Integrating Humboldt County Energy Systems

Maximizing Local Renewable Energy

Michael Winkler – Schatz Energy Research Center

Structure of Humboldt County Energy, 2007

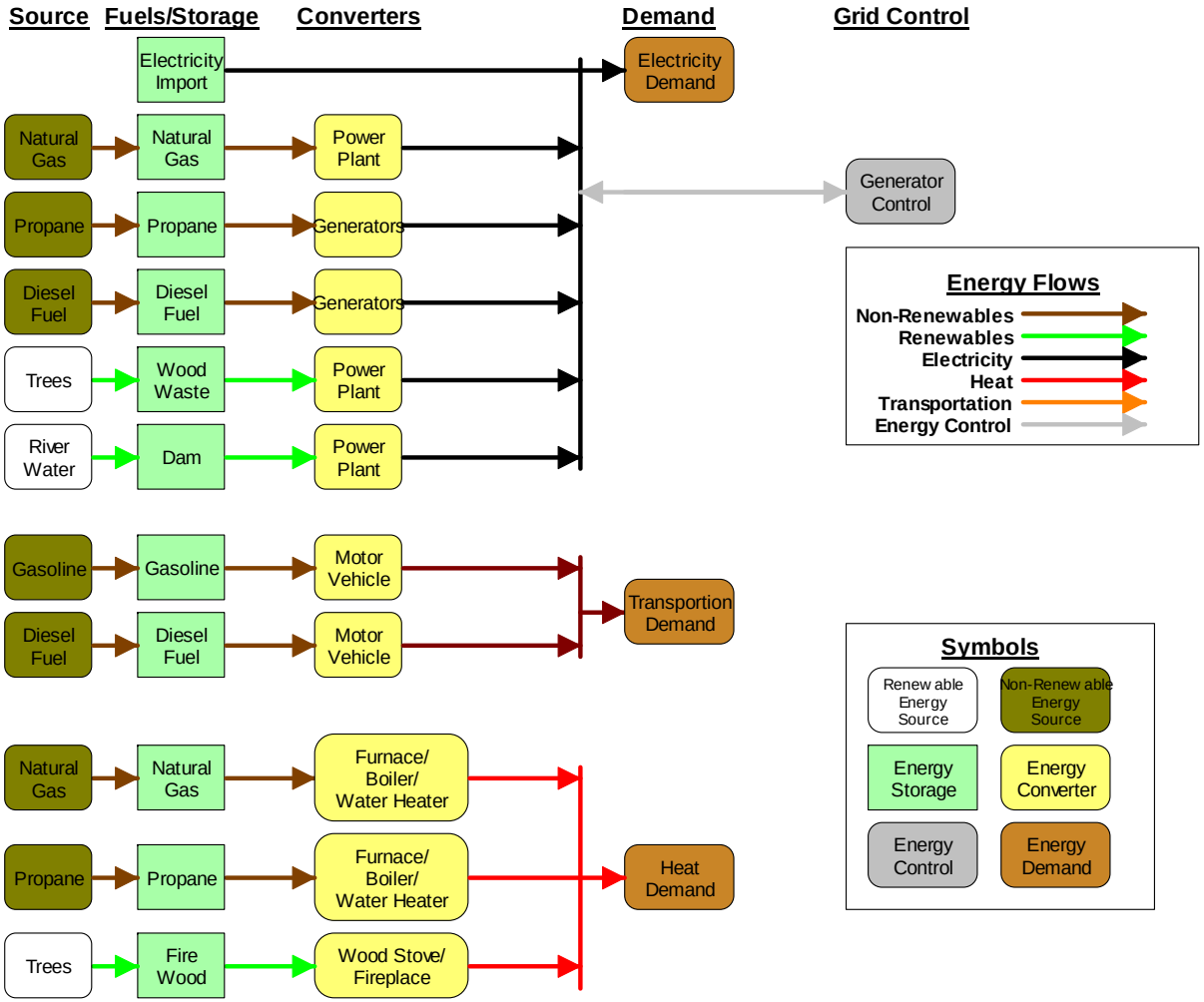
- Three Separate Systems
  - Electricity
  - Transportation
  - Heating

