350 PPM Pathways for Florida
Frequently Asked Questions with Answers from the Research Team

Q: Why is this report groundbreaking? What does it mean?

A: This report provides a detailed roadmap to transition Florida off of fossil fuels quickly, also known as decarbonization. using a pace and approach that is consistent with transitioning the U.S. off of fossil fuels – as described in 350 PPM Pathways for the United States. It is the first of its kind to illustrate several low carbon energy pathways for Florida consistent with returning atmospheric carbon dioxide (CO_2) to 350 parts per million (ppm) by 2100.

Q: **How exactly does this study relate to the 350 PPM Pathways for the United States? Do they share the same target? Do they share the same assumptions?**

A: Both studies aim for greenhouse gas emissions reductions rapid enough to enable a return of atmospheric CO_2 to 350 ppm by 2100, which is what scientists say is needed to stabilize the climate system, so they share the same science-based target. They both assume the same very limited carbon budget for the United States and the Florida decarbonization study represents Florida's share of meeting that nationwide target. Both the U.S. study and the FL study use the U.S. Department of Energy estimates (and assumptions) about the future demand for "energy services" like lighting, transportation, industrial production, and building heating and cooling. Both studies assume the same pace of technology development.

Q: How does this research relate to the *Reynolds v. State of Florida* legal case?

A: While the youth plaintiffs in the *Reynolds* case are not asking the Court to implement any specific policies, this study illustrates several technically and economically feasible decarbonization pathways that are consistent with the 350 ppm CO_2 target by 2100, the science-based target plaintiffs' experts say is needed to protect the constitutional rights of youth. The pathways analyzed in the report would not be ordered or implemented by the Court, as that is not the proper role of the Court, but could constitute evidence of the feasibility of alternatives to Florida's fossil fuel energy system.

Q: **Are there other deep decarbonization studies that come to similar conclusions?**

A: This study is consistent with many of the conclusions of other decarbonization studies, although this study uses a unique analytical approach that gives us additional insight into electricity system operations and the role that some new technologies might play on the system. In addition, this study analyzed pathways consistent with the 350 ppm CO_2 target by 2100, while most other studies assume a larger carbon budget.

Q: **Why do you use the energy forecast provided by the U.S. Energy Information Agency (EIA) as your baseline? Are EIA's forecasts and data reliable or do they overestimate energy demand?**

A: We use the underlying energy services demand forecast (space heating, industrial production, vehicle miles traveled, etc.) from the U.S. EIA to support the idea that we can decarbonize the economy - the same economy that is predicted by the U.S. government to run primarily on fossil fuels - without necessitating changes in lifestyle or a reduction in economic output. The EIA's forecasts suffer from the same limitations as all forecasting exercises and will inevitably deviate from actual future service demands but they are important because they provide an apples to apples comparison.

Q: **Why don't you assume more people will walk or bike or take public transit?**

A: We wanted to support the hypothesis that we could support the same level and type of energy services that the U.S. government predicts we'll need to satisfy to 2050. Lifestyle changes, however, are important and will make the transition easier, cheaper, and necessitate less additional infrastructure and so should continue to be encouraged for those and other reasons, even if they're not a requirement for decarbonization.

Q: **If we conserve more energy and consume less, can we meet all U.S. energy demand with 100% renewables by 2050?**

A: Yes! Meeting our energy demand with 100% renewables (wind, water, solar, hydro, biomass + storage) by 2050 is possible even under the projections of steady energy demand provided by the U.S. Energy Information Administration. Meeting all energy demand with renewables would just be more costly, under our assumptions, than to continue to deploy small amounts of fossil fuels in some areas of the economy.

Q: **Can I access the data sets you used for this research?**

A: The underlying data that we utilize for the modeling exercise is public and cited in our technical appendix.

Q: **Can I access the detailed results you used for this research?**

A: Many key outputs are available in the report and technical appendix. Additional outputs are available upon request.

Q: **Has an energy transition of this speed and magnitude ever happened in the U.S. or elsewhere?**

A: Significant energy and economic transitions have happened in the U.S. (rural electrification, nuclear deployment, World War II mobilization), sometimes at even greater rates of change, but there are no perfect analogs domestically or internationally for this transition. But the science is clear that significant climate impacts will result if we fail to initiate a transition of this speed and magnitude.

Q: **What would need to happen for this transition to be done in a way that is just and equitable?**

A: This transition offers two key inherent opportunities for making our energy system more equitable than it is today.

