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Climate Safe Pathways Modeling Methodology Summary

Project: GHG Reduction Pathways for Climate Safe California 2030

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Background

The Climate Center is initiating a Climate Safe California policy program to promote the fast reduction of in-state greenhouse gas (GHG) emissions. Earlier this year, Edward C. Myers, Consultant (ECMC) produced visual communication graphics to enable interested allies and policymakers to more readily grasp the GHG inventory sector emissions reductions necessary to yield an overall 80% reduction from 1990 emissions levels by the year 2030, along with sufficient carbon sequestration to meet net zero GHG going into the atmosphere.

To better understand how the Climate Safe policy will impact GHG emissions, at the Center's request, ECMC has developed a Pathways model. This model takes as inputs the extent of a number of tangible actions, and provides a first pass estimate of the resulting GHG emissions reductions. The model also incorporates a working lands carbon sequestration model developed by others, to quantify the net emissions from all emission related activities expressed in the model.

This is the third revision of the model. The electricity sector calculations were extensively revised at the recommendation of Robert Freehling, to better align with the State's terminology for and measurement of electricity flows, and revise the calculation of future GHG intensity estimates for electricity generation.

Methodology

To the extent feasible, the Pathways model is based on available data that has been accepted by the scientific and policy making community. This data was retrieved from various government and other websites, and entered into Microsoft Excel 2019 spreadsheet software. The data sources are documented in footnotes in the modeling spreadsheets. This should be considered a rough model, intended to indicate in a broad sense the emission reduction potential from specific actions (pathways).

The overall Pathways concept is to quantify the tangible actions with eight specific indices, and estimate the impact of each on statewide GHG emissions. These indices are intended to be adjusted by the users, allowing them to view the estimated impact on the resulting GHG emissions. The emission reduction indices are mainly taken from initiatives proposed by the Climate Safe policy:

1. A reduction Vehicle Miles Travelled (VMT) through mass transit and micro-mobility,
2. Gasoline demand reduction from adoption of electric vehicles (EVs), replacing gasoline fueled vehicles,
3. Building Electrification - Substitution of electricity for natural gas for building heating purposes,

4. Increased renewable energy content in electricity generation,
5. Accelerated adoption of rooftop solar photovoltaics (PV),
6. Increased energy efficiency savings reducing electricity demand,
7. Improved energy efficiency in industrial processes, and
8. Improved animal manure management to reduce methane emission from decomposition.

GHG emissions that are difficult to curtail can be mitigated through sequestration. Sequestration is incorporated into the model as new management practices on "working lands". These practices take better advantage of the ability of plants to absorb carbon dioxide from the atmosphere and convert it to forms of solid carbon, that is then sequestered in the soil. Working lands are generally those lands currently under active use or management, such as cropland, pasture, or forestry. The sequestration modeling was performed by Carbon Cycle Institute, and incorporated as-is to the Pathways model. Its indices consisted of nine distinct working land management practices:

1. Rangeland compost
2. Pasture compost
3. Cropland compost
4. Agr- forestry
5. Riparian restoration
6. Prescribed grazing
7. Urban Forest
8. Roadside forest buffers
9. N fertilizer avoidance

The nine sequestration practices become indices directly, expressed as thousands of new acres per year that incorporate one (or more) of the practices.

The Pathways emission reduction modeling is based on CARB's (California Air Resources Board) 2017 GHG inventory, which categorizes the state's GHG emitters into the following sectors: Electricity Generation, Transportation, Industrial, Commercial, Residential, and Agricultural & Forestry. Each sector is further broken down into line items. The Pathways emissions reduction indices impact a varying number of line items in each sector. Therefore, the modeling effort first groups each remaining inventory sector's line items (activities) into sub-sectors: one or more groups for those line items impacted by an index, and one group for those not impacted. In the modeling algorithm, the impacted sub-sectors emissions are reduced each year over the 2020-2030 Climate Safe time horizon in a linear progression; the non-impacted sub-sectors are assumed to remain unchanged.

All the Electricity Generation sector's line items (and therefore the sector as a whole) are impacted directly by three indices: renewable electricity, efficiency, and solar PV. The Electricity sector is indirectly impacted by EV adoption and building electrification indices, since they will cause new electricity demand.

