Net Emissions Analysis Tool (NEAT) Working Group

Formally the Residential Commercial Appliance Life Cycle Analysis Working Group

Meeting #5
September 28, 2018

South Coast
Air Quality Management District

Development Status Update

Sang-Mi Lee, Ph.D.

Planning and Rules Division

Working Group Meetings and Comment Letters to Date

- Five working group meetings including today's and eight comment letters
- Working group meetings
  - Meeting #1 August 30, 2017
  - Meeting #2 November 16, 2017
  - Meeting #3 January 31, 2018
  - Meeting #4 April 18, 2018
  - Meeting #5 September 28, 2018
- Comment Letters
  - Sierra Club – November 2017
  - PSE Healthy Energy – February 2018
  - Sustainable Analysis, LLC – February 2018
  - SoCalGas – March 2018
  - Sierra Club – April 2018
  - Tim Kabat – April 2018
  - SoCalGas – June k2018
  - Sierra Club – September 2018

Development Progress

- Meeting #1 August 30, 2017
  - Initiative to develop a tool to estimate cost effectiveness of emission reductions in residential sector
  - Solar Technology Initiative
- Meeting #2 November 16, 2017
  - Demand segment
  - Solar PV calculator
  - Collecting input data
- Meeting #3 January 31, 2018
  - Electric rate calculator
  - Net metering
  - Emissions from electricity generation

Development Progress (continued)

- Meeting #4 April 18, 2018
  - Natural gas rate calculator
  - Fugitive methane emissions from natural gas use
  - Continued discussions on emissions from electricity generation
- Meeting #5 September 28, 2018
  - Battery storage module
  - Electricity transmission and distribution loss
  - Renewable natural gas
  - Lifecycle Emissions from Gasoline and Diesel

Comments and Responses
(since last meeting)

Scott A. Epstein Ph.D.

Planning and Rules Division

Summary of Submitted Comments

- Four letters, received after the last workgroup meeting, are summarized here
- Staff appreciates the thoughtful feedback during the meetings and in the comment letters
- All comment letters posted to the NEAT website
  - www.aqmd.gov/NEAT

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South Coast AQMD

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Net Emissions Analysis Tool (NEAT), formally known as the LifeCycle Analysis Working Group

The purpose of this working groups is to assess the cost-effectiveness of technologies and life-cycle emissions.

The South Coast Air Quality Management District is forming a working group as described in the 2016 AQMP to discuss assessing the cost-effectiveness of technologies and life-cycle emissions. The 2016 AQMP includes a number of control measures which seek emission reductions with zero and near-zero NOx appliances in commercial and residential applications, and integrate energy efficiency enhancements with criteria pollutant (e.g., NOx) co-benefits. To this end, the SCAQMD staff will develop an emissions tool to estimate changes in criteria and GHG emissions and costs associated with upgrades in commercial and residential appliances, in conjunction with installation of zero and near-zero emission technologies. This tool will also be critical in developing a Solar Technology Initiative which will be a guiding document to provide for better integration of major planning issues regarding solar technologies including benefits, current market conditions and potential of emission reductions along with corresponding action items.

Working Group Meeting #5
Friday, September 28, 2018, 1:30 p.m.
South Coast Air Quality Management District
Conference Room CC-8
21865 Copley Drive, Diamond Bar, CA 91765

Working Group Meeting #4
Wednesday, April 18, 2018, 2:00 p.m.
South Coast Air Quality Management District
Conference Room CC-8
21865 Copley Drive, Diamond Bar, CA 91765
Agenda - (PDF, 120kb)
Presentation - (PDF, 1MB)

Working Group Meeting #3
Wednesday, January 31, 2018, 2:00 p.m.
South Coast Air Quality Management District
Conference Room CC-8
21865 Copley Drive, Diamond Bar, CA

For more information, please contact:
Michael Krause, Planning and Rules Manager
(909) 396-2706

Comment Letters
SoCalGas - June 22, 2018 (PDF, 588kb)
Tim Kabat - April 16, 2018 (PDF, 111kb)
Sierra Club - April 8, 2018 (PDF, 392kb)
SoCalGas - March 19, 2018 (PDF, 291kb)
Sustainable Analysis, LLC - February 20, 2018 (PDF, 590kb)
PSE - February 6, 2018 (PDF, 116kb)
Sierra Club - November 28, 2017 (PDF, 186kb)

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Local Government
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Rules
SCAQMD Rules and Regulations - The offical AQMD rule book; list of recent rule amendments and adoptions, how to read the rules.

Organization
How the South Coast AQMD is structured, the responsibilities and management personnel for each office, and biographies of the Executive Management staff.

Summary of Submitted Comments (continued)

- Installation of highly efficient heat pump water heaters (HPWH) can help the South Coast Air Basin meet climate and air quality goals
  - ➢ Leakage of refrigerants used in HPWH releases GHGs to atmosphere
  - ➢ CA set target of reducing HFC-based refrigerants 40% below 2012 levels by 2030
    - R-134a is typically used today (GWP of 1430)
    - R-1234yf may closely match performance of R-134a (GWP of 4)
    - CO_2 is commonly used as refrigerant in advanced HPWHs in Japan (GWP of 1)
  - ➢ Analysis in Raghavan et al. 2017* calculates GHG emissions of different water heater technologies including refrigerant leakage from 2020 to 2040
    - Even with current R-134a usage, heat pump water heaters have less energy usage and GHG emissions than natural gas storage water heaters, instantaneous or tank-less natural gas water hears, and electric resistance water heaters

South Coast
Air Quality Management District

*Raghavan, Wei, Kammen, Scenarios to decarbonize residential water heating in California, Energy Policy 109 (2017) 441-451

Summary of Submitted Comments (continued)

- Reflecting Renewable Portfolio Standards
  - Use of marginal emissions based on NG units only ignores the increase in renewable sources mandated by the Renewable Portfolio Standards
  - *Marginal emissions from NG electricity generation is one of the options that NEAT provides to calculate grid emissions. NEAT is not designed to model a future grid, but we are considering options to include a more comprehensive approach to model the grid dynamically that would incorporate renewables. Until this is incorporated, NEAT provides three options for the user to model bounding cases for renewable penetration.*
- Hydro Modeling
  - Slides presenting hydropower dispatch modeling are questionable
  - *Those slides were for illustration purposes and that modeling approach is not implemented in NEAT*

Summary of Submitted Comments (continued)

- Explore upstream emissions of both NG and electric systems
  - Include upstream emissions along with fugitive emissions from incomplete combustion
  - Include drilling, production, treatment, and compression shrinkage consumption
  - Include fugitive emissions along the path
  - Fugitive emissions of natural gas system is about 5% of consumption and several additional percentage points of upstream consumption from gas processing and compression along pipelines
  - *NEAT does consider fugitive emissions of methane consumption in both the NG and electric systems. Methane leakage inventories consider emissions from drilling, production, processing, and transportation/distribution. Behind-the-meter emissions was discussed in WG meeting #4 and will be addressed again in this meeting*

Summary of Submitted Comments (continued)

- NEAT should be consistent with balanced energy policies and procedures adopted by the SCAQMD Governing Board
  - AQMD Air Quality-Related Energy Policy (2011)
  - SCAQMD Climate Change Policy (2008)
  - Interim CEQA GHG Significance Threshold for Stationary Sources (2008)
  - *The primary goal of NEAT is to use the best-available science to capture the NOx and GHG emissions from retrofits and replacements in the residential sector. We believe that NEAT is consistent with past policies adopted by the SCAQMD Governing Board.*

Summary of Submitted Comments (continued)

- NEAT should use a default methane leakage rate of 1.3% based on the EPA's GHG Inventory
  - Consistent with CARB's CA-GREET model to measure carbon-intensity of fuels in the Low Carbon Fuel Standard
  - A default methane leakage rate that is not reported and verified and state, national, and international levels is inconsistent with CA energy policies
  - *The EPA GHG Inventory will be the basis for the default methane leakage rate in NEAT and it will be updated as new GHG inventories are released*
  - *Values from two additional leak studies will be included along with the option for the user to enter their own value*

Summary of Submitted Comments (continued)

