

Lecture 1: The Science of Energy and Power

In an increasingly complex and technology dependent world, we are frequently faced with societal imperatives whose thorough understanding challenges even the best informed of the general population. Whether it is cyber security, a global pandemic, the mysterious mass death of honey bees and coral reefs, or global climate change, the complexity of these problems and their solutions is often overwhelming. Too often we feel we have no alternative but to retreat to the familiar: “well, they’ll figure it out”. But who are the “*they*” that we are referring to?

In her engaging and informative lecture on October 30th Professor Debora L VanNijnatten discussed the headwinds being encountered by Canadian Climate Policy in the context of domestic issues and the broader geopolitical situation. In this lecture series we will discuss the real world scientific, engineering and technology tools currently at hand, or under development, that will give force to our public policies and help get us to that important goal of climate stability.

Below are a few basic foundational terms and definitions that we will encounter as we examine “The Challenge of Powering a Sustainable World”.

Renewable vs Sustainable

Renewable and Sustainable describe different energy parameters. Not all renewable energy sources are sustainable – in 18th century Britain, wood fuel and crop residue could not keep up with energy demand. Not all sustainable energy resources are renewable – despite its fixed supply, we will never run out of fusion fuel.

Two Principal Forms of Energy

Kinetic Energy – the energy that is contained in a mass that is in motion, e.g. a cannon ball in flight.

Potential Energy – the energy that is contained in a mass by virtue of its position, e.g. the Collingwood water tower.

Energy vs Power

Energy is defined as the capacity to do work, and is measured by *quantity*.

Power is the *rate* that we use energy and is measured as a function of energy *quantity and time*.

Dispatchable Energy

An energy *source* that can be turned ON, OFF, or Modulated as desired.

Primary Energy vs Secondary Energy

Primary Energy is the energy that's harvested directly from natural resources, e.g. coal or geothermal

Secondary Energy (sometimes called Energy Carriers) are energy forms that are manufactured from Primary Energy. Hydrogen for example.

Prime Mover

Is the Primary Energy source that is driving a downstream energy system, e.g. the Prime Mover of a diesel generator is Crude Oil.

Energy Transition

Is a societal, national or global shift from one dominant form of Primary Energy to another dominant form of Primary Energy. Historically energy transitions have moved from less energy dense sources to more energy dense sources, e.g. the 19th century transition from wood to coal.

Latent Heat of Vaporization

The substantial increase in energy that is necessary to transform a material from solid to a gas without a temperature change. For example: the energy required to turn 1 gram of 100 °C water into 1 gram of 100 °C steam is 600 times *greater* than the energy required to raise 1 gram of water from 99 °C to 100 °C. This is important for understanding how thermal electric generating stations limit and manage their use of fresh water for cooling.

CO₂e

There are many greenhouse gasses besides CO₂ (methane for example). Carbon Dioxide Equivalent, (CO₂e) is the term used to express the warming effect of other greenhouse gasses based on their relative global warming potential.

United Nations population division

An interesting and revealing look at the world's population trends and demographics. World population increases between now and 2050 will have a major impact on the possibility and probability of reaching net zero by the year 2050.

<https://www.un.org/development/desa/pd/>

Gridwatch: Similar to the Electricity Map, but gives real time data on the Ontario Grid.

<https://live.gridwatch.ca/home-page.html>

Electricity Map Live: A terrific interactive map that shows you how much power is being generated, what methods are being used to generate it, and how much greenhouse gas is being emitted (the unit is grams of CO₂e per kWh). Hover over a province or country to see how clean or dirty their electricity production is. Click on a point of interest to get more detailed data. See the difference between how much power they're producing, and how much power they're consuming. It's interesting and fun.

<https://app.electricitymaps.com/zone/CA-ON>