The modeling of the first six emission reduction indices (VMT, EVs, electrification, renewable electricity, efficiency, solar PV) focuses on the energy carriers that will be impacted by the proposed changes.

Three major energy carriers - gasoline, natural gas, and electricity, will see the most significant impacts of the Climate Safe policy. These three energy carriers are closely measured by the state, so we know both their usage and current (baseline) contributions to GHG emissions. For gasoline and natural gas, the ratio of GHGs produced to mass consumed is known from combustion stoichiometry, so we can confidently predict future emissions when we model these carriers based on mass consumed. For electricity, the calculation of GHG emissions is considerably more involved, as will be discussed below.

These energy carriers also have interdependent relations, as more electricity will be needed to replace phased-out gasoline and natural gas. The Pathways modeling makes a first pass at capturing these interdependencies at the energy-supply level, using published ratios for the amount of the preferred form of energy carrier (electricity) needed to serve the same purposes as the phased-out form (natural gas or gasoline).

There are a number of key assumptions in our modeling approach:

1. The same level of energy services (e.g. vehicle capacity and mobility, and building comfort) are maintained when substituting electricity for natural gas and gasoline. For instance, those who prefer large gasoline vehicles will trade them in for large EVs.
2. The vast majority of gasoline is consumed by light vehicles (cars and pickup trucks) which are currently candidates for EV conversion (EV meaning battery-electric, not plug-in hybrids). The model does include parameters that allow set-asides for off-road gasoline use, and on-road gasoline vehicles that have no EV substitute.
3. We model gasoline sold as an assumed proxy for the number of gasoline vehicles remaining on the road. The implication is that one new EV sold means one less gasoline car on the road, yielding a proportionate drop in gasoline demand (and emissions). However, there are at least two complicating factors:
    a. If buyers of new EVs would have otherwise purchased new fuel-efficient gasoline vehicles, the remaining gasoline vehicle fleet becomes, on average, less fuel efficient. As a result, gasoline sales (and emissions) decline less than expected from vehicle sales.
    b. Any newer gasoline vehicles traded-in for EVs will likely remain in service to the end of their useful life and add to the number of active vehicles in the state (and total VMT). This increase in active vehicles might keep gasoline demand higher than would be the case if the EVs only replaced gasoline vehicles headed for the junkyard. In other words, proposing that the rate of EV purchases be faster than the rate of gasoline vehicle retirement may not yield the hoped-for emissions reductions.
4. All diesel fuel is consumed by heavy vehicles that will have no EV substitutes in the next ten years. The implication is diesel fuel GHG emissions remain constant.
5. VMT reduction initiatives will only impact gasoline demand and its resulting On-Road emissions; the predominantly heavy vehicles using diesel fuel will not be affected.
6. Gasoline demand will drop in direct proportion to VMT reduction.
7. Petroleum refinery processing GHG emissions (in the Industrial sector) will drop in proportion to the total transportation fuel (gasoline, diesel, and jet fuel) produced. This could result from the

complete closure of smaller refineries, or turndown of gasoline specific processing units at larger refineries.

The Electricity sector is the most challenging to model for tracking flows and calculating GHG emissions. First, it can be generated by consumers, for instance by installing solar PV. Conversely, gasoline and natural gas move one-way from suppliers to consumers, and burned to release the energy (and GHG emissions). Second, the amount of GHG emitted per kWh of electricity varies widely by the generation source; nominally zero for renewable electricity sources, to very high for coal powered generators. Conversely, the amount of GHG emissions per mass of gasoline or natural gas burned is always the same, fixed by combustion stoichiometry.

To address the complexity of characterizing electricity flows, we have adopted the state electricity administrators' terminology (and baseline electricity data) to describe and predict these flows, as follows:

- Consumption – all electricity used, whether it was sold to the consumer by the utility, or the consumer generated it themselves (through solar PV and cogeneration)
- Self-generation – Produced by consumers who generate part or all of their own electricity, through solar PV or cogeneration. This is tracked by the State.
- "Behind the Meter" – All electricity related activity, initiated by the consumer, that has an impact on the demand the consumer will place on the utility. Solar PV and energy efficiency are the two non-consumption "behind the meter" flows accounted for in our modeling.
- Line losses – The electrical energy lost (turned into heat) due to the resistance of conductors, transformers, etc. in distribution between the generation station and the consumer.
- Generation – the electrical energy leaving the utility power facility.

