TEAMS 2015 Scenarios

Experience the power of engineering through the 2015 TEAMS competition!

“The Power of Engineering” provides students the opportunity to learn more about energy and how it relates to engineering. Scenarios focused on alternative energy, smart houses, the environment, solar, nuclear, wind, and water bring to light issues that engineers face every day.

The TEAMS scenario summaries presented here offer an overview of the topics that will be addressed in the 2015 TEAMS competition. Scenarios may be edited and expanded upon in the actual competition questions; however, the general content will be similar.

Students can begin to prepare for the competition by researching key concepts and terms presented in the scenarios. A list of web related links is provided at the end of each scenario summary for extended exploration. These links should not be considered all inclusive; team members and coaches are encouraged to research content beyond the provided lists.

General background information can be found on the TEAMS website: www.teams.tsaweb.org/Backgound

Original academic and innovative concepts are developed for the competition based on the National Academy of Engineering’s Grand Challenges (www.engineeringchallenges.org).

You can learn more about the NAE Grand Challenges at www.engineeringchallenges.org.

Disclaimer: These scenarios are for reference only and include links providing direct access to internet sites not controlled or maintained by TSA. TSA takes no responsibility for the content or information contained on or within the links and sites. TSA does not exert any editorial or graphic control over the sites. Refer students to these sites and links after your review.

Alternative Fuels

Renewable fuels are made from the products of fuel combustion, which are carbon dioxide (CO_2) and water (H_2O). The carbon emitted from renewable fuels remains in a cycle that does not increase the overall concentration of atmospheric carbon. Thus, the use of renewable fuels does not contribute to climate change. Many techniques being researched to convert CO_2 and H_2O into fuel. Biofuels present a critical set of methods, because they do not require the feed steam of CO_2 to be highly concentrated. For this reason, biofuel production is the only method able to extract carbon from the atmosphere (0.04 mol%) for use in renewable fuel production. For a biofuel to be renewable, the energy expended in growing, harvesting, transporting, and converting biomass into – for example, one ton of fuel - must not exceed the amount of energy in that ton of fuel.

Carbon Cycle Fuels has developed an improved version of Plasma-Arc Gasification. This is the process of converting carbonaceous materials (such as biomass or coal) into a gaseous stream by exposing it to a stream of argon plasma heated to 25,000°F by an electrical arc. The products of the reaction are carbon monoxide (CO), hydrogen (H_2), and carbon dioxide (CO_2), also known as "syngas", short for "synthesis gas".

Carbon Cycle Fuels wants to partner with a synthetic fuels manufacturer. The top two contenders are Advent Company and Barriston Company. While synthetic fuels have historically been made using syngas from gasified coal, both companies are eager to partner with Carbon Cycle Fuels to be the first to demonstrate the production of synthetic renewable fuel at the pilot scale. The Advent Company advertises a technology used in New Zealand in the 1980s known as the "Mobil Process," which first converts the syngas to methanol using copper, zinc oxide, and alumina catalysts, and finally converts the methanol into gasoline using a zeolite catalyst. The Barriston Company advertises a technology used by Germany in the 1940s known as "Fischer Tropsch synthesis," which converts syngas directly into diesel using either cobalt, iron, or ruthenium as the catalyst.

How can engineers help? Your engineering consulting group has been hired by the Carbon Cycle Fuels Company, a startup biofuels manufacturer, to evaluate the feasibility of partnering with certain synthetic fuel manufacturers, each which uses different fuel-production technologies.

Explore More:

- **http://en.wikipedia.org/wiki/Synthetic_fuel**
- **http://en.wikibooks.org/wiki/Introduction_to_Chemical_Engineering_Processes**
- **Chang, C. D. and A. J. Silvestri (1987). "MTG - ORIGIN, EVOLUTION, OPERATION." ChemTech 17(10): 624-631**
- **Stocker, M. (1999). "Methanol-to-hydrocarbons: catalytic materials and their behavior." Microporous and Mesoporous Materials 29(1-2): 3-48**
- **Van der Laan, G. P. and A. Beenackers (1999). "Kinetics and selectivity of the Fischer-Tropsch synthesis: A literature review." Catalysis Reviews-Science and Engineering 41(3-4): 255-318**