Humboldt County Energy (2007)

- Running primarily on fossil fuels
- One-way flow of energy from sources to users
- Generators use fuels
- Grid operator controls output of generators to meet independent time-varying demands

Energy Systems Analysis Model (Humboldt 2007)

Grid Operator Controls Fuel/Storage Based Generators to Meet Time-Varying Demand



Derived from: "EnergyPlan - Energy Systems Analysis Model", Henrik Lund, University of Aalborg, Denmark, http://energy.plan.aau.dk

Problems with Existing Energy Sources

- Imported from outside the County and outside the U.S.
- Fossil Fuels
- CO_2/Global Climate Change
- Major financial drain on citizens and community

Humboldt County Renewable Energy Opportunities

- Major renewable energy potential in County
- Much greater than total current County consumption (electricity, transportation, heating)

Barriers to Increasing Renewables

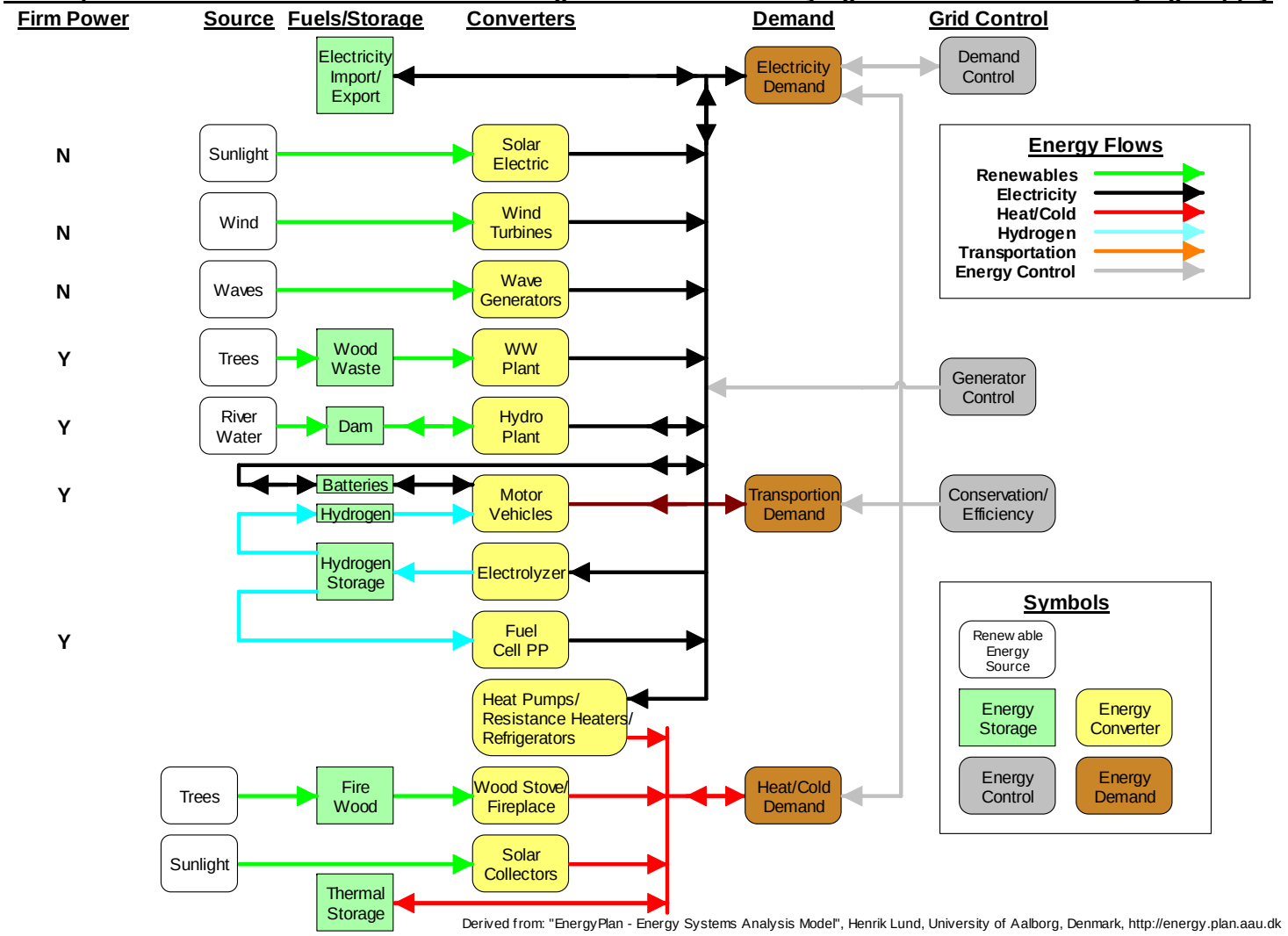
- Demand mostly for fuels, Supply mostly electricity
- Most renewables are intermittent; Supply/Demand time mismatch
- Transmission line capacity limits exports and imports
- Cost