Included in the model as Climate Safe indices are two significant "behind the meter" initiatives: 1) rooftop solar PV and 2) electrical energy efficiency. For rooftop solar PV, the index is expressed as a percentage of an optimistic forecast by the State for 2030 adoption. For electrical energy efficiency, the index is expressed as a percentage of the most aggressive statutory requirement for accelerated energy efficiency implementation.

The future GHG emissions from utility electricity generation are modeled from two main impacts: 1) changes in utility energy demand caused by the Climate Safe initiatives; and 2) the progression of the utility generation mix toward renewable energy. The latter impact is modeled using a GHG Emissions Intensity parameter (GHG emissions per unit of energy) taking into account anticipated changes in generation during the Climate Safe time frame, and the index value set in the model for the 2030 renewable electricity content of the generation mix.

In the Industrial emissions sector, most of the inventory line items are assumed to be amenable to significant energy efficiency improvements, resulting in less fossil fuel use, and a decline in GHG emissions. We group these line items as a single emissions sub-sector and apply a percentage emissions reduction index to reflect the GHG reduction from reduced fossil fuel usage.

In the Commercial and Residential sectors, a different approach was taken to identify the activities and emissions impacted by the only index for this sector: Building Electrification. Building electrification is primarily the substitution of electrically driven heat pumps for space and water heating presently done with natural gas combustion. The Commercial and Residential sectors were combined into one (Com'l + Res.) for the purpose of modeling, since they both comprise buildings amenable to electrification. Published GHG emissions breakdowns from natural gas combustion and all other sources, along with natural gas usage breakdowns, enabled the division of Com'l + Res. into Natural Gas combustion emissions sub-sector (amenable to electrification) and Non-Gas emissions sub-sector (assumed to remain constant), for the purpose of modeling.

For the Agricultural emissions sector, the only inventory line item chosen for potential emissions reduction was Manure Management. The emissions reduction could be accomplished through more anaerobic digestion of manure collected from non-range-fed (eg, feedlot or penned) animals, and collecting the digester biogas for use. We use an index to estimate the percentage emissions reduction available.

Once all the above emission reduction strategies noted above are accounted for, we add up all the sub-sectors for an overall gross emissions estimate, based on the values set for indexes and other adjustable parameters.

The final section of the Pathways model is working lands carbon sequestration, as described above. The resulting atmospheric carbon dioxide sequestered as soil carbon is deducted from the gross emissions, resulting in a net GHG emissions that reflects the overall impact of all the Climate Safe initiatives.

<u>Excel Workbook Modeling Summary</u>

The Pathways modeling and graphics were incorporated into the previous workbook, Wedges Calculation Visualization.xlsx. Three new worksheet tabs (leftmost) encompass the Pathways model:

1. Pathways Background Calcs contains unit conversions and other calculations to determine key parameters.
2. Pathways Data Alignment takes the 2017 state GHG inventory and divides it into sub-sectors to distinguish emission sources impacted by the indices from those not impacted.
3. Pathways Model takes the sub-sector GHG data and the indices to predict the GHG reductions over the 2020-2030 Climate Safe time horizon.

The Pathways Data Alignment worksheet uses color coding of the 2017 emissions numbers to differentiate line items: green line items are included in sub-sectors impacted by the indices, and red items remain unchanged. All Electricity emissions are assumed to be reduced by further adoption of renewable energy. For Transportation, only the On-Road line item is impacted. For the Industrial sector, all the line items except Landfills, Oil & Gas Production, and Petroleum Marketing are believed to be capable of having emissions reduced via energy efficiency measures. For Commercial combined with Residential sectors, the breakdown is done differently. The Energy Commission's Integrated Energy Policy Report (see citation 4 at the bottom) provided an overall percentage of natural gas caused GHG emissions for these two sectors; these natural gas emissions alone will be the impacted by building electrification. Finally, for Agriculture, only Manure Management is deemed to have significant potential for emissions reductions.

The Pathways Model worksheet contains the emissions calculations. In the top rows, key parameters used in the calculations are stated. Those parameters in red are the eight emissions reductions indices and nine sequestration practices. These indices are intended for the user to manipulate in order to observe the impact on overall emissions. The parameters in blue are estimated values for which no precise value was known, or are subject to interpretation, and can be adjusted, particularly if better values are found. All the parameters in black are from literature sources, or unit conversions, and should not be adjusted unless they are found to be in error.

