Economics of Energy Independence

An example semantically linking DOE and other data using Executable Open Vocabulary English

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Agenda

- Making smart connections

  – Apps connect people and data

- A wiki for content in open vocabulary, Executable English

  – write applications as rules in English, run them, and get explanations

- An example semantically linking DOE and other data

  – energy independence

- Summary

Making Smart Connections

Good things happen when we make smart connections:

Software--------- **Linux** ----------------hardware

People----------- **Google** --------------all the web pages on the net

Buyers----------- **Ebay** --------------sellers

People-------- **Executable English Apps** -------- open networked data

Making Smart Connections
# data.gov

data.gov has over 400,000 datasets

- Raw data in many different formats

- Plus many data extraction tool UIs

- Mostly useful only to developers

- More than 1,000 apps and counting

Applications assign useful *meaning* to data

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- **A wiki for content in executable open vocabulary, English**

    – **write applications as rules in English, run them, and get explanations**

- An example semantically linking DOE and other data
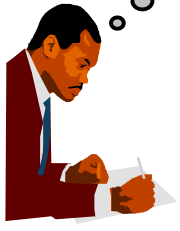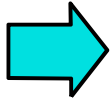
    – energy independence

- Summary

A Wiki for content in executable open vocabulary English
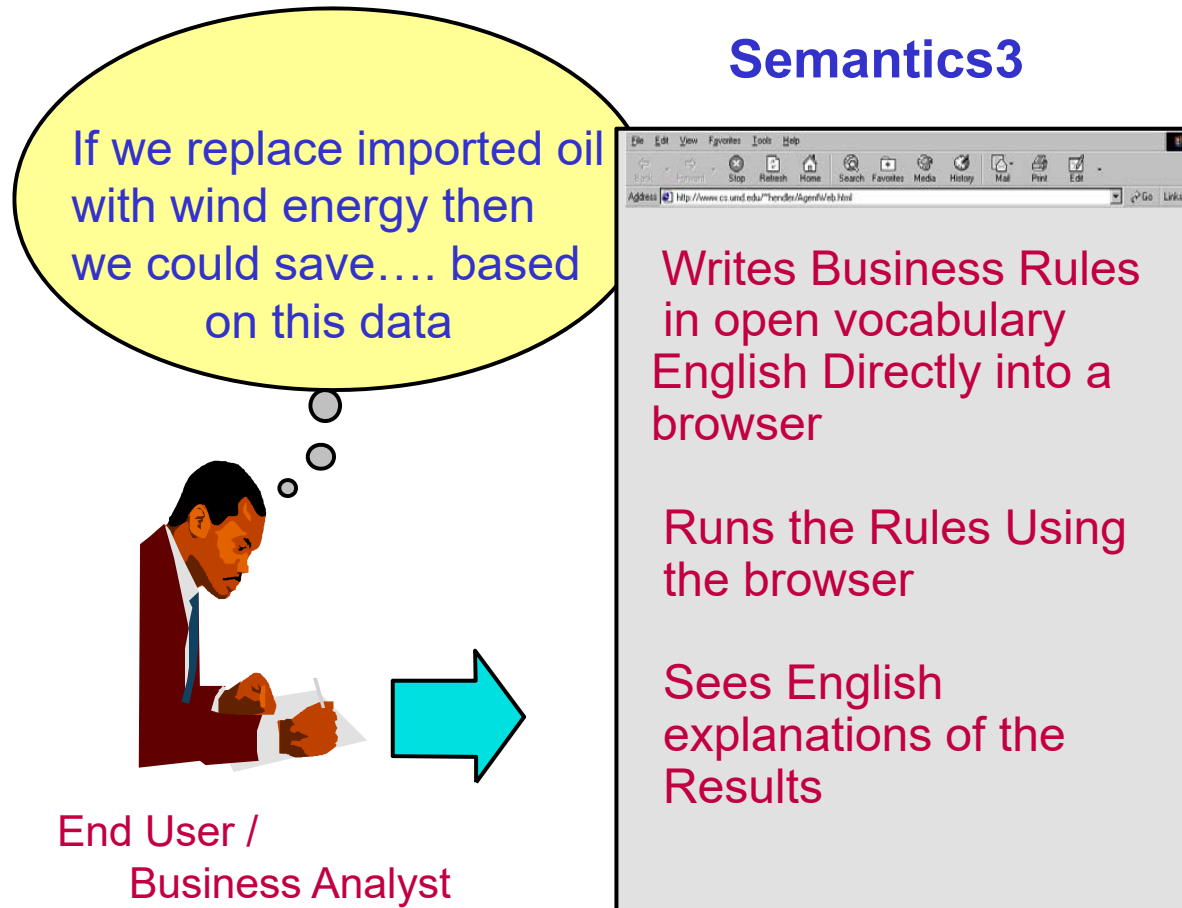
Semantics3