Solution – Create Single Integrated Energy System

1. 100% renewable, eliminate fossil fuels
2. Heating – switch to electric heating (heat pumps)
3. Transportation – switch to Plug-In Hybrids and H_2 (ICE's & fuel cells)
4. Energy Storage – vehicle batteries, H_2
5. Flexible Demand
6. Smart Grid – control demand, storage and biomass generators
7. Energy Efficiency – reduce demand
8. Financing - Revenue bonds through JPA/CCA

Energy Systems Analysis Model (Humboldt 100% Renewable)

Grid Operator uses Demand Control and Storage to Match Time-Varying Demand with Time-Varying Supply



Derived from: "EnergyPlan - Energy Systems Analysis Model", Henrik Lund, University of Aalborg, Denmark, http://energy.plan.aau.dk

	Current System	**100% Renewable System**
% Renewable	11%	100%
% Imported	89%	0%
Electricity Sources	Mostly fossil fuels	100% Renewable
Vehicle Fuels	Gasoline and Diesel	Electricity and H_2
Heating Fuels	NG, Wood & Propane	Electricity & Wood
Generation Sources	Available on demand	Random output
Loads	Random & Independent	Demand-Responsive
Demand	Immediate	Flexible
Use of transmission lines	Import only	Bi-directional
Energy Storage	Mostly fossil fuels	Vehicle batteries, H_2 & Biomass
Rates (commercial & industrial)	Time of use	Real time, Flexible Demand
Rates (residential)	Flat	Real time, Flexible Demand
Meter Reading	In person	Remote
Grid Back-up	None	Vehicles
Net CO_2 Emissions	High	None
Energy Costs	Mostly fuel costs	Equipment and Labor
Energy Prices	Volatile	Stable
Home refueling	No	Yes

EnergyPlan Model

- Energy Analysis Software
- Designed to do Energy Scenarios for Single Countries
- Developed by Henrik Lund, University of Aalborg, Denmark
- Free to download and use

Simulations of Humboldt County Energy Use

- Simulations performed using data from: “**HUMBOLDT COUNTY GENERAL PLAN 2025 ENERGY ELEMENT BACKGROUND TECHNICAL REPORT**”