First, with nearly complete reliance on fossil fuels, the current energy system disproportionately impacts lower income households who pay a larger share of their income for energy. Without alternatives to fossil fuels, when energy prices spike, those same low income households get squeezed financially. In this way, the current energy system is extremely regressive. In contrast, in a low-carbon energy system, electricity becomes the centerpiece of energy service delivery, and the regulation of electricity rates gives policymakers the ability to support equity with different rate structures (i.e. low-income rates) and cost allocation mechanisms. Fossil fuels like oil are obviously not subject to regulated rates, eliminating this opportunity to improve price equity. Communities of color and low income households experience exposure to a disproportionate share of the air and water pollution that result from fossil fuel extraction, processing, transportation, and use. After transitioning to a low carbon energy system, most of those sources of fossil fuel pollution from power plants, vehicles, and petroleum refineries, will be eliminated, reducing the unfair burden placed on disadvantaged households.

Second, in terms of managing the transition effectively, it will be necessary to focus on policymaking to account for the changes to industries that may decline or change significantly. In our scenarios, for example, there are some very obvious transition paths: while petroleum refining declines, we have an entirely new advanced biofuels, carbon capture, and power-to-fuels industry that requires much of the same skillset. Policymakers will need an understanding of how to manage the changing nature of energy system costs from one that is primarily operating costs (i.e. gasoline, natural gas, etc.) to one that is capital intensive (discussed in more detail below).

Q: **How does this type of energy transition get paid for? How much does the state or federal government need to spend on this transition?**

A: As shown in our net cost results, the key to this transition is that the shift in energy system spending is large, but the overall net cost is relatively modest. That means that most of the new spending is offset by reduced spending on fossil fuels. The adoption of electric vehicles (EVs) is a good example: buying an EV is a significant upfront expense but then the lifecycle costs of owning an EV become lower than gas or diesel vehicles and the initial purchase price of the EV is more than paid back through fuel savings. However, the nature of these costs changes substantially. While fuel costs are saved over the vehicle's lifetime, the initial upfront cost is incurred over a shorter period (i.e. length of the car loan). If not carefully addressed through public policy, this increase in upfront purchase price can create extreme inequities by allowing those with disposable income to acquire a lower-cost vehicle than those who are cash poor.

Q: **Fossil fuel jobs will be lost in this transition. Will this energy transition create more jobs than the number lost?**

A: Fossil fuels are a necessary ingredient to make this 30-year transition happen, therefore fossil fuel jobs will not end quickly but will ramp down slowly over the course of the transition. If done well, the predictable and measured reduction in fossil fuel jobs can occur largely through natural retirements and then, rather than training and hiring more people to work in the fossil fuel industry, new energy workers will be trained to work on renewable technologies instead.

The number of fossil fuel jobs that will ultimately be discontinued over the course of this transition isn't calculated through this study nor is it a number that is possible to calculate with the types of modeling tools traditionally employed. Macroeconomic models are intended to represent small changes to the current economy, which is precisely calibrated. Huge transitions like the ones we model aren't well-suited for these types of analyses. We can say that the opportunity exists in a low-carbon economy for a vast number of infrastructure jobs and an increasing domestic share of overall energy production.

Q: **Have you modeled the macroeconomic impacts of this transition?**

A: This study does not include an evaluation of the macroeconomic impacts, and there are not currently plans to investigate the macroeconomic impacts part of this study. However, ICF International completed a study of macroeconomic impacts of reducing U.S. greenhouse gas emissions 80% by 2050. The conclusions of this study would be illustrative of the types of results we might expect from this 350 PPM Pathways research for Florida. Those results are available here: https://nextgenpolicy.org/wp-content/uploads/2015/11/ICF-Study-Summary-of-Findings-Decarb-Econ-Analysis-Nov-5-2015.pdf

Q: **What are your assumptions about passenger and freight rail?**

A: We don't assume significant changes in passenger and freight rail due to the uncertainty around costs/viability of alternative technologies like direct electrification.

Q: **Are there technologies that are not yet developed that would be needed to implement one of the pathways modeled?**

A: No technologies that are in the research phase are employed in this study, though some are employed that have only been piloted or not deployed at commercial scale.

Q: **What is the hardest part about deep decarbonization at this scale?**

A: Three primary challenges include: coordinating change across all sectors of the economy; siting large amounts of new infrastructure in short periods of time; and accelerating industrial production of key technologies (wind, solar, batteries) to support the timelines of the transition. A comprehensive national or state-level plan would greatly assist with the coordination of decarbonization and help overcome these hurdles.