Below the parameters section is the Pathways emissions model. Emissions are calculated for each year from 2020 to 2030 by applying one-tenth of the stated index to each year (a linear progression). The model also progresses from left to right. Groups of columns calculate each sub-sector in order: On-Road Transportation, Com'l + Res. Electrification, Electricity Generation, Industrial Energy Efficiency, Agriculture Manure Management, and finally Sequestration.

For On-Road Transportation, we use gasoline demand as the key tracking variable that will determine the emissions reduction from the VMT and EV initiatives. It should be noted that both the VMT and EV indices quantify directly the resultant gasoline demand reduction; the assumptions noted above address the implications of this approach. VMT reduction (column B) is the first index impacting gasoline demand (column C). Column D is the set-aside for off-road uses, and column E is the set-aside for gasoline vehicles with no EV substitutes. Column G tracks the gasoline sold to the remaining light vehicles which could be subsequently converted to EVs. Column H adds back the two set-asides, for total gasoline demand. Column I calculates emissions from gasoline combustion. Column J translates to total On-Road emissions, maintaining the 17 MMT year 2020 difference (156 MMT from the On-Road inventory line item, minus 139 MMT calculated from gasoline combustion), which is assumed to arise from diesel on-road emissions.

Two indirect (i.e. occur in other sectors) GHG emissions effects of EV conversion are given first pass estimates: 1) Gasoline related refinery emissions (Industrial sector) are assumed to be reduced in proportion to transportation fuel (gasoline, diesel, and jet fuel) production in columns K and L; 2) the emissions from added utility electricity demand from EV charging, based on a gasoline to electrical energy substitution ratio obtained from the literature, are estimated in columns N, O, and P. For the purpose of simplicity, here it is assumed the 2017 emissions intensity of power generation is maintained through 2030. Later, the model does account for the effect of more renewable electricity over time (and any reduced emissions intensity) when calculating total electricity GHG emissions.

Building electrification impacts are calculated in columns R through Z. The Gas to Electric Substitution index is a direct percentage reduction of natural gas GHG emissions from the combined Commercial plus Residential sectors, calculated in column S. Columns T through V estimate the potential indirect effect of reduced natural gas demand leakage, which would likely be counted in the Industrial sector. However, this benefit may be delayed in part until pressurized gas delivery lines are shut down entirely. These results are only for the purpose of the Bldgs Gas->Elec chart; they are not carried into the total emissions numbers, as this leakage emission reduction could overlap the Industrial Energy Efficiency blanket reduction (resulting in potential double counting).

Columns W through Y estimate the emissions added electrification energy demand by converting the thermal energy content of the displaced natural gas to electricity to drive heat pumps, using a literature ratio for the amount of natural gas thermal energy to electrical energy for the same heat output. This reflects the electric heat pump's ability to output several times more heat energy than it takes in as electrical energy. This emissions calculation (column Y) is only for the purpose of the Bldgs Gas->Elec chart, and uses the 2017 electricity emissions intensity parameter for simplicity.

Perhaps the main downside, from a GHG perspective, of heat pumps is that most refrigerants they currently use are complex halogenated (chlorinated and fluorinated) hydrocarbons. They are typically gases at atmospheric pressure. When they leak into the atmosphere, their high global warming potential means even a small quantity can have significant climate impact. In column Z, we estimate that impact based on literature data. This calculation is used only for the Bldgs Gas->Elec chart, and is not carried into the total emissions summation.

Columns AB through AO model the changes in electricity usage, and electricity generation emissions. Column AB sets a constant electricity consumption baseline for modeling purposes. It is recognized that actual consumption will change during the model timeframe; indeed, the State provides estimates of future consumption up to 2030. However, the State's estimates incorporate their own projections for impacts this model also accounts for, such as EV charging and rooftop solar PV. Using the State's future consumption values could cause double counting of consumption changes subsequently included in the model.

Column AC accounts for ramped-up electricity energy efficiency implementation. The Climate Safe Energy Efficiency index, which determines the extent that energy efficiency will reduce consumption, is expressed as a percentage of the SB 350 statutory policy mandate. SB 350 requires a doubling of the current implementation rate; setting the index to 100% allows the model to reflect the SB 350 implementation rate. Column AD calculates the GHG emissions impact of efficiency, due to reduced utility generation demand.