- NEAT should not provide other methane leakage rate options in the tool
  - Allowing a menu of options for different methane leakage rates implies that SCAQMD has vetted those sources
  - Balanced panel of scientists and technical experts would be necessary to analyze different leak rate options
  - Users should take sole-responsibility for entering alternative methane leakage rates
  - *We strive to use the best-available science in the development of NEAT*
  - *Currently, we plan to include three comprehensive studies in the tool*
  - *Additional information and references for each study will be provided in the documentation embedded in the tool at the point of selection*
  - *Non-default studies included in NEAT are conducted by leading experts, published in prestigious journals, and are vetted by peer-review*

Methane Leak Studies Included in NEAT

	Title	Leak Rate	Source	Considerations
A	EPA GhG Emissions Inventory	1.28% (95% CI 1.09 to 1.49%)	2018 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 • Behind-the-meter leakage not included • Summary of studies and references https://www.edf.org/sites/default/files/methane_studies_fact_sheet.pdf
C	Alvarez et al. *Science* paper	2.3% (2.0 to 2.7%)	Collaborative effort involving 16 government and academic institutions. Published in Alvarez et al. 2018. *	• Inventory for 2015 emissions • Facility-based bottom-up measurements validated with top-down measurements • Captures emissions released during abnormal operating conditions • Local distribution and behind-the-meter leakage not included

* Alvarez et al, Assessment of methane emissions from the U.S. oil and gas supply chain, Science, (2018)

Summary of Submitted Comments (continued)

- NEAT should use a 100-year GWP to be consistent with other state energy policies
  - CARB's 2017 Climate Change Scoping Plan Update uses 100-year GWP
  - CARB's Short-Lived Climate Pollutant Reduction strategy uses 20-year GWP
  - CARB uses a 100-year GWP to compare SLCP reduction strategy with other AB32 policies
  - SCAQMD requires the use of 100-year GWP for industrial GHG emissions in CEQA documents
  - *Both the 100-year GWP and 20-year GWP are included in the tool. 20-year GWP is default.*
  - *20 year GWP is more appropriate for methane because its atmospheric lifetime is relatively short (~12 years)*
  - *Near-term effects of climate change are evident today. A shorter time-window GWP is a more relevant metric for assessing the contribution towards climate change.*

Summary of Submitted Comments (continued)

- *Fischer et al. 2018, An Estimate of Natural Gas Methane Emissions from California Homes was recently published by LBNL researchers
  - *SCAQMD staff have reviewed the manuscript*
    - *Mass balance method used to measure behind-the-meter whole-house emissions of methane in 75 California homes*
    - *Researchers assume that methane emissions from multi-family homes can be estimated from single-family homes*
    - *Homes represented various locations and building types*
    - *Advanced statistical tools with California housing statistics (2009 RASS) and gas usage information were used to extrapolate the data to a state-level*
    - *Methane to CO2 emission ratios were used to determine combustion appliance emissions*
    - *$^{13}CH_4$ were used to confirm that methane enhancements come from natural gas sources*

***An Estimate of Natural Gas Methane Emissions from California Homes**
Marc L. Fischer, Wanyu R. Chan, Woody Delp, Seongeun Jeong, Vi Rapp, and Zhimin Zhu
Environmental Science & Technology **2018** *52* (17), 10205-10213

Summary of Submitted Comments (continued)

Results of Fischer et al. 2018 and comparison to literature on behind-the-meter leak rates

Study	Leak Percentage	Location	Number of Homes
Fischer et al. 2018	0.5% (0.3%-0.9%) *Includes leaks from quiescent houses, pilot lights, & combustion appliances*	California	75 homes across the state + statistical methods to scale up
*Fischer et al. 2017	0.2% (preliminary study) *Includes leaks from quiescent houses & pilot lights only*	San Francisco Bay Area	10

What default number should NEAT use? What values should be options in NEAT? *Actual choice for policymaking should be addressed in other forums.*

* **A Survey of Methane Emissions from the California Natural Gas System** Fischer, Jeong, Faloona, Mehrota, 2017, CEC-500-2017-033

Electricity Transmission & Distribution Losses

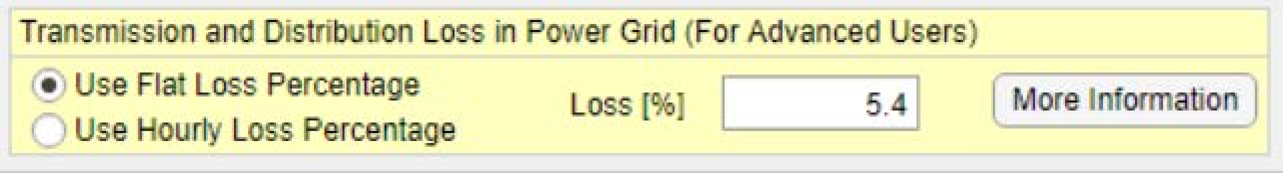
Scott A. Epstein Ph.D.

Planning and Rules Division

Electricity Transmission & Distribution Losses

- Electricity is lost to heat throughout the grid
- NEAT calculates the change in electricity required at the source
- Transmission & Distribution loss must be accounted for when determining the electricity that must be generated
- We implement an average electricity loss rate across the entire grid in NEAT

Electricity Transmission & Distribution Losses

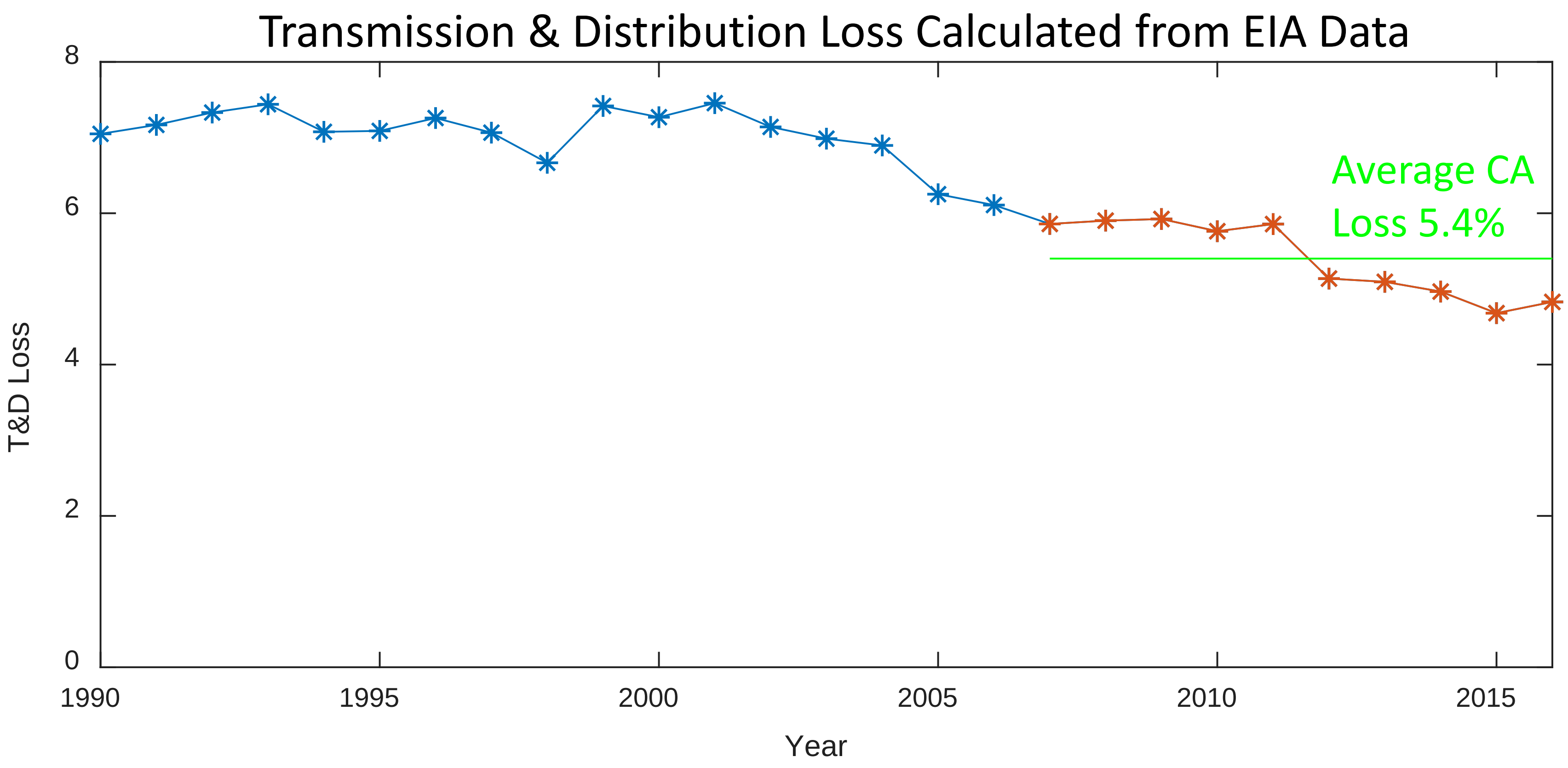


- Two options specified for transmission loss:
  - **Flat Loss** is a single value that represents the entire grid for the entire year
  - **Hourly Loss** allows the user to upload hourly loss percentages

