Where are your BTUs?

Watt are you doing about it?
Assist the Early and Cost Effective Implementation of Emerging Technologies in:

Energy Efficiency
and
Renewable Energy

To Better Foster Planetary Sustainability.
Net Usage = 101.6 Quads \((10^{15} \text{ BTUs})\)
USA Per Capita Energy Consumption

YOUR BTU Consumption Rate

Peak: 359 in 1978 and 1979
337 in 2007

6.2% Drop

EIA AER 2007
More People, More Energy

USA Population Growth
1949-2007

Millions

0 50 100 150 200 250 300 350


202% Increase
OUR BTU Consumption Rate

USA Energy Consumption

EIA AER 2007
USA Energy Sources

- Imported: 29.0%
- US Production: 71.0%

EIA AER 2007
USA Energy Control

Personal Control = 30%

- Pers. Trans: 11%
- Transportation: 15%
- Residential: 19% (75% Heat)
- Commercial: 17%
- Industrial: 38%
Energy Efficiency Benefits

27% Savings

• 3 Yr. Payback for Business
• 6 Yr. Payback for Individuals

Cost Effective

Reinvestment
• $1.5 – 2.0 Trillion
• 25 MM Job Yrs.
• 10 Yr. Program

Trade Balance
• No Net Energy Imports
• Net Export of 1%

No new Technology, No Change in Comfort Parameters
Electricity Energy Usage

42 Quads Input, 13.3 Quads to load
Electrical Losses

- Power Plant (Generator)
- Switchyard (Voltage-increasing transformer)
- Substation (Voltage-decreasing transformer)
- High Transmission Line Voltage (up to 700,000 volts)
- Distribution Network Voltage (about 2200 volts)
- House Current Voltage (110 and 220 volts)
Energy Efficiency Potential

USA = 101.6 Quads 2007 Usage

- 28.81 (28.4%)
- 29.10 (28.6%)
- 30.41 (29.9%)

4-5 Year Payback, 25% Total Reduction
Historic USA Energy Use

Impact of Cost Effective EEMs

- 25% savings with a 4 year or less payback
- Kyoto Protocol Target: 95% of 1990 CO2
Fossil Fuels vs Renewable Energy

World Energy Scenario
Today

Energy Need (%)

Time

Renewable Non-Renewable

Its only a Matter of Time
Biomass
Biomass
Hydro
Geothermal
Wind
Wind
Photovoltaics
FIG. 4.1 Solar residential heating system schematic diagram—water-cooled collector (standard valves not shown).
Renewable Sources of Energy?

Total energy system uses electricity from solar cells and windmill to electrolyze water into oxygen and hydrogen. Gases combine with source of carbon, form methanol and methane. Methanol can be converted into ammonia for fertilizer. Remainder flies through powered generator when there isn't enough solar-based energy. Inverted nap, house heating, cooking, electricity are tipped off main system.
GREEN ENERGY OPTIONS

21ST CENTURY URBAN HOME GREEN ENERGY SCHEMATIC
Economics of Energy Sustainability

- Forget about renewable energy
- *We* waste too much energy and shouldn’t make renewable fuels until *we* won’t waste it too.
- It’s conservation of capital, not energy: renewable energy presently costs a lot more than saving the energy we presently waste.

**WASTE NOT, WANT NOT**
Energy Efficiency Related Facts

<p>| | |</p>
<table>
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<td>• Energy Efficiency for existing buildings is a high yield investment.</td>
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<td>• There are more old than new buildings</td>
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<td>• There is a gold mine in your utility bills.</td>
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<td>• It is a well kept secret.</td>
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Existing Buildings

- Buildings last a long time
- Building systems have Life Cycles
  - HVAC
  - Lighting
  - Envelope
- Small premiums paid at life cycle replacement times yield tremendous dividends
Energy Efficiency Works

- Missouri Botanical Garden
Missouri Botanical Garden Results

- Since 2000
  - Reduced Energy Use in Existing Buildings 27%
  - Reduced CO₂ Emissions 22%
  - Saving ~ $300,000+/year
  - Invested < $1,000,000
  - < 4 year payback
1. Set a Board Policy for guiding investments in energy efficiency
Invest in energy measures that:

