

# **Energy Solutions to Combat Climate Change**

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### Citizens for Nuclear Technology Awareness (CNTA)

### Nonprofit organization

- Approximately 450 individual members
  Almost 200 young professional members
- 30 corporate and business sponsors
- Largely a volunteer organization
- Visit our website: cntaware.org

### **OUR CORE MISSION IS EDUCATION**

COMMUNICATING THE VALUE OF NUCLEAR SCIENCE & TECHNOLOGY FOR OUR

#### - HEALTH

- ENVIRONMENT
- NATIONAL SECURITY
- ECONOMIC DEVELOPMENT

# **CNTA's Activities**

- Education
  - Workshops
  - Scholarships
  - Teach-ins
- Outreach
  - STEM events
  - Published articles
  - Speaker's Bureau
- Networking
  - Up and Atom breakfasts
  - Teller Lecture
  - Young Professional Events
  - Golf tournament





### **Presentation Outline**



- Power Generation
  - Base, Intermediate and Peak loads
- Global Warming Greenhouse Effect
- Current "Zero Carbon" energy sources
  - Types
  - Statistics
  - Challenges

Future "Zero Carbon" energy sources



## Electrical Energy

• Electricity is the end product of converting another form of energy to electrical energy





# **Electric Industry Components**



Source: U.S. Energy Information Administration



### Base, Intermediate, Peak Load



### Base, Intermediate, Peak Load





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### Base, Intermediate, Peak Load

	Base	Intermediate	Peak
Coal	Х	Х	Х
Natural Gas	Х	Х	Х
Oil			Х
Hydro	X (Where Available)		
Wind		Х	?
Solar		Х	?
Geo Thermal	X (Iceland — 70%)		
Nuclear	Х		





# EARTH

About half the solar radiation is absorbed by the Earth's surface and warms it.

Infrared radiation is emitted from the Earth's surface.

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Nuclear Awareness	GHG	Water Vapor/ Clouds	Carbon Dioxide	Methane	Ozone
	Formula	H <sub>2</sub> O	CO <sub>2</sub>	CH <sub>4</sub>	0 <sub>3</sub>
	Contribution	36-72%	9-26%	4-9%	3-7%

- Greenhouse gases (GHG) greatly affect the temperature of the Earth; without them, Earth's surface would average about <u>33°C colder</u> than the present average of <u>14°C</u>.
- Since the beginning of the Industrial Revolution, the burning of fossil fuels has contributed to a <u>40% increase</u> in the concentration of <u>carbon</u> <u>dioxide</u> in the atmosphere from 280 ppm to 400 ppm.

### Current "Zero Carbon" emission energy sources

- Hydroelectric power
- Wind power
- Nuclear power
- Solar power
- Geothermal power
- Tidal power













### Worldwide share of energy sources





### Lifecycle CO<sub>2</sub> Emissions by energy source



Source	GHG, g/kWh (mean value)
Coal	888
Oil	733
Natural Gas	499
Solar PV	85
Biomass	45
Nuclear	29
Hydro	26
Wind	26

Lifecycle emissions including manufacture, installation, operation and waste management Source: "Comparison of Lifecycle Greenhouse Gas Emissions of Various Electricity Generation Sources", World Nuclear Association

### Future "Zero Carbon" emission energy sources



- Small modular nuclear reactors (SMR)
- Fusion reactors
- Hydrogen power systems
- Space power
- Advanced energy storage











### Nuclear Fission vs. Fusion





### **SMRs and Fusion Reactors**

- Small Modular Reactors
  - Under development and deployment by end of decade
  - Utilize nuclear fission
  - Bill Gates founded and is primary investor in SMR company Terrapower!
- Fusion Reactors
  - Potential as enormously powerful clean energy source
  - Extreme conditions (high temperatures and pressures) make containment challenging!
  - ITER is an international fusion research and engineering megaproject in France – start of deuterium-tritium operation by 2035?







## Hydrogen Power and Space Power

- Hydrogen Power
  - Low efficiency but large benefit of easy storage
  - Need method to produce hydrogen
    - Nuclear reactor (or other clean energy source) to "split water"
    - Reforming natural gas with carbon capture system

### Space Power

- Space-based mirrors concentrate/reflect solar energy to collectors
- Beam to earth via microwave or laser







## Advanced Energy Storage

- Limitations of lithium ion batteries
  - Relatively short storage life
  - Materials intensive strain on world-wide natural resources reserves
  - Low efficiency = high relative cost for industrial scale
- Energy storage future solutions
  - Flow batteries liquid electrochemical reactions
  - Gravity based system convert excess electrical energy to mechanical energy and use gravity to discharge when needed
  - Thermal storage convert excess electrical energy to thermal energy and discharge via a heat pump principle
  - Compressed air convert excess electrical energy to pump/store gas and store under high pressure until needed









## **Clean Energy for the Future**

- Overcoming limitations
  - Intermittent availability wind, solar, hydro
  - Land requirements wind, solar
  - By-products nuclear waste
  - Natural resource limitations batteries, solar
- "All of the Above" strategy
  - Many promising technologies best approach may be to use them all!

