To: Carol Browner and Heather Zichal, Energy and Environment Policy Team

From: Pat Naughtin, Geelong, Australia

When I heard Carol Browner's line (on YouTube) concerning the development of a new energy and environment policy, "*... you don't have to sit in the traditional government stove pipes ...*", it struck me that there are two major causes of mis-communication in these important policy areas, namely energy language and energy measurement.

Energy language

It is not possible to have meaningful debates or discussions on issues such as peak oil and global warming if many of the people involved have quite different definitions for the seemingly common words used in their discussion.

I am referring to the words *energy* and *power* that are the obvious key words in any discussions about climate change, greenhouse effect, global warming, oil depletion, peak energy, and peak oil.

In any discussion of these issues, the word *power* is not synonymous with the word *energy* and so for clarity of discussion it should not be used as if it is.

To be absolutely clear you probably need to define how you intend to use these words in the introduction of any document you write or edit. Fortunately, both *energy* and *power* have definitions that are relatively simple and readily understood. In scientific and engineering circles, energy always refers to the ability to do work and power always refers to how quickly energy is used. A little more formally, these definitions are:

- Energy is the capacity for doing work, which is the result of the conversion of energy from one form to another. Energy cannot be created or destroyed but it can be converted from one form to another. Internationally, energy has been measured in joules since 1889.
- Power is the rate at which energy is used; it is a measure of how quickly energy is used, transferred, or converted from one form to another. Power is measured in watts.

Energy appears to be more complex than its simple definition because it occurs in many different forms such as: chemical energy, electrical energy, gravitational energy, heat energy, mechanical energy, motion energy, nuclear energy, radiation energy, solar energy, sound energy, thermal energy, and wind energy. When a source of energy is used to do work of any sort, it is converted from one form of energy to another. Despite this, I often hear politicians and the media use terms like nuclear power when they mean nuclear energy, solar power when they mean solar energy, etc.

Power cannot be bought or sold. Utilities sell energy not power. Nor can power be started or stopped. To say, '*we need to start powering our buildings with solar power*' or '*we had a power blackout*' is to demonstrate that the speaker simply doesn't understand that power is the rate of using energy.

Because politicians often use the words energy and power interchangeably, this bad habit is then commonly heard in the media and in everyday speech. The end result of this linguistic confusion is that many in our community do not feel confident discussing energy and power issues because they can't understand the basic key words: *energy* and *power*. However, we cannot understand the real world, how things work, and how to predict our environmental future using language in such a sloppy way.

Recommendation

Energy

> *Examine every instance where you use the word, energy to make sure that you are using it in such a way that anyone with a reasonable education can understand what you mean. Whenever you refer to an amount of energy use the SI unit, joule or one of its multiples.*

Power

> *Avoid the use of the word, power, in all of your reports and recommendations. In fact, go further than this and advise the politicians not to use the word, power, at all in any energy or environment discussion unless they use it in the strictly defined way as used in the technical community. At all times avoid using power as a synonym for energy.*

Energy measurement

I think that many of the communication problems that arise between '*the traditional government stove pipes*' are because the people operating within each of these stove pipes measure energy and power differently. They often use historical measuring words, that were more or less randomly generated and that are no longer relevant. I believe that we cannot have meaningful discussions on issues such as peak oil and global warming if the language we choose is completely muddled by our choice of measuring words.

I have been able to find 198 different methods of measuring energy that are currently used in the USA, and these are only understandable and comparable if you appropriately, and correctly, apply the necessary 39 006 conversion factors between them. Here is a list of the energy words that I have collected — so far — that are in use in the USA in 2008 compared to the single unit, joule, of the International System of Units (SI) more commonly known as the modern metric system.