- **Have an ROI > Endowment** &:
  - Envelope payback < 15 yrs
  - HVAC payback < 10 yrs
  - Lighting payback < 7 yrs
  - Renewables < lifecycle
1. Set a Board Policy for guiding investments in energy efficiency
2. Measure current energy use by building and establish baselines
Measurement is vitally important:

- To get where your going you have to know where you are. Establish a baseline

- Measurements feedback the effect of strategic changes

- Measurements across time show trends for forecasting
Energy Program Elements

1. Set a Board Policy for guiding investments in energy efficiency
2. Measure current energy use by building and establish baselines
3. Establish design criteria for future buildings
Equipment Standards

Part Load Chiller Comparisons

- 100 Ton Scroll Air
- 100 Ton Screw Air
- 100 Ton Scroll Water
- 100 Ton Screw Water
- 100 TurboCor Water

60% less energy
Save 75% Lighting Energy

- No more incandescent lights

Compact Fluorescents last 8-10 times as Long
1. Set a Board Policy for guiding investments in energy efficiency

2. Measure current energy use by building and establish baselines

3. Establish design criteria for future buildings

4. Recommission existing buildings (min. 10-15% savings) [Remember, most of the buildings are existing and will be here for a long time to come.]
Recommissioning Savings

- Donald Danforth Plant Science Center
  - Recalibrated OA for labs
  - Replaced 30 MMbtu boilers – 8 MMbtu
  - Saved
    - 42% natural gas
    - 13% electricity
    - $210,000/yr
  - 1.5 yr payback (72% ROI)
Value of Measurement and Verification

DD Plant Science Center
Energy Savings Cashflow Analysis
Calendar YE 2008

$912,000 saved since 02/2005

$409,000 total net savings

$89,000 Spent Prior to 02/2005

$503,000 spent since 02/2004

$800,000

$900,000

$1,000,000

$500,000

$600,000

$700,000

$800,000

$900,000

$1,000,000

$100,000

$200,000

$300,000

$400,000

$500,000

$600,000

$700,000

$800,000

$900,000

$1,000,000

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Expenditures
Savings
Keys to Energy Sustainability

- Economics
- *It is very cost effective*
- Marketing Marketing Marketing
- Implement New Technologies
- Better Design & Systems Integration
Costs Rise "linearly" as improvements are made (e.g., R Value)
Operating Costs respond to incremental investments “non-linearly.” Each successive drop in operating costs gets less. (e.g., R Value)
Savings respond to investment steps "non linearly." Each successive savings step saves less. (e.g., R Value)
Economics of Sustainability

Net Savings result from subtracting the investment from the savings.

- Point of Maximum Net Savings
- Point of Net Loss

Investment Region

Increasing Efficiency Measures

Relative Dollars

Invest, Operating, Savings, Net Savings
The Real World is ...

Dynamic
Solar Facts

Solar System Velocity
900,000 kph
562,000 mph

Solar Distance
1.5 x 10^8 km
92.9 x 10^6 m
8 minutes

SUN DIAMETER
1.39 x 10^6 km
8.65 x 10^5 mi

SOLAR MASS
1.97 x 10^{30} kg
2.17 x 10^{27} ton

SUN’S SURFACE
GRAVITY: 28 Gs

Relative Distance
Earth to Moon
3.84 x 10^6 km
2.38 x 10^5 mi

Solar Fuel
3.6 x 10^9 kg/sec
4.0 x 10^6 tons/sec

109 earth diameters
to cross the sun
Solar Dynamics

Solar Output $5.4 \times 10^{23}$ Quads/Yr

Earth Intercepts
0.000000000000001%
5,364,000 Quads

Earth Annual Energy Budget

-400 Quads = 0.007%
of planetary solar input
Dynamics of Load

Part Load Operating Range

Boiler Design Conditions

Chiller Design Conditions

Temperature
Typical St. Louis Winter
Hourly Temperature Distribution

- 190 hours (4.9%)
- 671 hours (17.5%)
- 1572 hours (41.0%)
- 1405 hours (36.6%)

- 3838 hours (75%)