Q: **What is the benefit of deep decarbonization at this scale?**

A: The most significant benefit is reducing greenhouse gas emissions commensurate with what science says we need to achieve to stabilize the climate system and avoid the worst impacts from climate change (e.g., multi-meter sea level rise). There are numerous co-benefits including huge reductions in air pollution (pollution that disproportionately harms people of color and low income households), potential for national energy independence and improved national security, reduced environmental degradation from fossil fuel extraction (an impact that disproportionately harms indigenous communities, people of color, and low income households), and energy system costs that are lower and less volatile once the transition is complete.

Q: **How will this energy transition impact an ordinary person? What will our lives look like if this happens?**

A: Most of the change will be in the way that you pay for energy services. Instead of oil bills, gas bills, and paying at the pump, much of your household expenses will be concentrated into one electricity bill. The total amount of money each household spends will not be significantly different. Because these scenarios don't necessitate significant lifestyle changes, the average American won't see a significant difference in day to day activities. Many of the changes occur "under the hood" of the energy system, or well before a consumer interacts with it. For example, operations of the electricity system will need to change drastically, but the (LED) lights will still come on when you turn on a switch and you will still be able to drive your (electric) car.

Q: **How much harder does it get to stay within the targets and the carbon budget with each year of delay?**

A: Each year of stasis in the energy system is *hugely detrimental* to meeting the targets simply because today's emissions represent such a huge portion of the remaining emissions budget. If we continue to burn fossil fuels at the current rate, even for a few years, the descent will have to be that much steeper and deeper over the rest of the first half of this century.

Q: **What are the most important things that need to happen in the next 5-10 years?**

A: In the report we identify key actions by decade. For the 2020s we state the following as the most important actions both for near-term reductions and setting us up for a transition to a longer-term low emissions economy:

- Begin large-scale electrification in transportation and buildings
- Switch from coal to gas in electricity system dispatch
- Ramp up construction of renewable generation and reinforce transmission
- Allow new natural gas power plants to be built to replace retiring plants
- Start electricity market reforms to prepare for a changing load and resource mix
- Maintain existing nuclear fleet
- Pilot new technologies that will need to be deployed at scale after 2030
- Stop developing new infrastructure to transport petroleum fuels

- Begin building carbon capture for large industrial facilities

Q: **How is Direct Air Capture different from Carbon Capture and Storage (CCS)?**

A: Direct air capture is a technology that captures CO_2 from the air, at the low concentrations that occur in the atmosphere. Traditional carbon capture technologies rely on capturing a more concentrated stream of CO_2 from a combustion source like a natural gas power plant. Direct air capture technologies are considered “negative” emissions technologies because they extract CO_2 from the atmosphere where carbon capture, when applied to sources that are actually generating CO_2 through fossil fuel combustion, only avoids additional CO_2 emissions.

Q: **Why is Direct Air Capture an important component of deep decarbonization?**

A: Direct Air Capture can be an important backstop technology if other strategies that we intend to rely on (zero-carbon biomass, electrification, etc.) don’t materialize at their expected scale. When powered by zero-carbon electricity, direct air capture can remove CO_2 from the atmosphere and either sequester it (resulting in negative emissions) or utilize it with hydrogen to produce a carbon-neutral alternative to fossil fuels (gas, diesel, gasoline, etc.).

Q: **Has Direct Air Capture of carbon dioxide been proven at scale? How do you know it will work?**

A: Direct Air Capture hasn’t been proven at scale but has been demonstrated in pilot projects. It is not deployed in all scenarios and is only deployed at any volume in later years of the analysis to offset certain hard-to-decarbonize corners of the economy if other mitigation pathways fail to materialize. In this way, it’s an important “backstop” technology.

Q: **What are the risks or downsides of Direct Air Capture technology?**

A: Capturing CO_2 from the atmosphere is an energy intensive process. Therefore, these direct air capture plants are most cost effective if they operate on excess low-carbon electricity – solar or wind, for example – when they are producing more than is needed. This electricity that would otherwise be “curtailed” is inexpensive from a system perspective. If there is not excess electricity available, the operation of Direct Air Capture facilities will require the construction of new renewables to support their energy needs. It isn’t possible to run these economically on the grid as it looks today because the emissions associated with fossil-fueled electricity would offset much of the benefit of the capture process. It only “fits” on a low-carbon grid. Like other new infrastructure, there will be land use and siting challenges, though there is no imperative to locate them near human habitation.