Column AE sums the effect of all modeled behind-the-meter non-generation impacts (EVs, Electrification, Energy Efficiency) on total electricity consumption.

Column AF accounts for the future installation of behind-the-meter solar PV, using the Climate Safe PV Capacity index to quantify the rate of new solar PV installations. This index is expressed as a percentage of the highest rate of adoption estimated by the state. Setting this index to 100% allows the model to reflect the impact of the state's highest estimated adoption rate on consumption. Column AG calculates the resultant emissions reduction from utility power generation.

Columns AH through AJ calculate required utility power generation. Column AH sums up "at the meter" electricity sales, accounting for all behind-the-meter effects. Column AI determines distribution line losses, which add to sales to determine utility power plant generation (column AJ).

The final electricity sector calculation estimates the GHG emissions from utility generation (columns AK through AO). The emissions intensity factor of Column AK is calculated separately in the Pathways Background Calcs worksheet, using the current breakdown of the utility generation types as a baseline, then accounting for anticipated changes in the future. The "2030 Renewable Content" index can be adjusted to view the effect or more or less aggressive moves toward renewable utility generation on the emissions index (and resultant electricity sector GHG emissions).

Column AL estimates the GHG emissions reductions from improving generation GHG emission intensity alone. Columns AM and AN break out the emissions contributions from EV charging and building electrification, using the predicted emissions intensity values. Finally, column AO determines the total electricity sector emissions.

Columns AP through AQ use overall emission reduction indices to estimate potential savings for Industrial and Agricultural emissions. In the Industrial sector, a number of inventory line items deemed amenable to significant energy efficiency improvements are combined in a sub-sector and adjusted base on the index. For Agriculture, in columns AS and AT, Manure Management becomes a sub-sector with an index for reduced emissions from improved manure treatment (such as anaerobic digestion).

Column AR totals all GHG emissions, showing for 2020-30 the net effect of all emissions changes.

Columns AX through BG incorporate each sequestration model practice as developed by Carbon Cycle Institute. The sequestration practice index values were provided by the authors. Column BC sums the total emissions sequestration from all practices. Finally, Column BH calculates the net GHG emissions, after sequestration.

<u>Excel Workbook Graphics Summary</u>

For visualization of the modeling results, a number of stacked bar charts showing the following GHG impacts are included:

1. VMT reduction and EV conversion – includes key impacts in non-transportation sectors;
2. Building electrification – includes refrigeration leakage, plus cross-sector impacts from natural gas leakage and added electricity demand;
3. Electricity sector, breaking out solar PV, energy efficiency, electrification, and EV charging impacts;
4. Industrial Energy Efficiency and Agricultural Manure Management are combined;
5. All Pathways sub-sector emissions, along with the indices, show the comprehensive Climate Safe impact;

6. Sequestration, showing the relative impacts of each practice;
7. Total emissions are re-combined as inventory sectors, total sequestration, and resultant net emissions.

These charts are fully dynamic; they will change as the values of the indices (in red) in the Pathways tab model are adjusted, and the model itself re-calculates.

The intent of the first three charts is to isolate the 2030 emissions impacts of the indices in focus (shown at the top), and incorporate resultant cross-sector emissions losses or gains. Impacts of other indices are "locked out", so these chart values change only as the indices in focus change.

For instance, the VMT Reduction and EV conversion chart (EV VMT Chart tab) calculates 2030 EV charging emissions using the 2017 (baseline) electricity emissions intensity. In that way, the EV electricity emissions won't fluctuate as the unrelated 2030 renewable energy electricity content index is changed. Conversely, we note that the subsequent summary emissions charts, the EV charging emissions will use the 2030 renewable electricity content, and the resulting lower emissions. The separate emissions impact of EV or VMT indices can be observed by setting one of the indices to zero in the Pathways Model tab and changing the other.

The Building Electrification chart (Bldgs Gas->Elec Chart) shows significant net reductions from electrification, even when taking into account new electricity demand and refrigerant leakage emissions.

The Electricity Sector Chart shows the combined effect of the five indices that impact electricity emissions: renewable content, EV charging, building electrification, energy efficiency, and solar PV. It breaks the 2030 emissions changes down by their indexed components. PV, Energy Efficiency and Renewable Generation effects are shown below the zero line, as their effect is to reduce emissions. Building Electrification and EV adoption are above the zero line, as they increase generation demand and emissions.