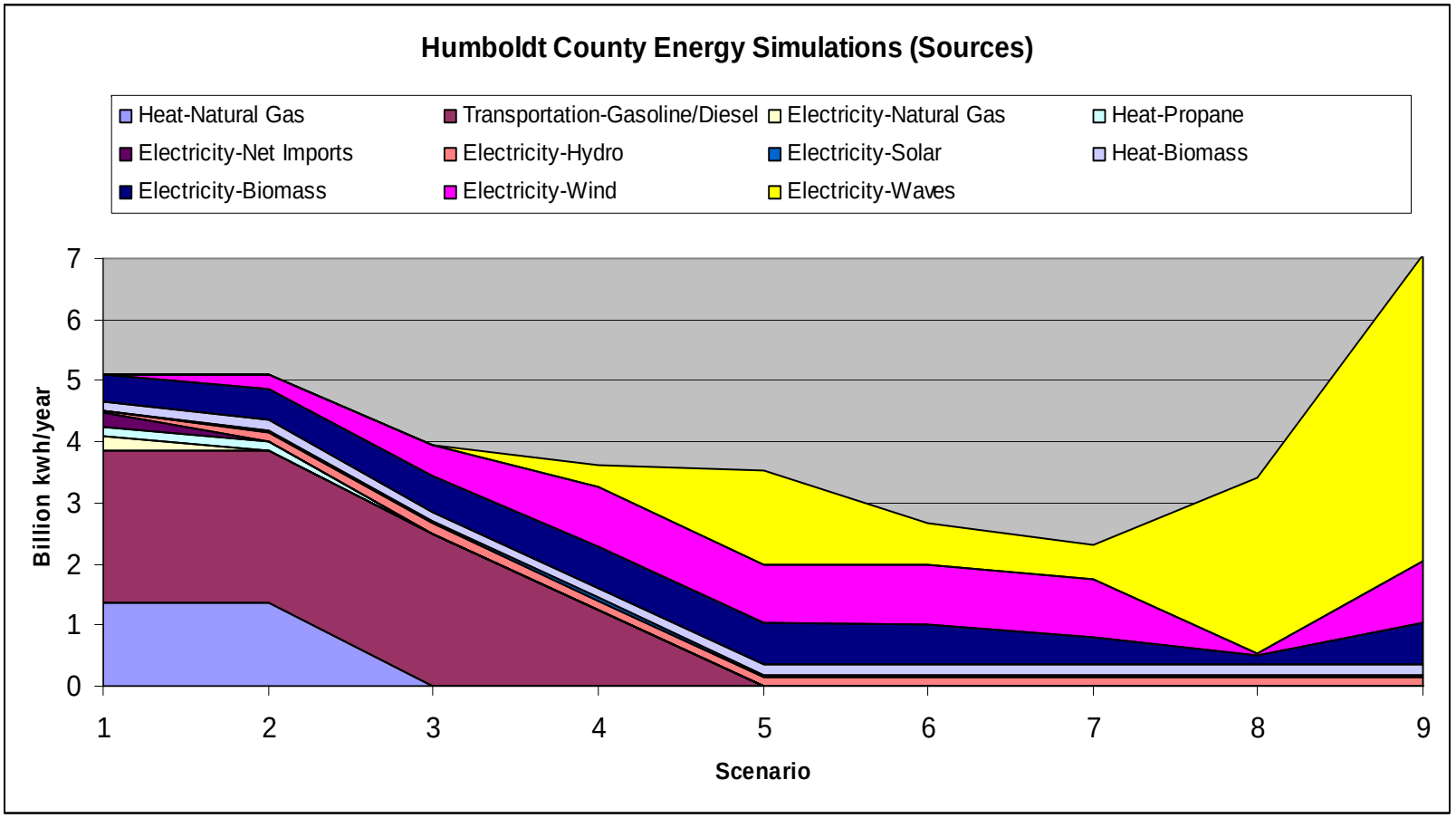
Energy Units of Measurement

- **Power - Rate of Energy Flow**
- W – Watt, unit of electric power
- KW – Kilowatt, 1000 Watts
- MW – Megawatt, 1 Million Watts