Concentrating Solar Power (CSP)

Engineers are continually designing new ways to harness and use solar energy. Early solar technology efforts looked at ways to dry food, distill water, or heat homes. More recent designs, such as Concentrating Solar Power (CSP) technologies, concentrate or focus the sun's rays, resulting in higher temperatures and the ability to heat larger amounts of materials. CSP units heat fluid to generate electricity in a process similar to that in a conventional power plant, except that coal or natural gas combustion is replaced with heat from concentrated solar energy. This process is different from the photovoltaic effect of solar panels, because it allows CSP units to generate power in a cloudy sky using sufficient thermal reserves.

The main sub-systems of a CSP unit include the solar island (used to capture the sun's energy) and the power island (used to generate electrical power). Many of the latest CSP technologies also integrate thermal energy storage, which allows power to be generated four to six hours after sunset by drawing on energy collected during the daytime. This is a great improvement over solar panels or older CSP units, because the sun does not need to shine for power to be generated.

Innovations in concentrating solar power can reduce reliance on fossil fuels, reduce emissions that affect air quality, and reduce the extent of global warming.

How engineers can help? Your team has been challenged to improve the efficiency and extend the night time operating hours of a concentrating solar power unit. Beginning with principles related to the conservation of energy and learning new principles about solar energy conversion, compare and evaluate the effects of solar energy availability, material properties, heat losses, thermal energy storage, and working fluids on a variety of pertinent technical merits.

Explore more:
Overview on concentrating solar power - http://energy.gov/eere/sunshot/concentrating-solar-power

Energy 101 video on concentrating solar power - http://energy.gov/eere/videos/energy-101-concentrating-solar-power

Configurations of CSP units - http://energy.gov/eere/sunshot/csp-systems-research-and-development

CSP unit with thermal energy storage - http://www.solarreserve.com/what-we-do/csp-technology/

CSP example (Ivanpah Solar Electric Generating System) - http://www.ivanpahsolar.com

CSP example (AORA Solar) - http://www.ivanpahsolar.com

Energy and the Environment

Energy is essential to meeting basic human needs. Until recently, the United States relied primarily on fossil fuel sources – oil, natural gas, and coal – for the generation of energy. There are obvious disadvantages to maintaining the use of fossil fuels at past rates - including concern about depleting these resources and concern about the pollution that occurs from burning these fuels. Alternative energy sources, such as solar, wind, biodiesel, and hydro power, are increasing in use, but there are concerns related to their use, as well.

When engineers analyze an energy source, they must consider a number of factors - including anticipated demand, availability of the source of energy, cost of the infrastructure, and cost of the fuel/power. For example, in 2012 the US Energy Information Administration reported that over 36 billion gallons of No 2 diesel was sold for on-highway use alone. As demand for transportation fuels continues to increase both domestically and internationally, coming up with alternative transportation fuels that are more sustainable is essential to greening the economy.

How can engineers help? As the world relies less on fossil fuels and more on alternative sources of energy, engineers are tasked to improve energy efficiency and minimize negative effects on the environment. Your team will be challenged to explore issues related to alternative fuels for transportation. For example, while 100% biodiesel fuel can be used directly in diesel engines, it is typically manufactured using a mixture of petroleum and vegetable based oils.

Explore more:

United States Office of Energy Efficiency and Renewable Energy
http://energy.gov/eere/office-energy-efficiency-renewable-energy

Calculating CO_2 emissions: Guidelines for Measuring and Managing CO_2 Emission from Freight Transport Operations:
http://www.cefic.org/Documents/IndustrySupport/Transport-and-Logistics/Best%20Practice%20Guidelines%20-%20General%20Guidelines/Cefic-ECTA%20Guidelines%20for%20measuring%20and%20managing%20CO2%20emissions%20from%20transport%20operations%20Final%2030.03.2011.pdf

National Biodiesel Board - http://www.biodiesel.org

US Department of Energy, Alternative Fuels Data Center www.afdc.energy.gov/fuels/biodiesel.html

US Department of Energy, Energy Efficiency & Renewable Energy
http://www.fueleconomy.gov/feg/biodiesel.shtml