- Default Flat Loss percentage is based on 10-year (2016-2007) average of US Energy Information Administration statistics for California
  - 10-year average is needed to smooth out year-to-year variation in hydroelectric usage

T&D Losses: https://www.eia.gov/tools/faqs/faq.php?id=105&t=3
CA EIA Data: https://www.eia.gov/electricity/state/california/

Electricity Transmission & Distribution Losses



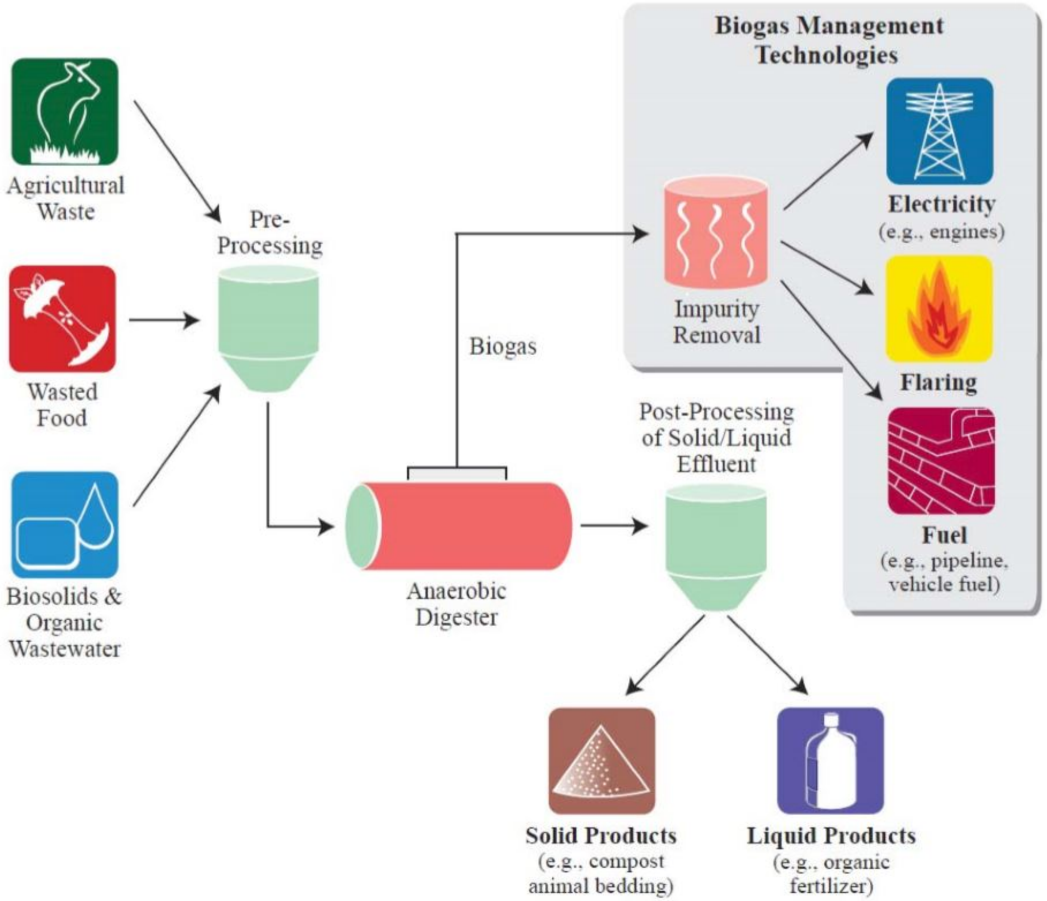
Treatment of Renewable Natural Gas in NEAT

Marc Carreras Sospedra Ph.D.

Planning and Rules Division

South Coast
Air Quality Management District

Potential for Renewable NG



- California Potential (91-93 bcf/year)[1,2]:
  - Animal Manure: 10.1-19.7 bcf/year
  - Landfill Gas: 50.1-53.0 bcf/year
  - Municipal Solid Waste: 12.6-16.3 bcf/year
  - Wastewater Treatment: 5.6-7.7 bcf/year

- California NG Demand: 2,177 bcf/year[3]
- Maximum potential for biogas: 4.3% of total demand in California

[1]California Biomass Collaborative, 2015

[2]UC Davis, 2016

[3]US Energy Information Administration, 2018

Carbon Intensity from Biogas Production

- Carbon Intensity (CI) based on ARB's Low Carbon Fuel Standards (LCFS) certified pathways
  - 82 pathways certified, from in and out of state
  - Include biogas from landfill, and anaerobic digestion of wastewater, manure, and food and green waste
- Weighted CI of NG with max potential for biogas pipeline injection: 76.3 gCO_2e/MJ
  - What is the potential maximum contribution from biogas to pipelined NG?

		# paths	CI (gCO_2e/MJ)
Biomethane			
	Landfill	76	46.7
	Wastewater	3	19.3
	Manure	2	-264.0
	Food and Green Waste	1	-22.9
North America NG			
	Natural Gas	4	79.7

NO_X Emissions Displacement from Biogas Use

Extraction and Transmission:

- Use of biogas reduces the need for conventional NG, reducing emissions from NG extraction and transmission
- Emissions from extraction and transmission of conventional NG occur predominantly outside the Basin
  - We assume NO_X emissions displacement from reducing extraction and transmission of NG in the basin are *de minimis*

NO_X Emissions Displacement from Biogas Use

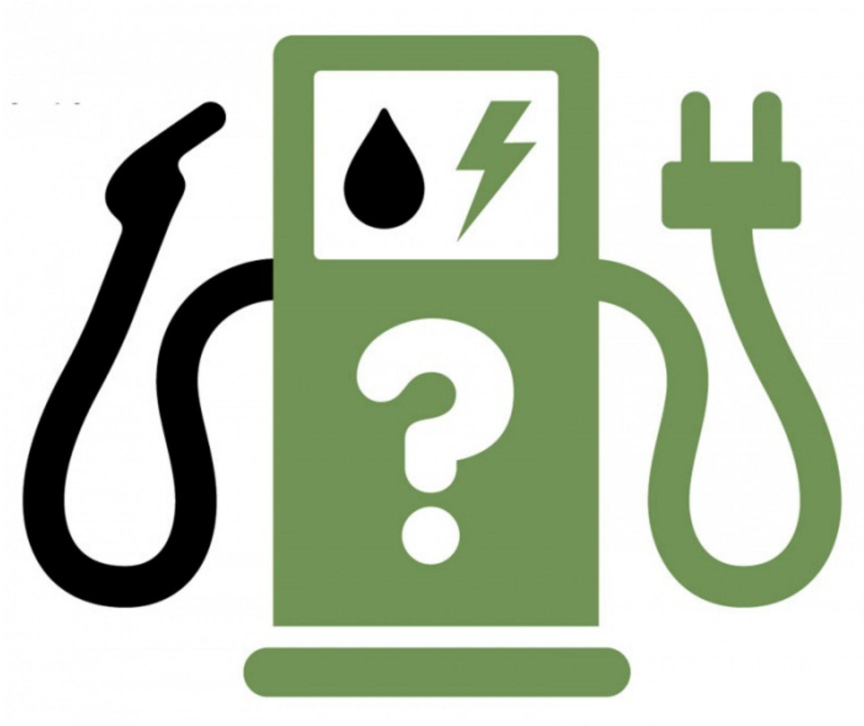
- Consumption of biogas:
  - Process heat
  - Electricity production (~1% in CA)
  - CNG/LNG for vehicles
  - Injection to pipeline
  - Flares
  - Venting

Lifecycle Emissions from Gasoline and Diesel Combustion in Light-duty Vehicles

Marc Carreras Sospedra Ph.D.