If we replace imported oil with wind energy then we could save…. based on this data

End User /
Business Analyst

Writes Business Rules in open vocabulary English Directly into a browser

Runs the Rules Using the browser

Sees English explanations of the Results

A Wiki for content in executable open vocabulary English

Semantics3

If we replace imported oil with wind energy then we could save…. based on this data

End User / Business Analyst

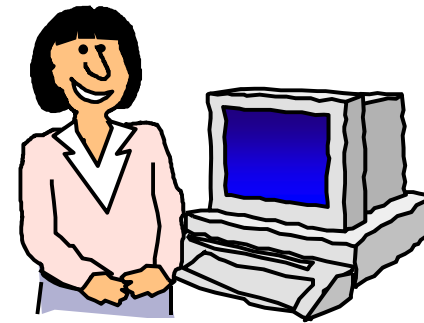Writes Business Rules in open vocabulary English Directly into a browser

Runs the Rules Using the browser

Sees English explanations of the Results

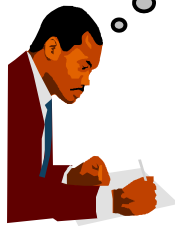**Semantics2**

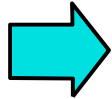**Theory of Declarative Knowledge**

Programmer

A Wiki for content in executable open vocabulary English

Semantics3

If we replace imported oil with wind energy then we could save…. based on this data

End User / Business Analyst

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Internet Business Logic

Application Independent Engine

Theory of Declarative Knowledge

Semantics2

Programmer

A Wiki for content in executable open vocabulary English

Semantics3

How much can we save in 2030 by switching to ….?

End User / Business Analyst

Writes Business Rules in open vocabulary English Directly into a browser

Runs the Rules Using the browser
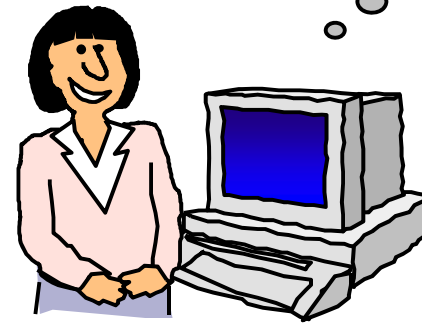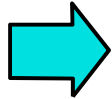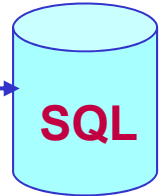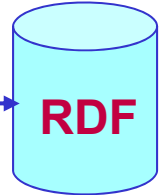
Sees English explanations of the Results

Internet Business Logic

Application Independent Engine
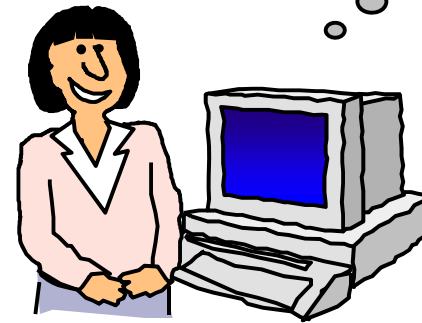
SQL

Semantics1

RDF

Semantics2

Theory of Declarative Knowledge

Programmer

A Wiki for content in executable open vocabulary English

- The vocabulary is open, and so -- to a large extent -- is the syntax

  - *not* yet-another-controlled-English-system

- No external dictionary or grammar maintenance is needed

- Strict English semantics is achieved via a trade off

  - if you want two English sentences to mean the same thing, you must say so

  - you must use place holders, such as "some-name" and "a-number"

- But, you are free to write executable English knowledge containing...