Biofuels as Renewable Energy: Biodiesel from Soybeans
http://www.youtube.com/watch?v=8IbnRYTgSGM

University of Idaho Extension – Biodiesel
http://web.cals.uidaho.edu/biodiesel/

Greenhouse gas related to climate change: http://climate.nasa.gov/causes/

Hydropower

Hydropower generation involves the continuous flow of water to produce electricity. Today, approximately 20% of the world's total energy production comes from hydropower stations. Hydroelectric dams are among the most widely recognized engineered structures in the world. The energy they produce brings life to communities and provides economically competitive and renewable power for entire regions.

Hydropower generation offers many benefits compared to fossil fuel-based power generation. The benefits include nearly emissions free generation, flood control, pump-storage opportunities, and long production life. However, hydropower generation also has some known challenges. Hydroelectric dams greatly impact natural hydrologic flows in a geographic region, and they affect aquatic ecology and water quality. While the sustainability of hydroelectric power generation has been called into question over the past few decades, hydropower will continue to significantly contribute to the world's power generation for the foreseeable future.

How can engineers help? Your team will determine the amount of power generated by a hydroelectric generation station. You will examine and learn about turbine selection, and you will be asked to consider the environmental, social, and economic impacts of a hydroelectric project.

Explore More:

Idaho National Laboratory, Hydropower - http://hydropower.inel.gov/

US Geologic Survey, Hydroelectric power: how it works - http://water.usgs.gov/edu/hyhowworks.html

UN Environment Programme, Dams and Development Project – http://www.unep.org/dams/

International Commission on Large Dams - http://www.icold-cigb.org

US Society on Dams - http://www.ussdams.org

Bureau of Reclamation, Hoover Dam - http://www.usbr.gov/lc/hooverdam/

Nuclear Power Plant Safety

The world needs reliable, cost effective, carbon free energy to meet the future power demands of the planet. Nuclear energy creates a significant amount of power without producing greenhouse gases. Nuclear power plants can operate for 18 to 24 consecutive months without being refueled.

Nuclear energy facilities employ hundreds of highly trained and qualified individuals who must operate these facilities safely 24 hours a day, 365 days a year. Individuals at these facilities include men and women who hold positions as engineers, technicians, operators, and mechanics, as well as security guards and other support staff. The engineers at a nuclear power plant are responsible for maintaining large mechanical and electric components that allow a nuclear reactor to generate electricity safely.

How can engineers help? Your engineering and operations groups are responsible for maintaining the safe operation of a nuclear power plant while optimizing the water-steam flow through the plant to ensure maximum electricity output.

Explore More:

Nuclear Plant Safety Features - http://www.nei.org/Issues-Policy/Safety-Security/Plant-Security

Safety of Nuclear Power Plants - http://nuclearinfo.net/Nuclearpower/WebHomeSafetyOfNuclearPowerPlants

Enhancing Safety at U.S. Nuclear Plants - http://www.power-eng.com/articles/print/volume-116/issue-5/features/enhancing-safety-at-us-nuclear-plants.html

Nuclear Power Plant Spent Fuel

Reliable nuclear power plants are able to produce large amounts of affordable electricity. Nuclear power plants generate electricity by fissioning uranium fuel. Fission is the process of splitting a large atom into two smaller atoms by hitting it with a neutron.

Fission simultaneously produces heat and additional neutrons, which can be used to fission the next uranium atom. Nuclear energy does not emit greenhouse gases because it uses fission, not combustion, to generate electricity. This means that nuclear energy technology is one way to combat climate change.

Nuclear power, however, does generate used fuel that must be safely stored and ultimately disposed. Typically, used fuel is removed from a nuclear power plant's core after six years of operations. It is then transported to a spent fuel pool where it stored for 10+ years while it cools enough to be placed into canisters.

This is necessary because uranium fuel will continue to create heat even after being removed from the core. This heat, called decay heat, is the result of radioactive decay. Decay heat occurs naturally from the decay of long-lived radioisotopes produced during the fission process.