Planning and Rules Division

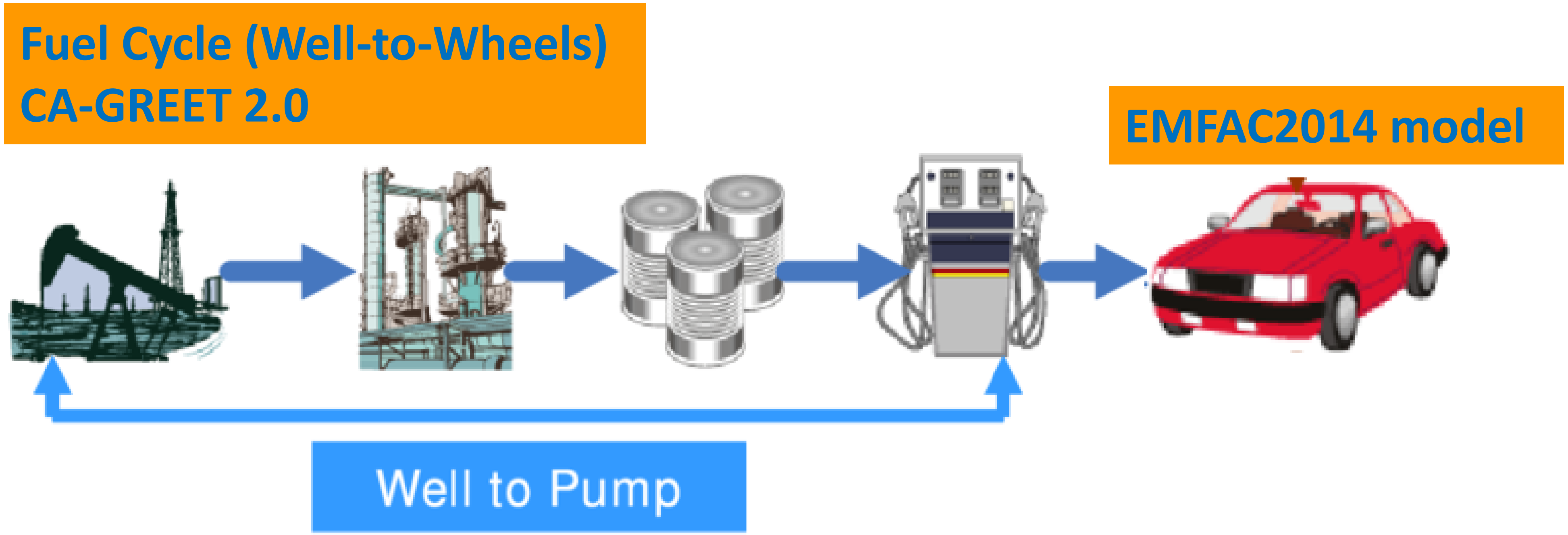
Fueling vs Electric Charging



Switching from gasoline/diesel cars to EVs:

- Extends benefits of using solar panels for some households
- Reduces tailpipe emissions of NOX and GHG emissions
- Reduces emissions from gasoline/diesel production
- Increases electricity bills
  - Solar panels would lower electricity bills

Well-to-Pump Emissions for Gasoline Fueling



- CA-GREET 2.0 model used for Well-to-Pump emissions
- EMFAC2014 model used for tailpipe emissions

Emissions Factors for Vehicles

	Gasoline (g/mile)			Diesel (g/mile)	
Process	GHG	NOX		GHG	NOX
Feedstock	50.2	*0.15**		46.3	*0.17**
Fuel Production	115.7	0.16		90.3	0.12
Tailpipe Emissions	351.3	0.10		297.7	0.17
Total	517.23	*0.31**		434.37	*0.34**

CA-GREET 2.0 → Feedstock, Fuel Production

EMFAC2014 Calendar Year 2017 → Tailpipe Emissions

*69% of the oil consumed in CA is produced out of state (CEC, 2018). Only 31% of feedstock life-cycle emissions included in NEAT

EV Charging Needs and Emissions Displacement

Average VMT per vehicle
35 miles

EV

Average EV battery consumption
30 kWh/100 miles

Total EV electricity demand
10.5 kWh*

Added electricity demand
to household load
Added emissions from electric grid

Gasoline

Average EF per mile
NO_X = 0.31 g/mile
CO_2 = 0.52 kg/mile

Total displaced emissions
NO_X = 10.8 g/day
CO_2 = 17.8 kg/day

Diesel

Average EF per mile
NO_X = 0.34 g/mile
CO_2 = 0.43 kg/mile

Total displaced emissions
NO_X = 11.9 g/day
CO_2 = 15.1 kg/day

Well-to-pump emissions: CA-GREET 2.0
Tailpipe emissions: EMFAC2014, Calendar Year 2017

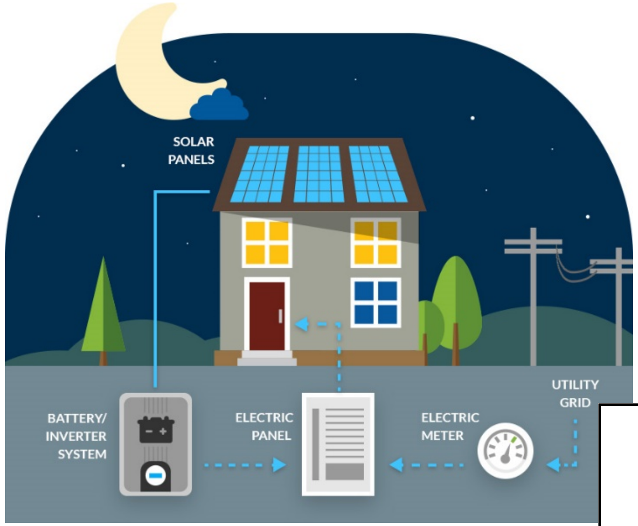
*This is an input parameter that users can modify

Residential Battery Modeling in NEAT

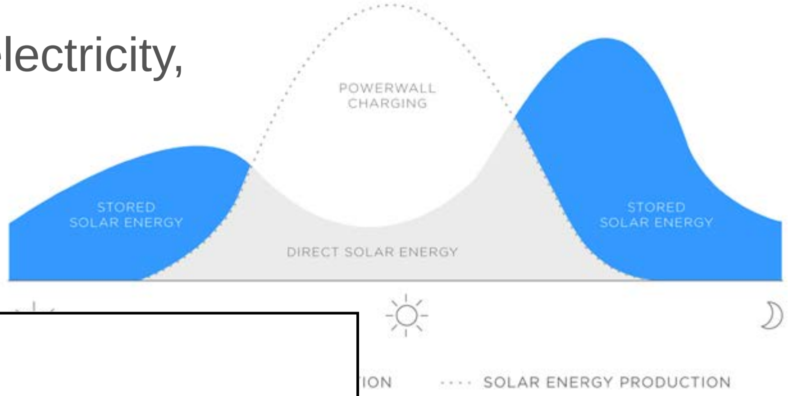
Seungbum Ha Ph.D.