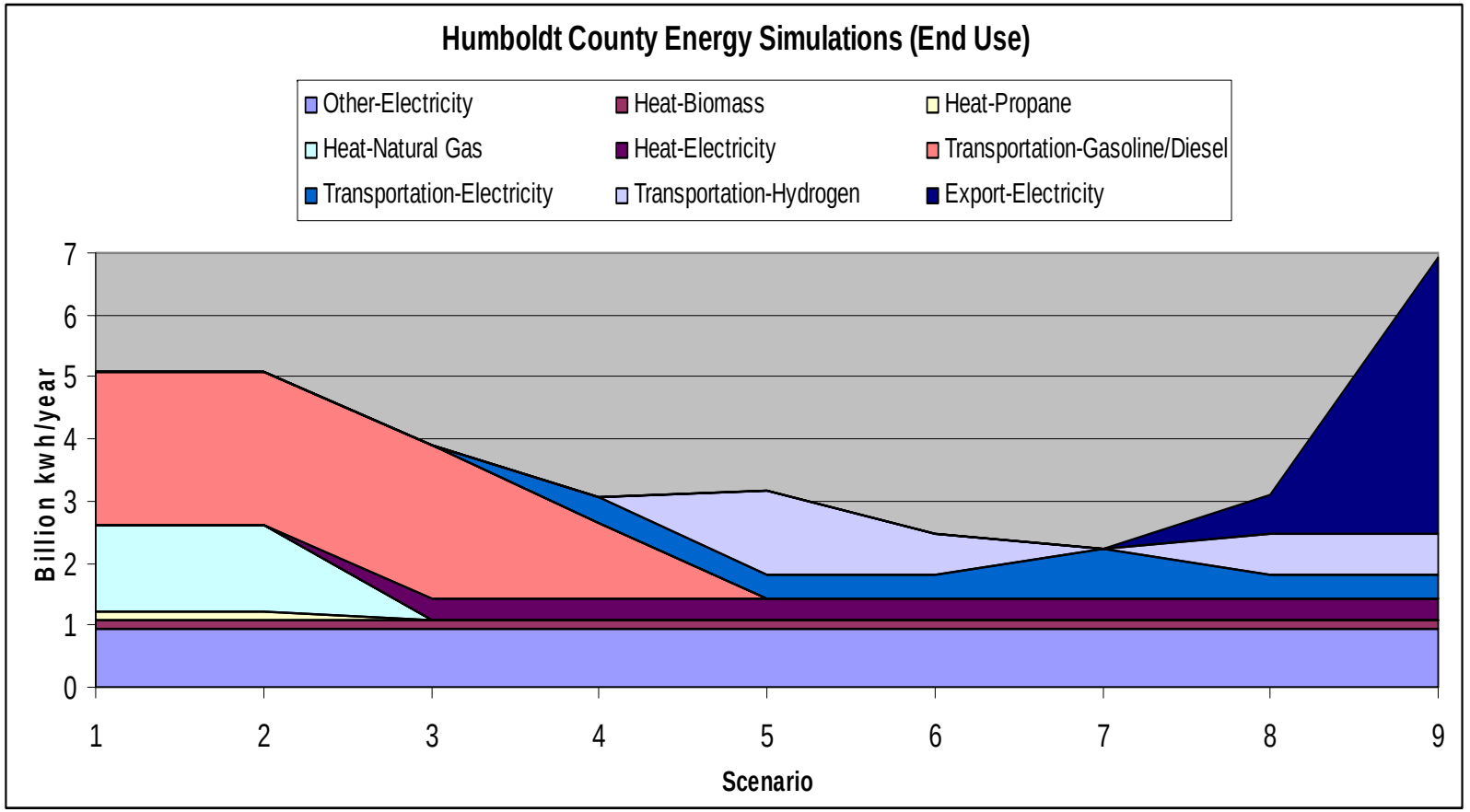
- A toaster uses about 1 KW
- PG&E power plant is 137 MW peak

- **Energy Quantity**
- Wh - Watt-hour, One Watt of power for one hour
- kWH – kilowatt-hour, 1000 Wh, Units on your electric bill
- MWh – Megawatt-hour, 1000 kWh
- GWh – Gigawatt-hour, 1 Million kWh
- TWh – Terawatt-hour, 1 Billion kWh