Q: **Why do the 350 ppm deep decarbonization pathways call for building more gas power generation capacity?**

A: In the near-term, the priority is displacing electricity generation from the existing coal fleet. We assume real world limitations on the speed of renewable energy deployment in the near-term, which means while much of the displacement can be renewables, gas still plays a role in the rapid drawdown of coal generation. If planned well, in the longer-term these aren’t wasted investments, as gas-fired electricity generation, running very rarely to provide capacity, is the most cost-efficient way to maintain electric reliability, even as we transition to a system where most of the energy is being provided by renewable sources. With load growth from electrification, in the longer term, the need for capacity is growing, even with higher energy efficiency, flexible load, and the deployment of significant renewables.

Q: Will the transition to low carbon require construction of new natural gas transmission pipelines?

A: New pipelines that transport biogas, synthetic gas from renewables, hydrogen, or CO_2, may be required. This is because the locations where these future sources of energy or carbon are sourced are not the same locations where we source natural gas today; and therefore, will require some new pipeline to connect them with loads or with carbon sequestration locations. As a general rule, new pipelines to transport natural gas are not needed in this transition, though exceptions may exist. As stated before, the priority is creating a switch from coal to gas as fast as possible and new pipelines, where they can make this transition happen faster, may be a part of the lowest cost strategy to reach 350 ppm.

Q: **How often would gas powered plants be used in the low-carbon scenarios?**

A: By the year 2050, gas generators would operate less than 15% of the hours of the year. This is approximately a quarter of the time they operate today on a grid that delivers ~2x more electricity. This gas does not need to be fossil, either. It can burn electrically-derived or bio-based fuels.

Q: **Why do most scenarios call for Carbon Capture and Storage (CCS) and Carbon Capture and Utilization (CCU)? Why can't we transition off of fossil fuels quickly enough to avoid the need for carbon capture?**

A: Carbon capture does not mean we are always capturing emissions from fossil energy. Most of our carbon capture is done in conjunction with biofuels production or accomplished through Direct Air Capture, which is not reliant on fossil fuel use.

These both contribute negative emissions without requiring fossil fuel consumption so the use of carbon capture in these scenarios does not necessarily support continued use of fossil fuels.

When fuels (aviation, for example) or the chemical components of fuels (cement, petrochemicals) are required for an application, the use of carbon capture is critical. This can be used either in the production of fuels (CCS on biomass production, power-to-x using direct air capture) and/or at the point of use (CCS on cement and petrochemicals). This can result in zero or negative emissions fuels pathways, which contribute to overall emissions reductions in the economy.

Q: **Are CCS and CCU already being used in the U.S.? How much more use would be needed?**

A: CCS and CCU in the applications we're describing is not common in the U.S. The only significant use for captured carbon, currently, is enhance oil recovery, which is not an application we analyze in any great detail and is not the purpose of CCS and CCU in our scenarios. This would therefore be an almost entirely new industry, but one in which the technical implementation is already well understood.

Q: **How are synthetic liquid fuels made? Are there facilities making synthetic liquid fuels? Can they be used the same as petroleum products?**

A: Synthetic liquid fuels are made by synthesizing a mixture of CO_2 (produced through carbon capture) and hydrogen (produced primarily through electrolysis). This is synthesized into liquid hydrocarbons through the Fischer-Tropsch process in our modeling, though there are other synthesis routes as well.

Q: **How does making synthetic gas by methanation work? Are there facilities making synthetic gas?**

A: Synthetic gas is made by methanating a mixture of CO_2 (produced through carbon capture) and hydrogen (produced primarily through electrolysis, a process of splitting water molecules into H_2 (hydrogen) and O_2 (oxygen) molecules with an electric current). There are dozens of projects in Europe but only one demonstration project in the U.S. as of 2019.

Q: **Can existing fossil fuel infrastructure be used with synthetic fuels and gases?**

A: Yes, these are what we refer to as “drop-in fuels” meaning all the components of the existing delivery (pipelines, storage facilities, etc.) and end-use consumption infrastructure (trucks, boilers, etc.) can use these fuels as if they were fossil-based.