Technology Advancement Office

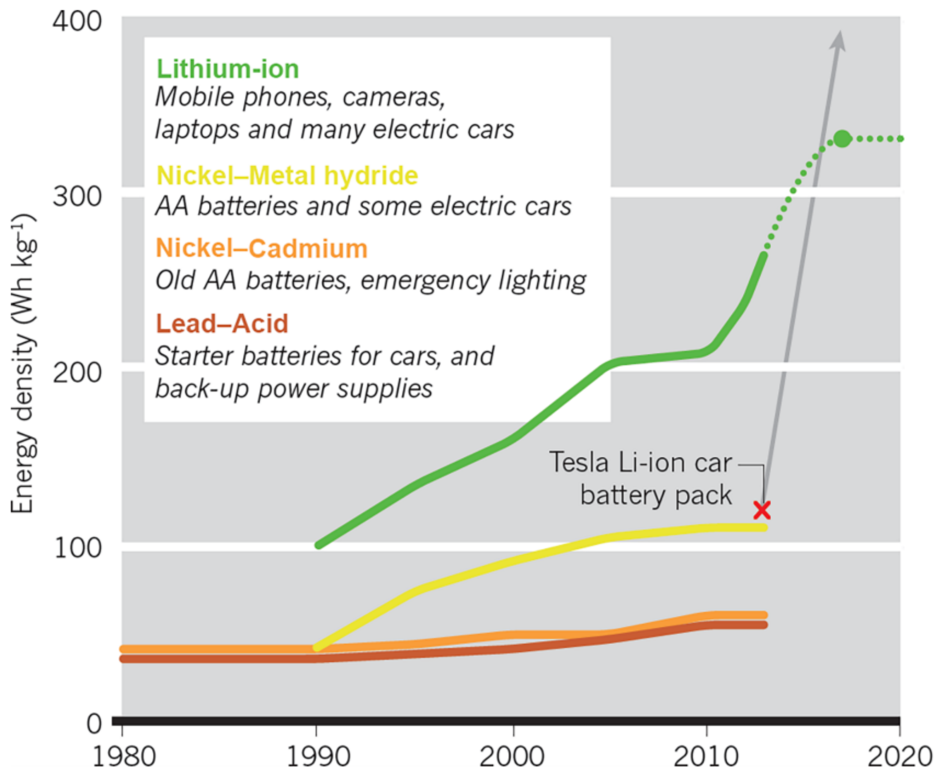
Self-Powered Home

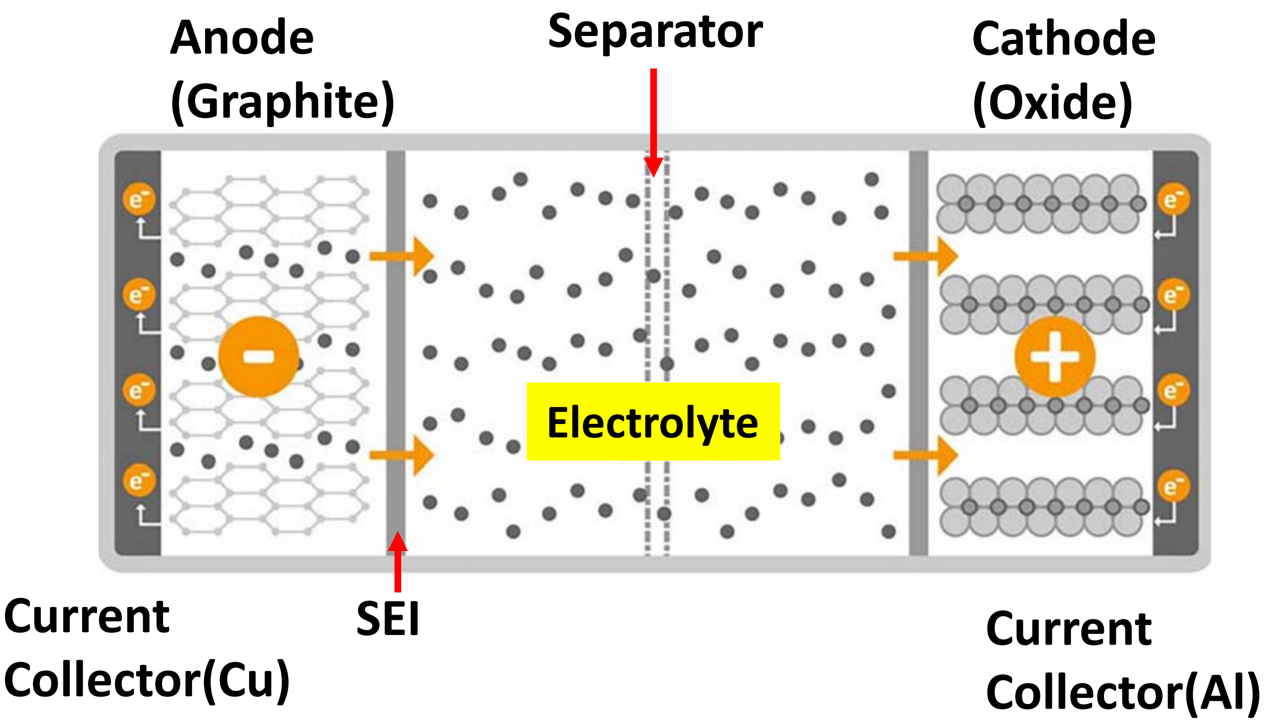


- When the solar panels produce more electricity than required in the home, the excess is stored in the battery pack
- When the panels aren't producing enough electricity, electricity stored in the battery can be used