- 473 hours (12.3% and 27.1% of load)
- 265 hours (6.9% and 16.3% of load)
- 107 hours (2.2% hrs and 7.2% of load)
- 35 hours (0.9% hrs & 2.5% of load)

- 0% to 100% Full Load Curve
Benefits of Improved Auto Mileage

Savings @ 12,000 miles per year

$3.25/Gal
4 Year
Savings

$10,400
$6,070
$3,900
$1,700
$650

$0
$500
$1,000
$1,500
$2,000
$2,500
$3,000
$3,500

$ Saved/Year

0 10 20 30 40 50 60

MPG

Hummer

Prius
Run Time Consideration

10/26/2002 Abacus Test at Jackson Park

Turning off the HP system saves 17.2 kWh/H at JP

This could save the District $25,000/year
Designing with the Sun

**SUMMER**
SUN HEATS EAST & WEST WALLS AND ROOF

**WINTER**
SUN HEATS SOUTH WALL

**ASPECT RATIO**
A compact rectangular box is easy to construct, minimizes exterior area which loses heat, and provides good solar input.
Use South Monitors instead of North windows or skylights for natural illumination. This needs 1/6 the fenestration and has greater potential for dynamic interest.
Net Savings result from subtracting the investment from the savings.

Point of Maximum Net Savings

Point of Net Loss

Investment Region
Dynamic Buildings
Dynamic Buildings
Use Efficient HVAC Equipment

- Properly size equipment. In the past, heating & cooling equipment was oversized and was inefficient.
- Stretch your comfort zone.
- Air Conditioners: Look for high EERs (12+) and avoid CFC/HCFC refrigerants
- Boilers/Furnaces: Look for condensing type equipment at 90+ efficiency with sealed combustion and outdoor air intakes.

Hot water heaters should heat water instantaneously, without a storage tank or standing pilot light. (no pilot saves $100+/year)
• One person at a time...
• Taking personal responsibility...
• Until all of us, working together, secure the future of this planet for all creatures
Solution

• **Become Informed**

• **Act! (for your own Benefit)**

• **Put your assets to work**
  • **Financial**
  • **Mental**

• **Allow time to work for you**

• **Work up the collective scale**
Community Energy Systems

- Usual Demand Control
- Site Load Leveling
- Utility Peak Assist
Community Energy Systems

Usual Renewable Approach

CES Approach

CES Future
Community Energy Systems

- **Site Energy**
- **Processing / Interconversion**
- **Storage**
- **Loads**

**Sewage**
- Methane Digester

**Biomass**
- Alcohol Fermenting
- Engine
- Fuel Cell
- Thermal Engine
- Chiller
- Thermal
- COLD
- HEAT

**Trash Garbage**
- Compost
- Pyrolysis

**Snow**
- Passive Thermal
- Photo Voltaics

**Solar**
- Wind Generator

**Wind**
- Elec/Chem Battery

**Grid Power**

- Nat. Gas
- Cooking Heating
- Chilled Water Hot Water
- Heating
- Power
Community Energy Systems

Newberry Terrace

- Existing sewer lines
- Possible location for C.E.S.
- Divert sewage to C.E.S.
- Sewage return from C.E.S.
- Divert sewage to C.E.S.
- New C.E.S. Power & Utility Distribution System
- New C.E.S. Power & Utility Distribution System

Power and Utility Options:
- Electricity
- Hot Water
- Steam
- Chilled Water

Community Energy System C.E.S. Union Sarah
Washington University CES

The Campus Becomes the Laboratory
Did you know:

• that to condition a 1000 cfm of outdoor air for a year has a cost of $3000+ per year (2007 rates)

• that one 60 x 68 patio glass door facing west adds one ton to AC loads

• birefringent films allow visible light in, but can block the rest of the solar spectrum
Be Open and Ready for Change

Expect New And Novel Approaches
SACRIFICE IS NEEDED!

• What do we have to sacrifice to achieve these ends?
  – Our habits of wastefulness
  – Squandering utility dollars
  – Some sense of consumerism
    (when we buy higher quality we replace “stuff” less often)
  – Our sense of hopelessness

WE CAN MAKE A DIFFERENCE
Thanks for listening ..... Questions ???