Table of energy units and old energy measures

Complete list of SI metric energy units	**Some words currently used as energy measures Old pre-metric, early metric, and cross-bred energy measures**
joule J The single SI metric unit can also be used with the SI metric prefixes to form multiples of the SI unit: **kilojoule kJ** **megajoule MJ** **gigajoule GJ** **terajoule TJ** **petajoule PJ** **exajoule EJ** **zettajoule ZJ** and **yottajoule YJ** Conversion factors needed for 1 unit = 0 Factor to go from one prefix to the next prefix is always 1000	Atomic energy unit, barrel oil equivalent, bboe, billion electron volts, Board of Trade unit, BOE, BOT, British thermal unit, British thermal unit (16 °C), British thermal unit (4 °C), British thermal unit (international), British thermal unit (ISO), British thermal unit (IT), British thermal unit (mean), British thermal unit (thermal), British thermal unit (thermochemical), British thermal unit-39, British thermal unit-59, British thermal unit-60, British thermal unit-IT, British thermal unit-mean, British thermal unit-th, BThU, BThU-39, BThU-59, BThU-60, BThU-IT, BThU-mean, BThU-th, Btu, Btu-39, Btu-59, Btu-60, Btu-IT, Btu-mean, Btu-th, cal, cal-15, cal-20, cal-mean, calorie, Calorie, calorie (16 °C), calorie (20 °C), calorie (4 °C), calorie (diet kilocalorie), calorie (int.), calorie (IT) (International Steam Table), calorie (mean), calorie (thermochemical), calorie-15, Calorie-15, calorie-20, Calorie-20, calorie-IT, Calorie-IT, calorie-mean, Calorie-mean, calorie-th, Calorie-th, cal-th, Celsius heat unit, Celsius heat unit (int.), Celsius heat unit-IT, Celsius heat unit-mean, Celsius heat unit-th, centigrade heat unit, centigrade heat unit-mean, centigrade heat unit-th, Chu, Chu-IT, Chu-mean, Chu-th, coulomb volt, cubic centimetre atmospheres, cubic foot atmospheres, cubic metre atmospheres, double Rydberg, duty, dutys, dyne centimetres, E-h, electron mass energy equivalent, electron volt, equivalent volt, erg, eV, foot grains, foot pound, foot pound force, foot poundal, ft-lb, ft-lbf, ft-pdl, gigaelectronvolt, gram calorie, gram calorie-15, gram calorie-20, gram calorie-IT, gram calorie-mean, gram calories (mean), gram calorie-th, grand calorie, grand calorie-15, grand calorie-20, grand calorie-IT, grand calorie-mean, grand calorie-th, hartree, Hartree energy, horsepower hours, horsepower hours (metric), inch pound force, Kayser, kcal, kcal-15, kcal-20, kcal-mean, kcal-th, kgfm, kilocalorie, kilocalorie (16 °C), kilocalorie (4 °C), kilocalorie (int.), kilocalorie-15, kilocalorie-20, kilocalorie-IT, kilocalorie-mean, kilocalorie-th, kiloelectronvolt, kilogram calorie, kilogram calorie-15, kilogram calorie-20, kilogram calorie-IT, kilogram calorie-mean, kilogram calories (int.), kilogram calorie-th, kilogram force metre, kiloton TNT equivalent, kilowatt hour, kilowatt minute, kilowatt second, kWh, large calorie, large calorie-15, large calorie-20, large calorie-IT, large calorie (mean), large calorie-th, Latm, latm, litre atmosphere, major calorie, major calorie-15, major calorie-20, major calorie-IT, major calorie-mean, major calorie-th, megaelectronvolt, megaton TNT equivalent, megawatt hours, metric ton oil, metric ton TNT, metric ton coal, micri-erg, natural unit of energy, newton metre, petit calorie, petit calorie-15, petit calorie-20, petit calorie-IT, petit calorie-mean, petit calorie-th, Q unit, quad, quadrillion, Rydberg, small calorie, small calorie-15, small calorie-20, small calorie-IT, small calorie-mean, small calorie-th, therm, therm (EC), therm (EU), therm (UK), therm (US), thermie (16 °C), ton coal equivalent, ton oil equivalent, ton TNT equivalent, tonne coal equivalent, tonne oil equivalent, tonne TNT equivalent, watt hour, watt minute, and watt second. Conversion factors needed for 198 names = 39 006 Note: Many of these vary in definitions and numerical size according to temperature; e.g. calories and British Thermal Units. Others vary according to spelling; e.g. a calorie is 1/1000th of a Calorie.

Recently, as I researched some dietary issues, I had to confront the linguistic problems that the leaders of the diet and nutrition industries have chosen to face every day. Their key measuring words, calories, Calories, kilocalories, kiloCalories, and (my favourite) the International Steam Table Calories don't necessarily have definite definitions and fixed numerical values. The various different calories arose partly because of the temperature dependence of their definitions —a 15 °C calorie is not the same as a 20 °C calorie — and partly because of spelling differences — a Calorie is 1000 times larger than a calorie because of the upper and lower case c — it follows that a Cal is a thousand times larger than a cal, and a kCal is a million times larger than a cal.

But these linguistic problems in the nutrition industries are relatively minor, compared to the worldwide linguistic problems when we consider the issues of global warming, climate change, peak energy, and peak oil.

Put simply, we are not able to sensibly discuss any issues related to our use of energy and its effects on global warming. Why? Too many people use too many different words to describe the amounts of energy relevant to their particular industry or to their particular nation.

