-installation-cost</a> (Accessed: August 2020).            Water Heater (NG): <a href="https://www.thumbtack.com/p/water-heater-installation-cost">https://www.thumbtack.com/p/water-heater-installation-cost</a> (Accessed: August 2020).            Water Heater (Electric): <a href="https://www.thumbtack.com/p/water-heater-installation-cost">https://www.thumbtack.com/p/water-heater-installation-cost</a> (Accessed: August 2020).</p> <p><sup>2</sup> Default installation costs provided in the NEAT model for All Housing Types and All Climate Zones.</p> <p><b>Abbreviations:</b>            NG – Natural Gas</p>						

### GHG Emission Factors and GWP Assumptions

- Changes to the methane (CH<sub>4</sub>) global warming potential (GWP) in the “Power Supply” tab of the NEAT model appears to only affect greenhouse gas impacts from methane leakage (before and behind the meter). Methane emissions from appliances and vehicles are not modeled in NEAT.
- Though emission factors are labeled as carbon dioxide equivalent (CO<sub>2</sub>e) in the NEAT model, CH<sub>4</sub> and nitrous oxide (N<sub>2</sub>O) emissions are not included in appliance and vehicle point-of-use emission factors.

- Vehicle greenhouse gas (GHG) emission factors are taken from EMFAC2014, which only includes carbon dioxide (CO<sub>2</sub>) emissions.<sup>16</sup>
- Appliance point-of-use GHG emission factors are based on United States Environmental Protection Agency (US EPA's) AP-42 database for CO<sub>2</sub>.<sup>17, 18</sup>
- Basin-average grid and peaker power plant GHG emission factors include CO<sub>2</sub> emission based on continuous emissions monitoring system (CEMS) monitoring data from US EPA's Air Markets Program Data<sup>19</sup> but do not appear to include CH<sub>4</sub> and N<sub>2</sub>O emissions.<sup>20</sup>
- Upstream well-to-pump GHG emission factors for transportation diesel and gasoline are based on CA-GREET 2.0.<sup>21</sup> However, the GHG emission factors do not appear to be adjusted based on the methane GWP input by the user in the "Power Supply" tab of the NEAT model.

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<sup>16</sup> SCAQMD NEAT Input Data, Working Group 2 Materials. Available online at: <http://www.aqmd.gov/docs/default-source/clean-air-plans/air-quality-management-plans/2016-air-quality-management-plan/life-cycle-analysis-working-group/neat-input-data-110317.xlsx?sfvrsn=10>. Accessed: August 2020.

<sup>17</sup> SCAQMD NEAT Input Data, Working Group 2 Materials. Available online at: <http://www.aqmd.gov/docs/default-source/clean-air-plans/air-quality-management-plans/2016-air-quality-management-plan/life-cycle-analysis-working-group/neat-input-data-110317.xlsx?sfvrsn=10>. Accessed: August 2020.

<sup>18</sup> US EPA AP-42 Chapter 1.4 (Natural Gas Combustion). Available online at: <https://www3.epa.gov/ttnchie1/ap42/ch01/final/c01s04.pdf>. Accessed: August 2020.

<sup>19</sup> US EPA Air Markets Program Data. Available online at: <https://ampd.epa.gov/ampd/>. Accessed: August 2020.

<sup>20</sup> SCAQMD NEAT Working Group #3. Available online at: <http://www.aqmd.gov/docs/default-source/clean-air-plans/air-quality-management-plans/2016-air-quality-management-plan/life-cycle-analysis-working-group/neatWG3.pdf?sfvrsn=8>. Accessed: August 2020.

<sup>21</sup> SCAQMD NEAT Working Group #5. Available online at: [http://www.aqmd.gov/docs/default-source/clean-air-plans/air-quality-management-plans/2016-air-quality-management-plan/life-cycle-analysis-working-group/neat\\_presentation-092818.pdf?sfvrsn=15](http://www.aqmd.gov/docs/default-source/clean-air-plans/air-quality-management-plans/2016-air-quality-management-plan/life-cycle-analysis-working-group/neat_presentation-092818.pdf?sfvrsn=15). Accessed: August 2020.