Q: **How are jet fuels made? Are there facilities producing low carbon jet fuels at scale?**

A: In our modeling, jet fuel is made through Fischer-Tropsch processes, like the processes employed to make power-to-liquids. In this case, biomass is gasified to produce the mixture of CO_2 and H_2 (syngas) needed to then be synthesized into liquid fuels using Fischer-Tropsch.

Q: **Can bio-based aviation fuels be produced at the quantity required without impinging on land needed for crop production?**

A: Based on previous analysis we conducted, the level of biomass we employ is consistent with a level that would not impinge on food production domestically or internationally. This is due in part to the fact that much of the biomass is waste or woody biomass, but there is also significant land that could be repurposed from corn ethanol production in our analysis. This corn ethanol production declines commensurate with the decline in gasoline demand as we electrify light duty vehicle travel.

Q: **How much more biofuel production would be needed nationally, compared the amount produced today?**

A: Current biofuel production nationally is approximately 1600 TBtu with the vast majority being corn ethanol. The most biofuel we see in any of our nationwide scenarios is 8400 TBtu. This would represent an approximately 5x increase in overall biofuel production. The low-biomass scenario for the U.S. uses 4,200 TBtu.

Q: **How is hydrogen made from electricity? Are there large scale hydrogen production facilities in use in the United States?**

A: Hydrogen is made from electricity through the process of electrolysis. This is a well understood process that is used in some industrial applications. There are not currently large-scale electrolysis facilities in the U.S. because the economics currently support hydrogen production through natural gas reformation. With higher levels of renewables on the systems and an imperative to reduce carbon, economics would dictate the deployment of electrolysis or the employment of carbon capture on natural gas reformation.

Q: **How does this study compare to a 100% renewable electricity study? Why is looking at electricity supply in isolation from other energy sectors counter-productive to stopping climate change?**

A: 100% renewable electricity studies focus only on reducing emissions in the electric sector. This is important, but too limited when trying to understand how to reduce all statewide emission to near-zero. The electric sector requires significant sectoral integration (production of electric fuels, direct electrification of transportation, etc.) both to meet its own targets and support the transition to zero-emissions economies for all sectors. Narrowly focusing on reducing emissions from the electric sector without considering its interaction with other sectors or its role in supporting the emissions reductions from other sectors (e.g. transportation) is likely to lead to counterproductive decision-making and investments. For example, rather than forecasting declining electricity demand in the future, we need to be planning for a two-fold increase in electricity demand. Even though we don’t directly model 100% renewable systems, we are modeling very high renewables and there are two key lessons to learn in terms of the economic operations of these types of systems in an economy-wide low carbon context:

1. The use of electric fuels as a balancing resource in order to address seasonal balancing challenges is critical to avoiding large amounts of overgeneration of electricity that would result in temporarily shutting down renewable generators, a practice known as “curtailment”.

2. Allowing new gas-burning electricity generators to be constructed, even if requiring them to be fueled with biogas or power-to-gas when they run, is essential for operating a high renewables system reliably and economically.

Q: **Does this study rely on offsets to meet the emissions reduction and carbon budget targets?**

A: No, this study does not rely on offsets to meet the targets. As explained by climate scientists like Dr. James Hansen, being on the 350 ppm by 2100 trajectory requires rapid emission reduction and carbon sequestration through improved forestry and agriculture.

Q: **How does your study address natural carbon sequestration from forestry and agriculture?**

A: This study did not model or evaluate sequestration potential, but assumed a certain amount of carbon sequestration from forestry and agriculture in the US based on recent research of what is feasible and based on the quantities necessary to return to 350 ppm in the atmosphere by 2100[1]. These amounts provided a constraint that informed the energy system decarbonization scenarios.

Q: **What would happen if we decommissioned nuclear power plants that are currently operating?**

A: Decommissioning nuclear without the time to replace them with renewable energy would result in higher operating levels for other online thermal plants (coal and gas). In the longer-term, they can be technically replaced with renewables, but in many cases, this would increase the cost of achieving emissions targets. Still, this would not affect our conclusion of the scenario being technically possible.

Q: **Do we need new nuclear to meet the emissions reduction and carbon budget targets?**

A: No, we do not. We see that in our “100% Renewable Primary” scenario where we remove all fossil and nuclear energy by 2050. Achieving the target requires more renewable energy generation, but this can be accomplished with little impact to overall compliance costs.

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[1] Fargione, et al., *Natural climate solutions for the United States*. 2018. https://advances.sciencemag.org/content/4/11/eaat1869