But what is even more concerning is that when converting from one to another, all these different energy words require thousands of conversion factors if energy issues are to be understood at even a basic level.

To repeat, the 198 measures in the table require 39 006 conversion factors to convert from any one measure to any other. And, in the International System of Units (SI), the modern metric system, there is only one unit for energy:

joule

Therefore conversion factors are not necessary — there aren't any.

The **joule** was first established as the international unit for heat and for other forms of energy in 1889. It is the only unit recognised internationally for all forms of energy since then. It is now the only unit for energy in the International System of Units (SI).

Since a joule is a relatively small amount of energy (enough to lift a medium sized apple from the floor on to a metre high bench), it is usual to describe larger amounts using the SI prefixes. Here is the complete list of those in use:

joules, kilojoules, megajoules, gigajoules, terajoules,

petajoules, exajoules, zettajoules, and yottajoules.

Let me quote from the Australian Bureau of Statistics (ABS) web page. In '*Detailed Energy Statistics, Australia*' I found that the choices of measuring units made by the ABS make it very difficult for me to compare energy from oil with energy from black or brown coal, with hydroelectric energy, or with energy from petroleum. I quote from the ABS web page:

> *... Non-renewable fuels used to generate electricity include black coal (53,576 kt), brown coal (65,075 kt), and natural gas (291,372 TJ). Hydro-electricity was the main renewable source of electricity, and in 2001-02, 15,567 GWh of hydro-electricity were produced ...*

How can a citizen, say a politician, who is concerned about global warming begin to comprehend the various jargons incorporated in the ABS statistics? How can that citizen compare the performance of the various energy sources to determine the most efficient or which has the least environmental impact? More importantly, how can national and world leaders sensibly discuss energy issues when the language of energy measurement is virtually incomprehensible?

Fortunately, there is an immediate solution to this communication problem and that is contained within the single metric unit, **joule**. As an example of its use, consider the Australian-energy-use figures, quoted above, lightly edited, sensibly rounded, and expressed in petajoules (PJ):

> *... Non-renewable fuels used to generate electricity include 1600* petajoules (PJ) *from black coal, 1000* PJ *from brown coal, and 290* PJ *from natural gas. Hydro-electricity was the main renewable source of electricity, and in 2001-02, 56* PJ *of hydro-electricity were produced ...*

Expressing energy in joules, whenever energy information is provided, means that all forms of energy are immediately comparable, and conversions are no longer necessary. You don't have to memorise, look up, or calculate with conversion factors because there aren't any.

This measurement muddle is even worse in the USA where you have yet to widely and openly adopt the International System of Units — the modern metric system. In the USA, there are some people still using things like:

toe's (for tons of oil equivalent measured in one or other of the British thermal units)

MMBtu/Mcf (for million million British Thermal Units per million cubic feet)

and using conversion factors like

1 short ton per cubic yard = 0.0330687831 long tons per cubic foot.

You need to understand the issues behind peak oil and global warming and so do your legislators and elected politicians. How can you do this when industries and nations choose to describe energy using incomprehensible numbers and so many undefined measures based on old pre-metric words?

I sincerely wish the USA well in analysing energy and environmental issues (and with your inevitable metrication transition), but I don't think that the USA will take a leadership role in the peak oil or global warming debates until you resolve your current language and measurement problems.

Recommendation

> *When you are writing your report on this inquiry, could you please confine yourself to using the International System Of Units (SI) especially when you are referring to amounts of energy.*
>
> *SI has only one unit for energy — joule — with these multiples to measure larger amounts of energy — kilojoules, megajoules, gigajoules, terajoules, petajoules, exajoules, zettajoules, and yottajoules.*

On a similar theme, you might also like to refer to my submission to the:

Australian Government Senate Inquiry

into Australia's future oil supply and alternative transport fuels.

You can directly down load my submission as a pdf from:
http://www.aph.gov.au/SEnate/committee/rrat_ctte/oil_supply/submissions/sub05.pdf

Or see where my submission fits in relation to others, at:
http://www.aph.gov.au/SEnate/committee/rrat_ctte/oil_supply/submissions/sublist.htm

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Pat Naughtin helps people understand how to go about their metrication upgrade– quickly and easily – by helping them avoid mistakes that he has made himself, or that he has seen made by others during his more than 35 years of involvement with metrication matters.

Pat specialises in the modern metric system based on the International System of Units (SI), but he is mostly concerned with the processes that people use for themselves, their groups, their businesses, their industries, and their nations as they go about their inevitable metrication process.

Pat Naughtin is a highly knowledgeable metric enthusiast, who is also a writer, professional speaker, editor, and publisher.