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The Pursuit of Renewable Energy

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Forms of Renewable Energy

POWER

- Hydroelectric
- Wind
- Solar
- Bioenergy
- Geothermal
- Ocean

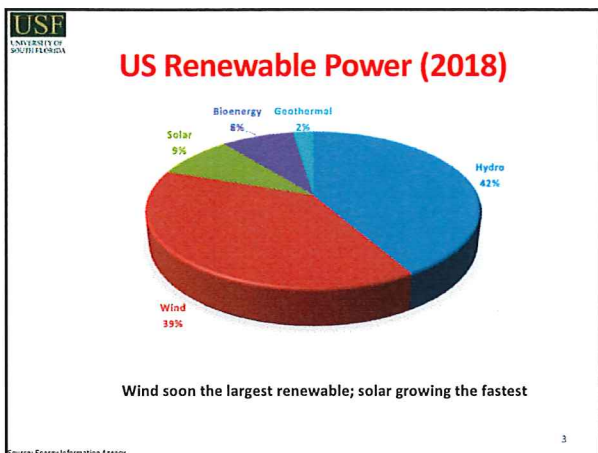
FUELS

- Biofuels
 - Ethanol (cars)
 - Biodiesel (buses, trucks)
 - Jet biofuel (planes)
- Electricity
- Hydrogen

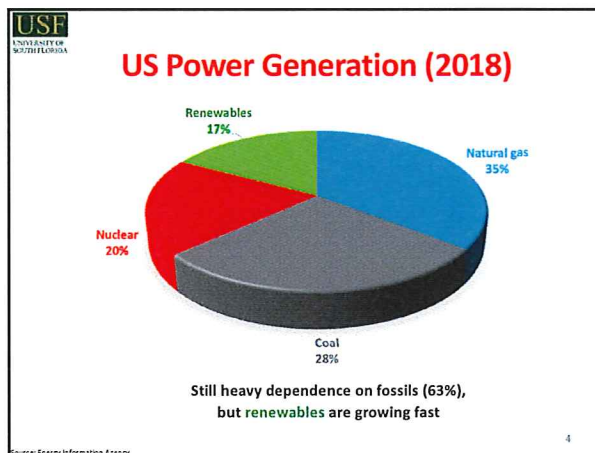
Source: Philippidis, G. "Powering America with sustainable energy in the 21st century", *J. Renewable Sustainable Energy*, 4, 062821 (2012)

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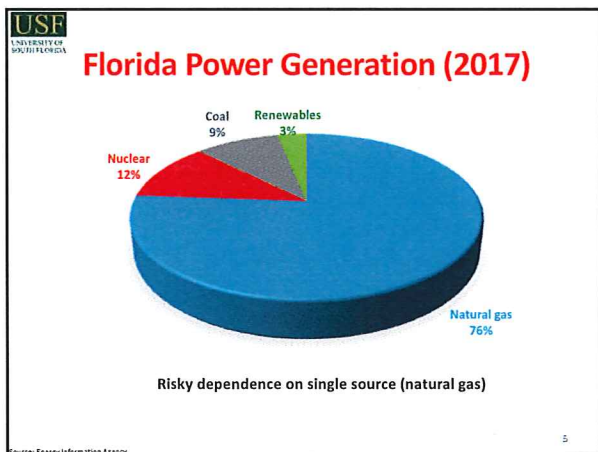
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Drivers of Renewable Power

- **Endless, clean, sustainable**
 - One or more forms of renewable energy available everywhere
- **Energy security**
 - Diversification
 - No dependence on imports
 - Benefits to domestic economy
- **No or low emissions**
 - Combat climate change
 - Protect air quality

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Climate Change

- Increasing atmospheric carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons alter earth's climate
 - CO₂: from power generation, transportation, industry
 - CH₄ and N₂O: from agriculture
 - CFC: from industrial applications
- Climate change leads to:
 - Global warming
 - Extreme weather phenomena (life and property loss)
 - Sea-level rise
 - Ocean acidification
 - Damages to agriculture
 - Damages to fishing
- Sea level rise threatens coastal large cities: adapt or relocate at huge costs
- Take steps to reduce GHG emissions as an insurance policy regardless of political beliefs

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Atmospheric CO₂ Level

Atmospheric CO₂ at Mauna Loa Observatory

Scripps Institution of Oceanography
NOAA Earth System Research Laboratory

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Solar Power

- Water heating
 - Solar energy heats up water
 - Widely practiced around the world in small scale
- Photovoltaics
 - Solar energy converted to electricity
 - Residential, commercial, institutional, utility
- Thermal (concentrated)
 - Solar energy converted to heat and then to electricity
 - Large power generation

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US Solar Insolation (average daily)

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Wind Power

- Expanding quickly (on-shore, off-shore)
- Already cost-effective at large scale (< \$0.05/kWh)
- Florida's FPL leading wind power producer in USA

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Geothermal Power

- Thermal energy from the earth
- Steam for electricity generation
- Hot water for space heating



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Bioenergy

- Power from agricultural residues, forest residues, and yard waste (biomass)
- Biogas from anaerobic digestion (industry, farms)
- Landfill gas
- In abundance in all states and countries

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Ocean Power

- Tides, waves, thermal, currents
- Emerging technologies
- Continuous source of power
- Florida: Gulf Stream looks promising






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Renewable Fuels

- **Biofuels**
 - **Ethanol** from corn, sugarcane, biomass
 - High octane fuel (113)
 - **Biodiesel** from vegetable oils, waste oils, grease
 - Cleaner than diesel (lower emissions)
 - **Jet Fuel** from vegetable oils
 - Inedible oils (sustainable agriculture)









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Biofuels = Agricultural Fuels

Source: North Florida Research and Education Center (2019)


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Jet Fuel from Carinata

- **Brassica carinata**
 - Mustard family crop, related to canola
 - Non-edible crop
 - Produces seeds rich in oil
- Winter cover crop in southeastern US
 - Complements summer crops (soy, cotton, peanuts, corn)
 - Additional income for farmers
 - Crop rotation improves soil quality
 - Cover crop reduces erosion




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Electric Vehicles


- Sustainable, but **only** if the power is renewable
- Electric and hybrid vehicles
- Battery technology:
 - Extend driving range
 - Shorten recharge time



Tesla Model S




Chevrolet Volt



Nissan Leaf

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Sensible Strategy

- No single energy source is a “silver bullet”
- For a sustainable economy:
 - Promote energy conservation and efficiency
 - Boost deployment of renewable energy

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What about Florida?

- Our best resources:
 - Solar
 - Utility, commercial, institutional, residential
 - Biomass
 - Utility
 - Ocean (gulf stream)
 - Utility

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