The effects of emissions reductions for those line items in the Industrial sector deemed amenable to energy efficiency improvements, along with improved manure management, are shown in the "Ind EE Ag Manure Chart" tab.

In the "Pathways Emissions Summary Chart" tab, all the sub-sectors are displayed to show the combined effect of all the indices, whose values are shown on the left side for reference. The color choice for the bars is intended to keep consistency with the sector colors chosen previously. The sub-sectors with the fade effect are those whose emissions are subject to reduction by one or more of the indices; the solid color sub-sectors are not affected and remain constant. The total of all sub-sectors is displayed above each of the bars.

The "Sequestration Chart" tab displays the emissions sequestration contributions of each of the nine practices, whose parameters are listed on the left.

Finally, the “Sectors Net Emissions Chart” tab pulls all the sub-sectors back into their respective sectors, to display the overall impact of the emission reduction indices and sequestration practices, and the resultant net emissions.

Summary

The overall goal of the Climate Safe policy is net zero emissions by 2030. The delivered version of the Pathways model had the indices set at values deemed aggressive:

- VMT down 20%,
- Light vehicle gasoline demand down 50%,
- Building electrification reducing natural gas heating demand 50%,
- Energy Efficiency savings rate 1.5 times SB 350 statutory (150%)
- Solar PV adoption rate 1.5 times the State’s highest case (150%)
- Electricity generation renewable content raised to 70%, vs. SB 100 at 60%,
- Industrial energy efficiency capable sub-sector GHG emissions down 30%,
- Agriculture - Manure GHG emissions down 30%.

The sequestration practices were left at the adoption levels prescribed by the authors, resulting in 103 MMT CO2eq removal by 2030.

The model result showed net emissions of 155 MMT in 2030, short of the net zero goal. However, that remains a very significant reduction from the 424 MMT 2020 baseline.

There are a number of factors that cause this set of Pathway model indices to fall short of the net zero goal:

1. There are 84 MMT of emissions in four sub-sectors that are not impacted by the indices: 1) Agriculture, other than manure management; 2) Commercial plus Residential, for all emissions not related to natural gas usage; 3) Industrial, those inventory line items not influenced by energy efficiency gains; and 4) Transportation, for inventory line items other than On-Road. This 66 MMT will remain unchanged in 2030 regardless of the indices’ values.
2. Within the sub-sectors impacted by the indices, there are set-asides which mean that even if an index is set to 100%, some emissions remain:
    a. For Gasoline demand, we set aside a total of 15% for current off-road uses plus those gasoline vehicles that can’t be converted to EVs in the next ten years;
    b. Diesel fuel powered on-road vehicles (assumed mainly heavy trucks) will not be replaced with EVs, so on-road emissions from diesel will remain constant;
    c. Refinery emissions due to diesel and jet fuel production (not affected by EVs’ gasoline reduction) will remain constant;
    d. In the Commercial sector, 11% of natural gas is used in applications not deemed amenable to electrification, and the resultant emissions remain constant;

3. There are practical limits to the values set for the indices, meaning it's not realistic to push them too high just to zero out net emissions. Some examples:
    a. It would be problematic to propose that EVs be sold at a higher rate than the existing rate of new car purchases. The traded-in newer gasoline vehicles will likely remain on the road until the end of their useful life, and continue to consume gasoline, so gasoline emissions would remain higher than predicted by the model. There are 32 million cars and light trucks registered in California, with about 2 million new vehicles purchased per year. A 50% reduction in gasoline by 2030 due to EVs implies half the 2030 light vehicle fleet will be EVs, requiring 1.6 million of the annual 2 million new light vehicles sold to be EVs. Pushing the index much higher than 50% by 2030 would exceed the traditional new car purchase rate.
    b. Given the intermittent nature of renewable electricity, until very significant investments are made in electricity storage, natural gas-powered generation will be required to prevent blackouts; 100% renewable electricity is not deemed practical in ten years.
    c. In the Industrial sector, energy efficiency improvements can only reduce wasted fossil fuel energy. The useful energy actually needed to drive the industrial processes (and the resulting emissions) cannot be easily eliminated.