  - technical terms or jargon -- Wildcat, Upstream, Mud (oil industry)

  - government acronyms and usage -- SRB, Single Regeneration Budget

  - logical expressions -- (A c,t) [that-C c t => (E c1) [that-C1 c1 t and c partof c1 at t]]

- Although the system is open vocabulary, it can be used to query and manage:

  - controlled vocabularies, taxonomies and ontologies

  - Data in RDF (Resource Description Format) – single table with 3 columns

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- **An example semantically linking DOE and other data**

  – **energy independence**

- Summary

Semantically linking DOE and other data

Potential savings from energy independence

Data from DOE and other sources

Levelized Cost Comparison for New Generating Capacity in the United States
(2004 Dollars per Megawatthour)

Cost Element	Technology			
	Coal	Natural Gas	Wind	Nuclear
Capital . . .	30.4	11.4	40.7	42.7
O&M.	4.7	1.4	8.3	7.8
Fuel	14.5	36.9	0.0	6.6
Total[a] . . .	53.1	52.5	55.8	59.3

-- www.eia.doe.gov/oiaf/archive/ieo06/special_topics.html

Some corresponding Internet Business Logic facts:

```
estimated cost of electricity from this-source is this-amount $/MWh

===============================================================
                            coal            53.1
                            natural gas     52.5
                            wind            55.8
                            nuclear         59.3
```

Semantically linking DOE and other data

Potential savings from energy independence

Data from DOE and other sources, plus a simple classification

Internet Business Logic facts:

```
this-fuel can be classified as being of type this-type
==========================================================
 Aviation Gasoline                              Liquids
 Coal Anthracite                                Coal
 Coal Bituminous                                Coal
 Coal Lignite                                   Coal
 Coal Subbituminous                             Coal
 Distillate Fuel Oil and Diesel                 Liquids
 Flare Gas                                      Natural Gas
```

Semantically linking DOE and other data

Potential savings from energy independence
Data from DOE and other sources

Table A3. Energy Prices by Sector and Source
(2007 Dollars per Million Btu, Unless Otherwise Noted)

Sector and Source	Reference Case							Annual Growth 2007-2030 (percent)
	2006	2007	2010	2015	2020	2025	2030	
Residential								
Liquefied Petroleum Gases	23.88	24.98	24.79	32.03	32.52	33.39	34.92	1.5%
Distillate Fuel Oil	18.46	19.66	17.74	23.46	24.12	24.97	26.71	1.3%
Natural Gas	13.70	12.69	11.96	11.97	12.50	13.05	14.33	0.5%
Electricity	31.21	31.19	30.75	31.76	32.70	34.06	35.90	0.6%
Commercial								
Liquefied Petroleum Gases	21.20	23.04	21.61	28.80	29.24	30.08	31.58	1.4%
Distillate Fuel Oil	15.02	16.05	15.22	21.50	22.06	22.93	24.70	1.9%
Residual Fuel Oil	8.88	10.21	10.34	16.01	16.66	17.05	17.99	2.5%
Natural Gas	11.90	10.99	10.42	10.55	11.13	11.72	12.97	0.7%
Electricity	28.38	28.07	27.14	27.11	28.12	29.25	31.10	0.4%

-- www.eia.doe.gov/oiaf/aeo/pdf/appa.pdf

Corresponding Internet Business Logic facts:

```
this-group    this-fuel                   this-06 this-07 this-10 this-15 this-20 this-25 this-30 ($/MillionBtu)
==============================================================================================================
Residential   Liquefied Petroleum Gases   23.88   24.98   24.79   32.03   32.52   33.39   34.92
Residential   Distillate Fuel Oil         18.46   19.66   17.74   23.46   24.12   24.97   26.71
Residential   Natural Gas                 13.70   12.69   11.96   11.97   12.50   13.05   14.33
Residential   Electricity                 31.21   31.19   30.75   31.76   32.70   34.06   35.90
Commercial    Liquefied Petroleum Gases   21.20   23.04   21.61   28.80   29.24   30.08   31.58
Commercial    Distillate Fuel Oil         15.02   16.05   15.22   21.50   22.06   22.93   24.70
Commercial    Residual Fuel Oil           8.88    10.21   10.34   16.01   16.66   17.05   17.99
Commercial    Natural Gas                 11.90   10.99   10.42   10.55   11.13   11.72   12.97
Commercial    Electricity                 28.38   28.07   27.14   27.11   28.12   29.25   31.10
```

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Semantically linking DOE and other data
Potential savings from energy independence