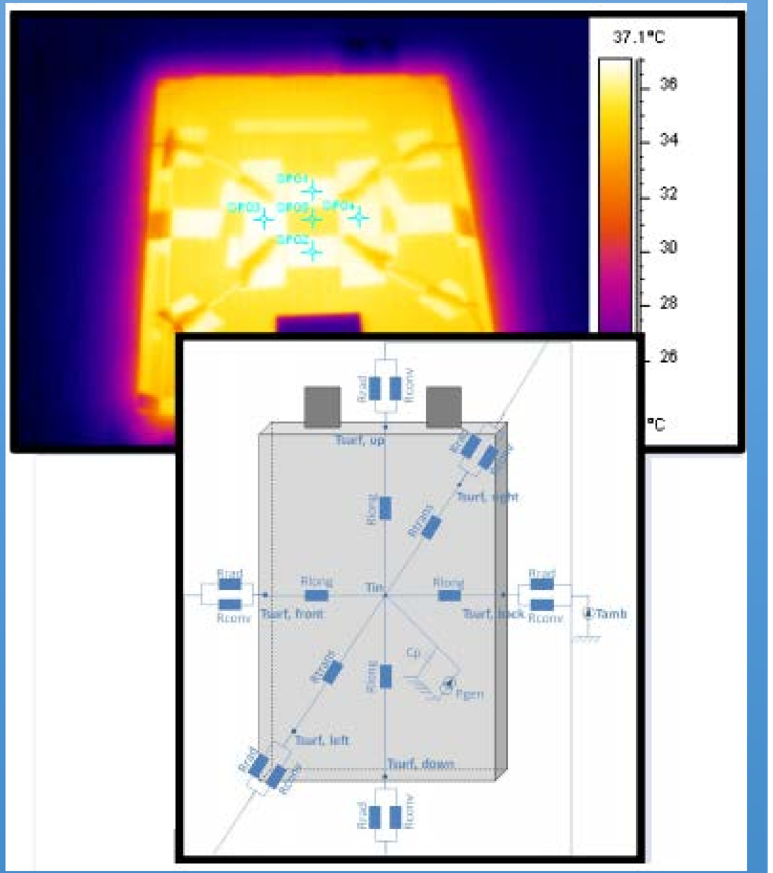
Li-ion Battery



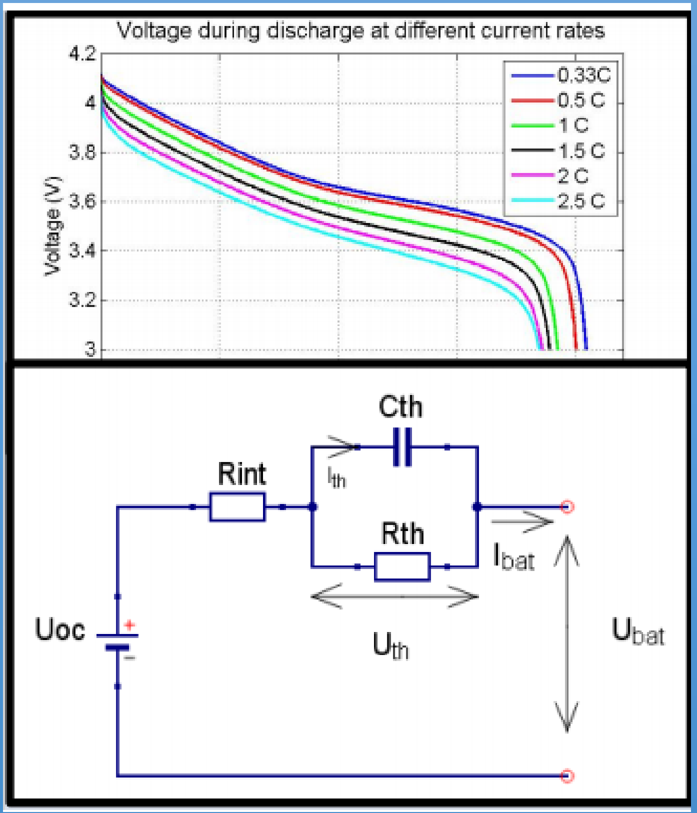


Li-ion Battery Cell Models

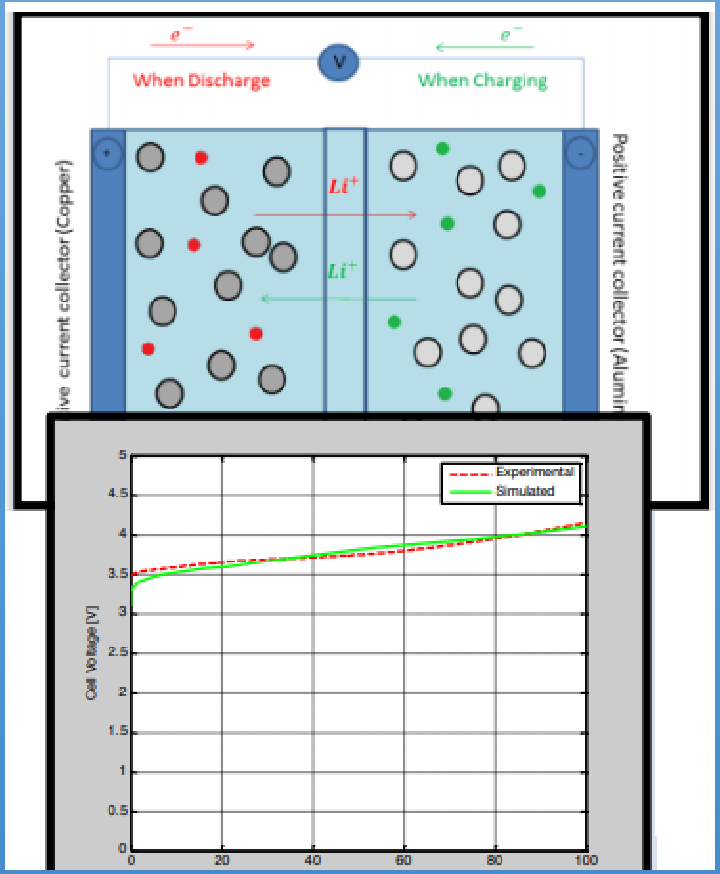
Thermal Model



Electrical Model

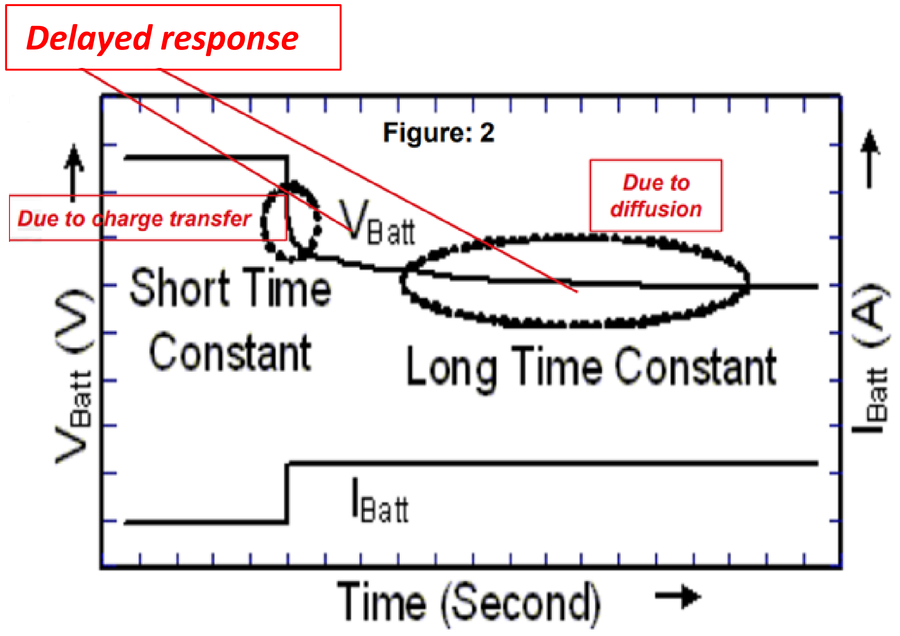


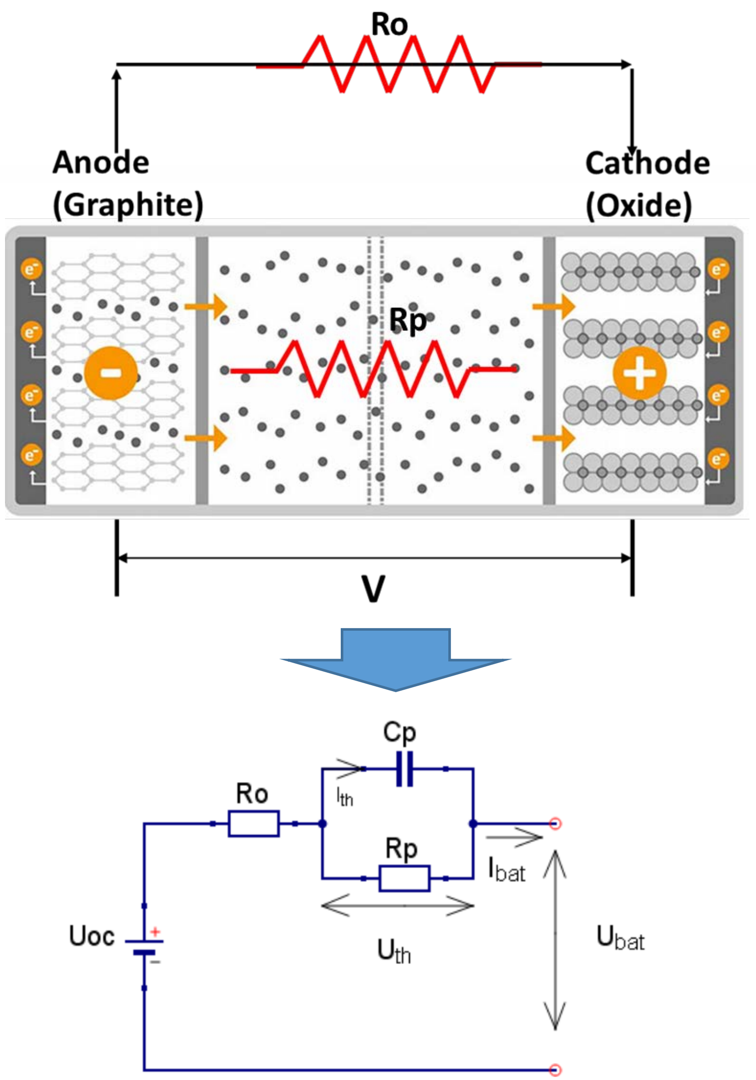
Electrochemical Model



Electrical Model - Continued

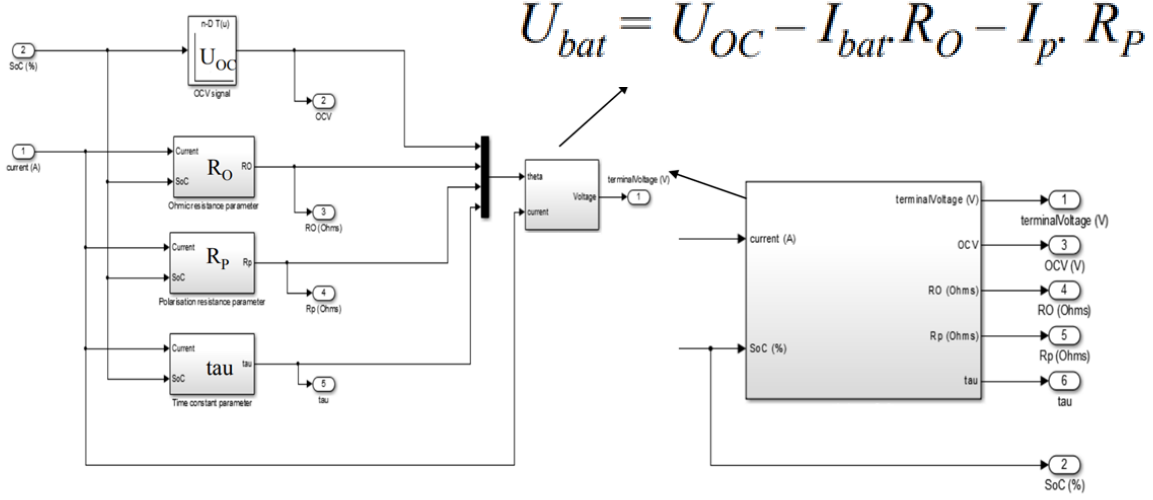
- First order model is a good compromise between complexity and accuracy
- Use of electrical characterisation tests