How can engineers help? Your team of engineers at a nuclear power plant is responsible for ensuring the safe operation of a nuclear power plant's spent fuel pool. A large earthquake has occurred that has damaged the pump and heat exchanger for your spent fuel pool. How will your team deal with this issue?

Explore More:

Safe Storage of Spent Fuel - http://www.ucsusa.org/nuclear_power/making-nuclear-power-safer/handling-nuclear-waste/safer-storage-of-spent-fuel.html#.VCl5zU10yos

Storage of Spent Nuclear Fuel - http://www.nrc.gov/waste/spent-fuel-storage.html

Used Nuclear Fuel Snapshot 2013 - http://www.nei.org/Master-Document-Folder/Backgrounders/Reports-And-Studies/Used-Nuclear-Fuel-Snapshot-2013

Smart Homes

All-in-one designs have become a popular alternative to multiple devices in the past few years, influencing the integration of technology in the design of houses. The idea of an "operating system for the home" has been research and recently published in a paper, *HomeOS* [1]. Such a system gives the resident complete control over the home environment through the interface on a central computer.

Some residents have opted for an *augmented* home, which is different from a *smart* home. Augmented homes use traditional technologies, with additional functionality. An example of augmented technology would be a light switch modified to produce the desired result, and provide extra benefits (e.g., adjustments to the brightness of lights.

Smart homes may have advantages over augmented homes because of the ways in which technology can be bundled. Some advantages include:

- convenience when common tasks are streamlined
- accessibility for the elderly and disabled (assistive technologies allow for independent living)
- security through cameras, keycards, and motion sensors
- increased resale value
- overall energy efficiency that reduces the stress placed on the environment's natural resources

How can engineers help? Your team will consider different ways that smart homes can increase energy efficiency by focusing on the nature of electricity and the use of solar panels and alternative light bulbs in a residential environment.

Explore More:

Dixon, Colin, et al. "An Operating System for the Home." ***NSDI*****. Vol. 12. 2012.**

Brush, A. J., et al. "Home automation in the wild: challenges and opportunities." ***Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*****. ACM, 2011.**

ECOS Consulting, 2006: ***Final Field Research Report for the California Energy Commission***

Bulb comparison - http://ext.homedepot.com/shopping-tools/light-bulbs/bulbcomparison.html

LED Light Bulb comparison - http://eartheasy.com/live_led_bulbs_comparison.html

Wind Power

Wind power is the conversion of wind energy into a useful form of energy. An example of such conversion is the use of a wind turbine to produce electrical power. Other examples include sails to propel ships, windmills for mechanical power, or wind pumps for water pumping or drainage.

Wind is a free, clean, renewable resource. Recent years have shown an increase in the development of wind farms (groups of wind turbines in the same location producing electrical power) – the result of growing needs for electrical power, coupled with concerns about global climate change created from greenhouse gasses. In 2008 the U.S. Department of Energy released an article entitled “Wind Energy Provides 20% of U.S. Electricity Needs by 2030.” The title speaks for itself.

Engineers are needed to design and build the wind turbines used in wind farms. Wind turbines, which convert kinetic energy from the wind into electrical power, can be devised to rotate either on a horizontal or vertical axis. The most popular wind turbine used in wind farms today is the “horizontal-axis wind turbine” (HAWT). Modern wind turbines typically consist of three large blades (made out of aluminum or a composite material), designed to spin at varying speeds.

How can engineers help? Your team must determine the amount of power a wind turbine can generate and how many wind turbines are needed in the development of a wind farm. You will learn about calculating wind loads and how variables related to the size of a turbine, the speed of the wind, and the efficiency of the turbine and generator determine how much wind power a turbine can generate.

Explore More:

The American Association for Wind Engineering - http://www.aawe.org

How Do Wind Turbines Work? - http://energy.gov/eere/wind/how-do-wind-turbines-work

Wind Farms - http://www.alternative-energy-news.info/technology/wind-power/wind-farms/

Wind Power Engineering and Development - http://www.windpowerengineering.com/

Learning about Renewable Energy - http://www.nrel.gov/learning/re_wind.html

National Wind Watch - https://www.wind-watch.org/

How to Calculate Wind Load - http://www.wikihow.com/Calculate-Wind-Load