An Executable English rule that semantically links DOE and other data

as a step towards energy independence, the US would like to reduce oil imports by some-number barrels per year

to convert from Quadrillion Btu to barrels of gasoline, multiply by some-factor

that-number / that-factor = some-quadrillion-btu

to change Quadrillion Btu to gigawatt-hours, multiply by some-btu-gwh-factor

those-quadrillion-btu * that-btu-gwh-factor = some-number-gigawatt-hours

that-number-gigawatt-hours * 1000 = some-number-megawatt-hours

estimated cost of electricity from some-source is some-quantity $/MWh   <---- DOE data

that-number-megawatt-hours * that-quantity = some-$amount

that-$amount / 1000000000 = some-long-amount

that-long-amount rounded to 1 place(s) after the decimal point is an-amount

----
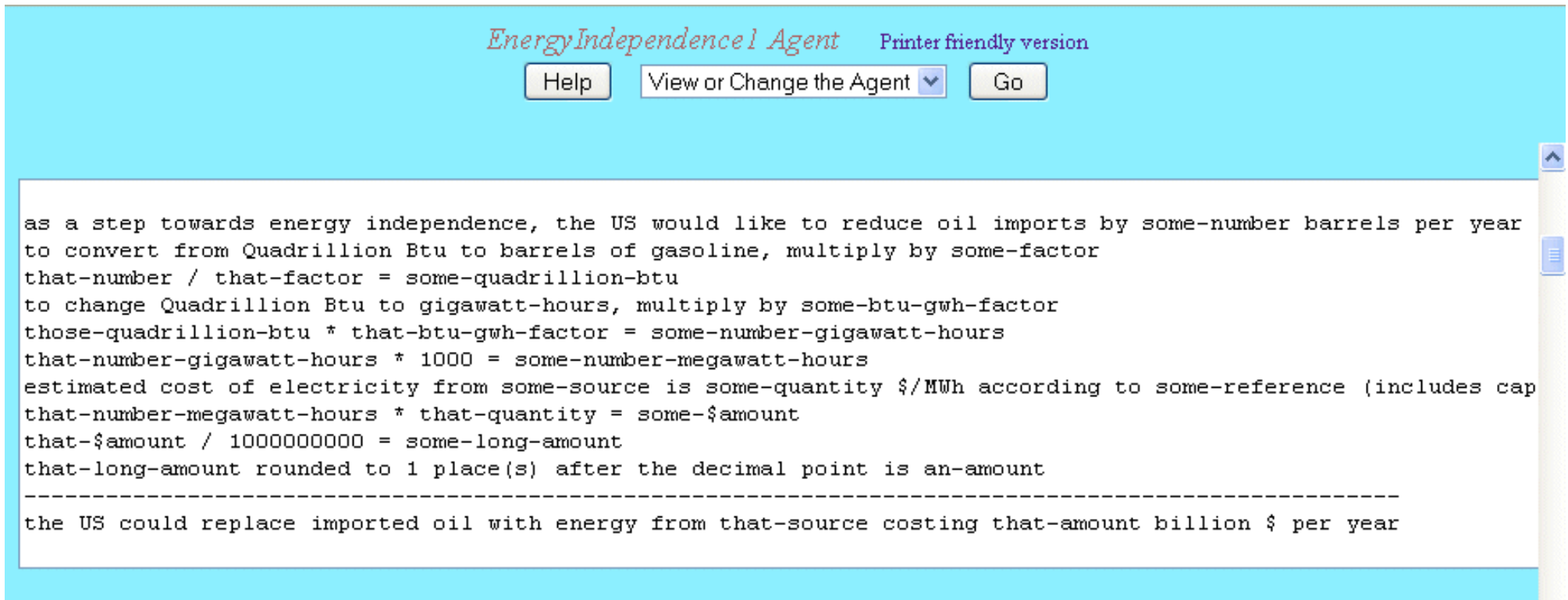
the US could replace imported oil with energy from that-source costing that-amount billion $ per year

Semantically linking DOE and other data

Potential savings from energy independence

The rule in an editable web page

EnergyIndependence1 Agent   Printer friendly version

[Help] [View or Change the Agent ▾] [Go]

```
as a step towards energy independence, the US would like to reduce oil imports by some-number barrels per year
to convert from Quadrillion Btu to barrels of gasoline, multiply by some-factor
that-number / that-factor = some-quadrillion-btu
to change Quadrillion Btu to gigawatt-hours, multiply by some-btu-gwh-factor
those-quadrillion-btu * that-btu-gwh-factor = some-number-gigawatt-hours
that-number-gigawatt-hours * 1000 = some-number-megawatt-hours
estimated cost of electricity from some-source is some-quantity $/MWh according to some-reference (includes cap
that-number-megawatt-hours * that-quantity = some-$amount
that-$amount / 1000000000 = some-long-amount
that-long-amount rounded to 1 place(s) after the decimal point is an-amount
---------------------------------------------------------------------------------
the US could replace imported oil with energy from that-source costing that-amount billion $ per year
```