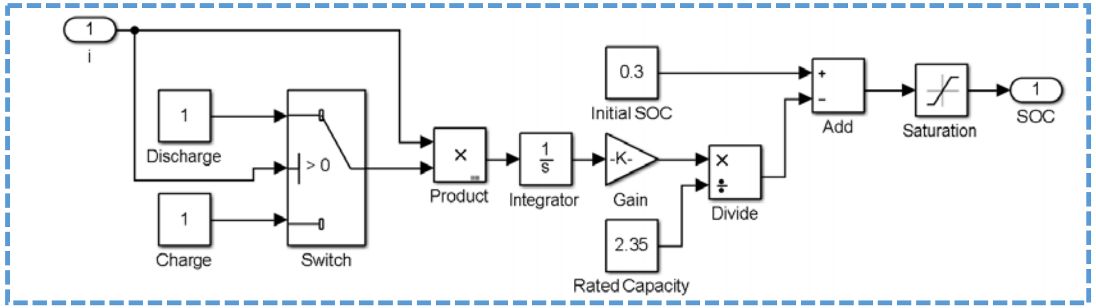
Li-ion Battery Cell Models

$$U_{bat} = U_{OC} - I_{bat} R_O - I_p R_P$$

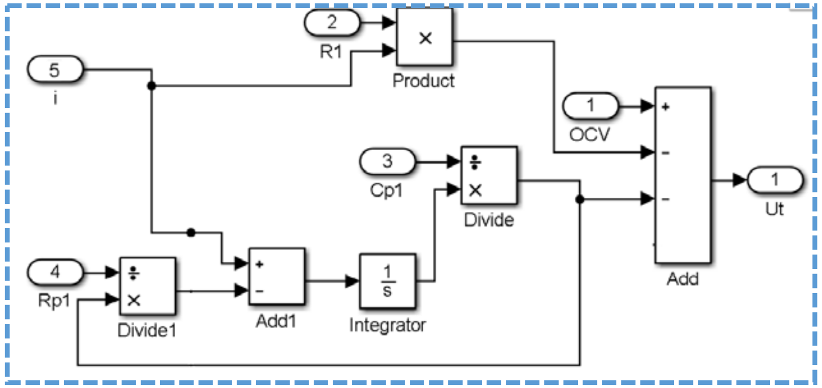


- The simulation model is composed of sub-modules
  - SOC calculation
  - Circuit parameter updating
  - Terminal output voltage calculation
- The model has two inputs
  - The load current profile
  - Initial SOC of the battery

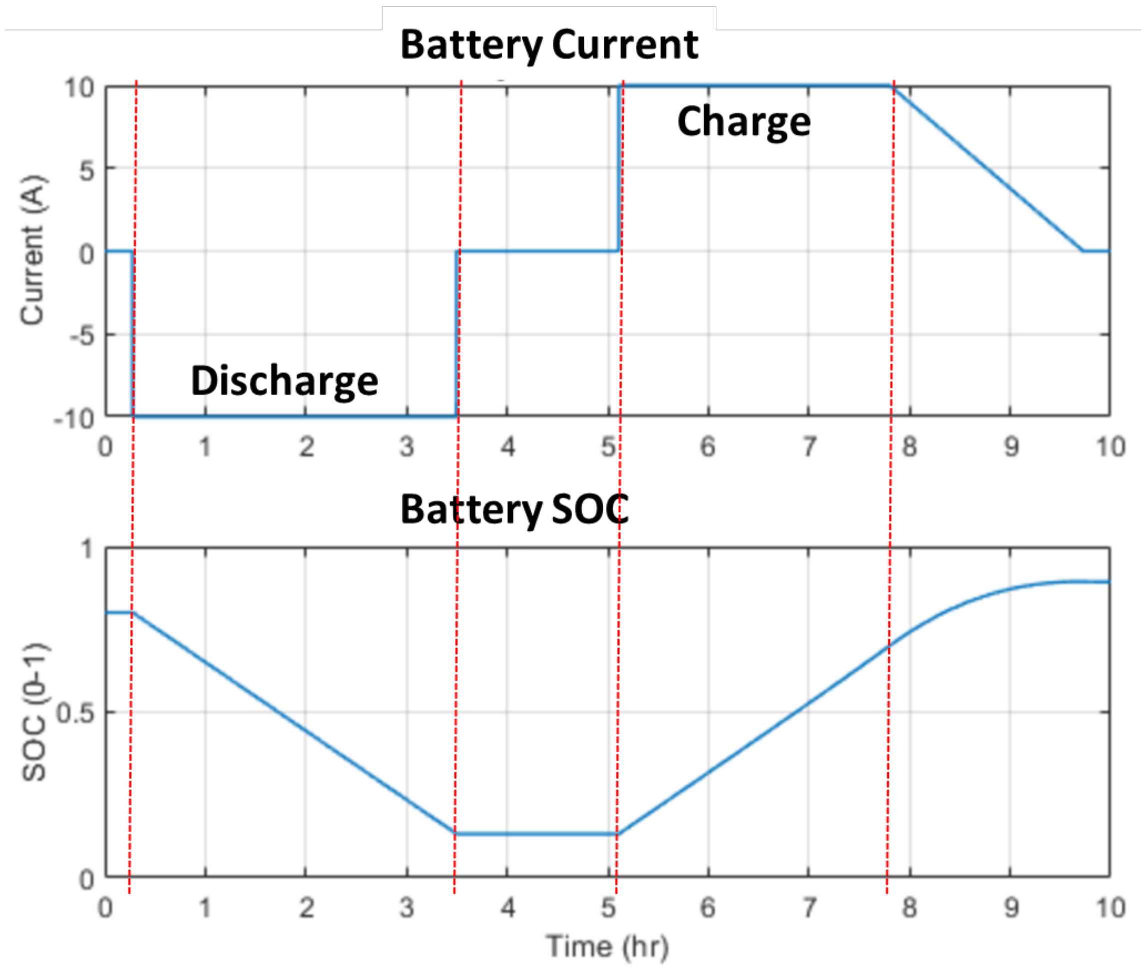
Submodule - SOC

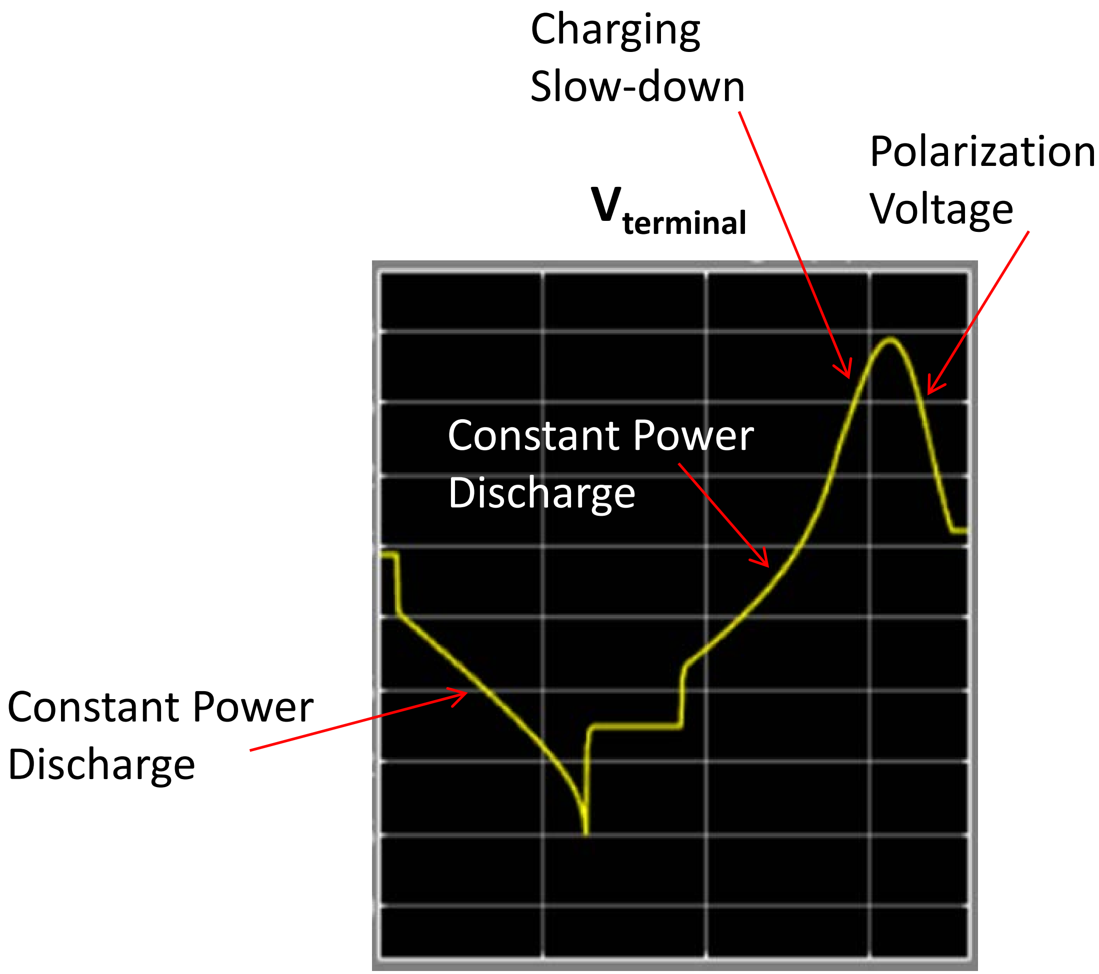


Submodule – Terminal V



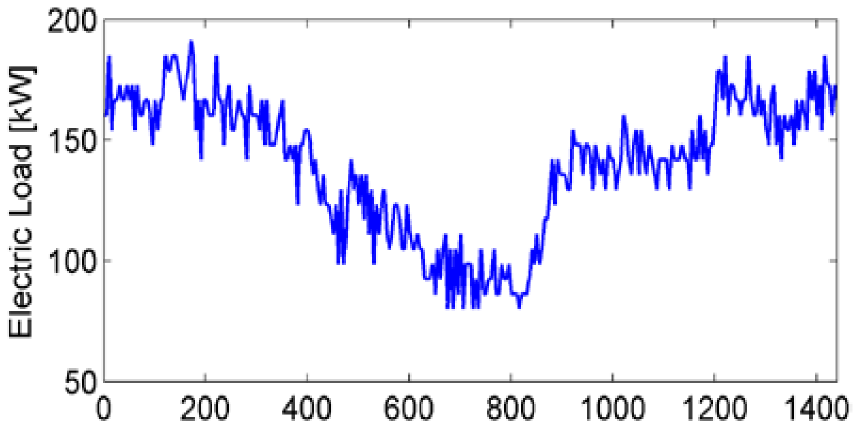
Li-ion Battery Cell Models – Continuous Current Charging / Discharging





System Design & Control - TBD

1. **NEAT Data Integration with Battery Model**
   - Load Power by residences
   - Generated power from PV



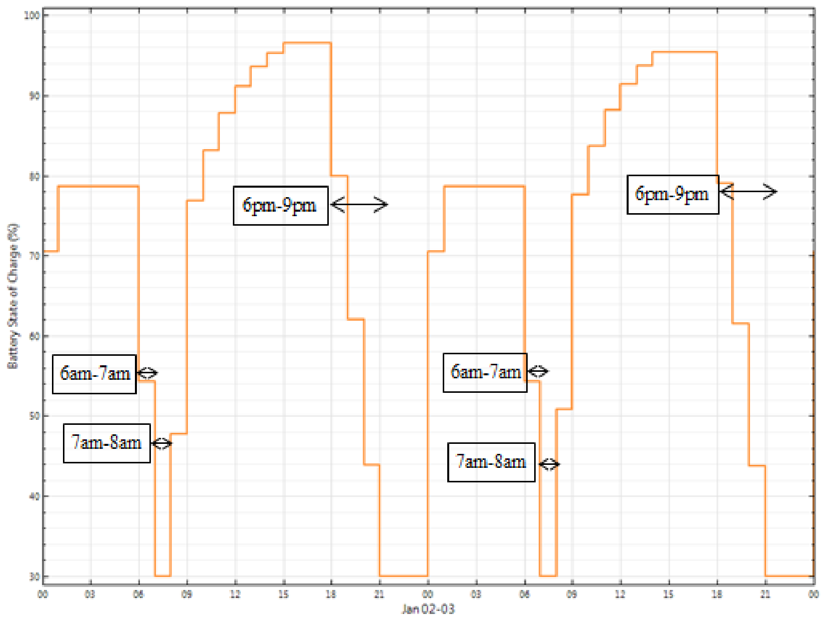
2. **Battery Specification**
   - Capacity, Power capability

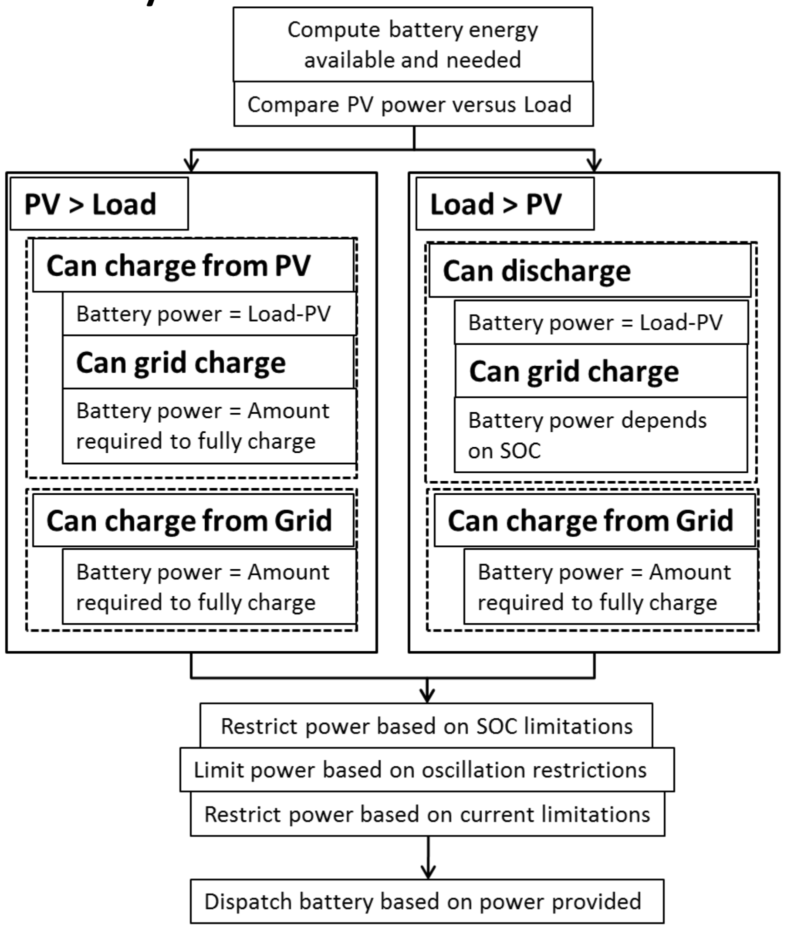
Property	Value
Price	$3000
Capacity	7 kWh
Power	2.0 kW continuous, 3.3 kW peak
Efficiency	92%
Voltage	350 – 450 V
Current	5.8 A nominal, 8.6 A peak
Weight	100 kg
Dimensions	1300 mm x 860 mm x 180 mm

Tesla Powerwall

System Design & Control - TBD

3. Control strategies
   - Control by considering physical limitation of battery
   - Maximize battery utilization





Summary and Next Steps

- **Where we are**
  - Battery model has been developed
  - Parameters for the model, test results from EV batteries, has been extracted from database provided by Argon National Laboratory
  - Simple charging/discharging has been tested in the model
- **What needs to be done next**
  - NEAT specific data will be integrated into model
  - Current default parameters from the Argon Nat'l Lab need to be tuned for residential battery.
  - The control strategy should be developed to control when the battery is charged/discharged and determine which power source (i.e. grid or PV) is used.
  - The battery size needs to be determined through optimization.

Discussion and Public Comment

Next Steps

- Next working group meeting – in next three to four month period
- Topics under development
  - Further Implementation of distributed battery storage
  - Solar and battery cost calculator
  - Results analysis tools
- Demonstration of the input, output and interpretation of the results
- Beta version to be released to working group members