To view, edit and run this example, go to www.executable-english.com and select EnergyIndependence1

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Semantically linking DOE and other data

Potential savings from energy independence
Question menu, generated from the rules

EnergyIndependence1 Question Menu

[Help]   [Select a Question to Ask ▾]   [Go]

Type a question here, then press Enter to reorder the menu

[   ]

or select a question from the menu below:

switching from imported oil to energy from some-source could potentially save the US some-number billion $ per year by 2030

the US could replace imported oil with energy from some-source costing some-amount billion $ per year

as a step towards energy independence, the US would like to reduce the cost of oil imports by some-total billion 2007 $ by 2030

as a step towards energy independence, the US would like to reduce oil imports by some-number barrels per year

to convert from Quadrillion Btu to barrels of gasoline, multiply by some-factor

to change Quadrillion Btu to gigawatt-hours, multiply by some-btu-gwh-factor

liquid fuel has an average price of some-amount in 2030 (2007 $ per Million Btu)

the US would like to reduce oil imports from some-country by some-amount barrels per year

some-fuel of type Liquids is priced at some-price in 2030 (2007 $ per Million Btu)

some-fuel of type Liquids is priced at some-price1 in 2007 and at some-price in 2030 (2007 $ per Million Btu)

some-group some-fuel is priced at some-price1 in 2007 and at some-price2 in 2030 (2007 $ per Million Btu)

adding some-number1 to some-number2 and rounding to 1 place gives some-number

To view, edit and run this example, go to www.executable-english.com and select EnergyIndependence1

Semantically linking DOE and other data

Potential savings from energy independence
Selected question

EnergyIndependence1 Question Menu

[Help]   [Select a Question to Ask ▼]   [Go]

Type a question here, then press Enter to reorder the menu

[   ]

or select a question from the menu below:

switching from imported oil to energy from some-source could potentially save the US some-number billion $ per year by 2030

the US could replace imported oil with energy from some-source costing some-amount billion $ per year

a   switching from imported oil to energy from some-source could potentially save the US some-number billion $ per year by 2030   [Ask]

as a step towards energy independence, the US would like to reduce oil imports by some-number barrels per year

to convert from Quadrillion Btu to barrels of gasoline, multiply by some-factor

to change Quadrillion Btu to gigawatt-hours, multiply by some-btu-gwh-factor

liquid fuel has an average price of some-amount in 2030 (2007 $ per Million Btu)

the US would like to reduce oil imports from some-country by some-amount barrels per year

some-fuel of type Liquids is priced at some-price in 2030 (2007 $ per Million Btu)

some-fuel of type Liquids is priced at some-price1 in 2007 and at some-price in 2030 (2007 $ per Million Btu)

some-group some-fuel is priced at some-price1 in 2007 and at some-price2 in 2030 (2007 $ per Million Btu)

adding some-number1 to some-number2 and rounding to 1 place gives some-number

To view, edit and run this example, go to www.executable-english.com and select EnergyIndependence1

Semantically linking DOE and other data

Potential savings from energy independence
Specialization menu, generated from the rules

EnergyIndependence1 Question Menu

[Help] [Select a Question to Ask ▼] [Go]

Type a question here, then press Enter to reorder the menu

[   ]

or select a question from the menu below:

switching from imported oil to energy from some-source could potentially save the US some-number billion $ per year by 2030

the US could replace imported oil with energy from some-source costing some-amount billion $ per year

as | switching from imported oil to energy from some-source could potentially save the US some-number billion $ per year by 2030 | [Ask]

as a step towards energy independence, the [ ] reduce oil imports by some-number barrels per year

to convert from Quadrillion Btu to barrels of | coal | by some-factor
to change Quadrillion Btu to gigawatt-hours | natural gas | -btu-gwh-factor
| nuclear |
| wind |

liquid fuel has an average price of some-amount in 2030 (2007 $ per Million Btu)

the US would like to reduce oil imports from some-country by some-amount barrels per year

some-fuel of type Liquids is priced at some-price in 2030 (2007 $ per Million Btu)

some-fuel of type Liquids is priced at some-price1 in 2007 and at some-price in 2030 (2007 $ per Million Btu)

some-group some-fuel is priced at some-price1 in 2007 and at some-price2 in 2030 (2007 $ per Million Btu)

adding some-number1 to some-number2 and rounding to 1 place gives some-number

To view, edit and run this example, go to www.executable-english.com and select EnergyIndependence1

Semantically linking DOE and other data

Potential savings from energy independence

Answer

To view, edit and run this example, go to www.executable-english.com and select EnergyIndependence1

Semantically linking DOE and other data

Potential savings from energy independence

Explanation -- hypertexted

EnergyIndependence1 Explanation

[Help] [Go to the Answer Page ▼] [Go]

as a step towards energy independence, the US would like to reduce the cost of oil imports by 414.647 billion 2007 $ by 2030
the US could replace imported oil with energy from coal costing 168.1 billion $ per year
414.647 - 168.1 = 246.547
246.547 rounded to 1 place(s) after the decimal point is 246.5

switching from imported oil to energy from coal could potentially save the US 246.5 billion $ per year by 2030

as a step towards energy independence, the US would like to reduce oil imports by 1928232000 barrels per year
to convert from Quadrillion Btu to barrels of gasoline, multiply by 1.78571e+08
1928232000 / 1.78571e+08 = 10.7981
liquid fuel has an average price of 38.4 in 2030 (2007 $ per Million Btu)
38.4 * 1000000000 = 3.84e+10
10.7981 * 3.84e+10 = 4.14647e+11
4.14647e+11 / 1000000000 = 414.647

as a step towards energy independence, the US would like to reduce the cost of oil imports by 414.6470092800001 billion 2007 $ by 2030

Semantically linking DOE and other data
Data Sources Used

www.eia.doe.gov/oiaf/aeo/pdf/appa.pdf

tonto.eia.doe.gov/dnav/pet/pet_move_impcus_a2_nus_ep00_im0_mbbl_m.htm

www.eia.doe.gov/oiaf/archive/ieo06/special_topics.html

www.physics.uci.edu/~silverma/units.html

```
this-fuel can be classified as being of type this-type

====================================================
 Aviation Gasoline                          Liquids
 Coal Anthracite                            Coal
 Coal Bituminous                            Coal
 Coal Lignite                               Coal
 Coal Subbituminous                         Coal
 Distillate Fuel Oil and Diesel             Liquids
 Flare Gas                                  Natural Gas
```

Google indexes and searches applications that are written in English

Search: for estimated demand that-id fraction of the order

Google indexes and searches applications that are written in English

Search: for estimated demand that-id fraction of the order

Summary

- Making smart connections

  - apps connect people and data

- A wiki for content in Executable open vocabulary English

  - socially write apps in English using a browser

  - run the apps, and get explanations, again using a browser

  - (also, run the system in SOE mode from Java client programs)

- An example semantically linking DOE and other data

  - energy independence

- Google indexes and searches apps that are written in English

Links

1. There is an overview paper at www.executable-
   english.com/A_Wiki_for_Business_Rules_in_Open_Vocabulary_Executable_English.pdf

2. Semantics2 -- what a reasoner **should** do:

   Backchain iteration: towards a practical inference method that is simple enough to be proved
   Terminating, sound and complete. Journal of automated reasoning, 11:1-22

3. The English inferencing example

   EnergyIndependence1

   (and many other examples provided) can be run, changed, and re-run as follows:
   1. Point a firefox or chrome browser to www.executable-english.com
   2. Click on Internet Business Logic
   3. Click on the go button
   4. Click on the help button to see how to navigate through the pages
   5. Select *EnergyIndependence1*

4. You are cordially invited to write and run your own examples. Shared use of the system is free

5. To make the system part of an SOA architecture, you can download and extend the java
   client stub http://www.executable-english.com/iblclient1.Java

About Adrian Walker

- Author of over 20 papers, and an Addison-Wesley book, on rules systems and databases

- Assistant professor at Rutgers university

- Manager of principles and applications of logic programming, IBM Yorktown research laboratory

- Manager, internet development at Eventra

  (A manufacturing supply chain company)

- http://en.wikipedia.org/wiki/Adrian_Walker_%28computer_scientist%29