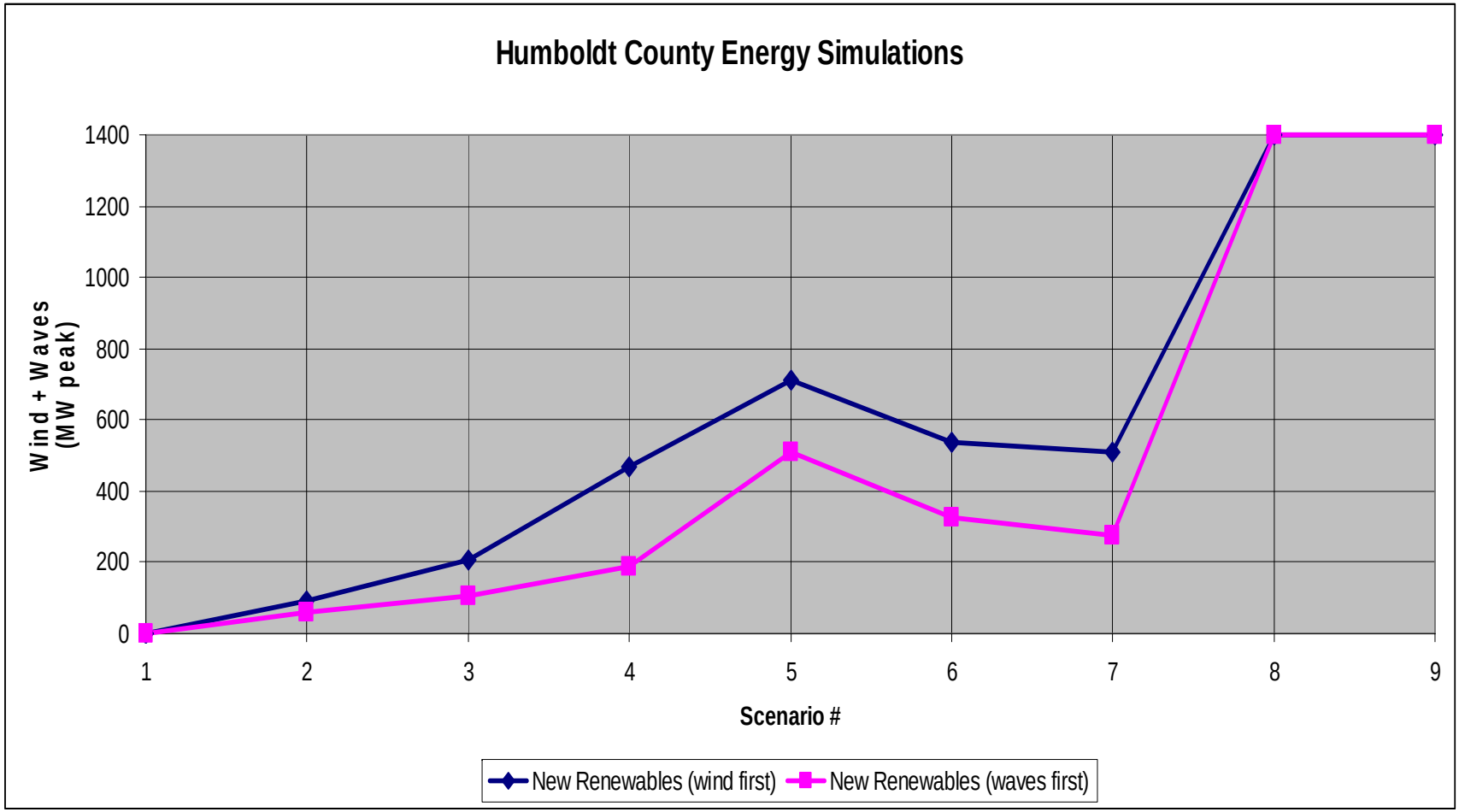
- Typical family uses 600 kwh/month
- County electricity consumption was 0.94 TWh (2003)



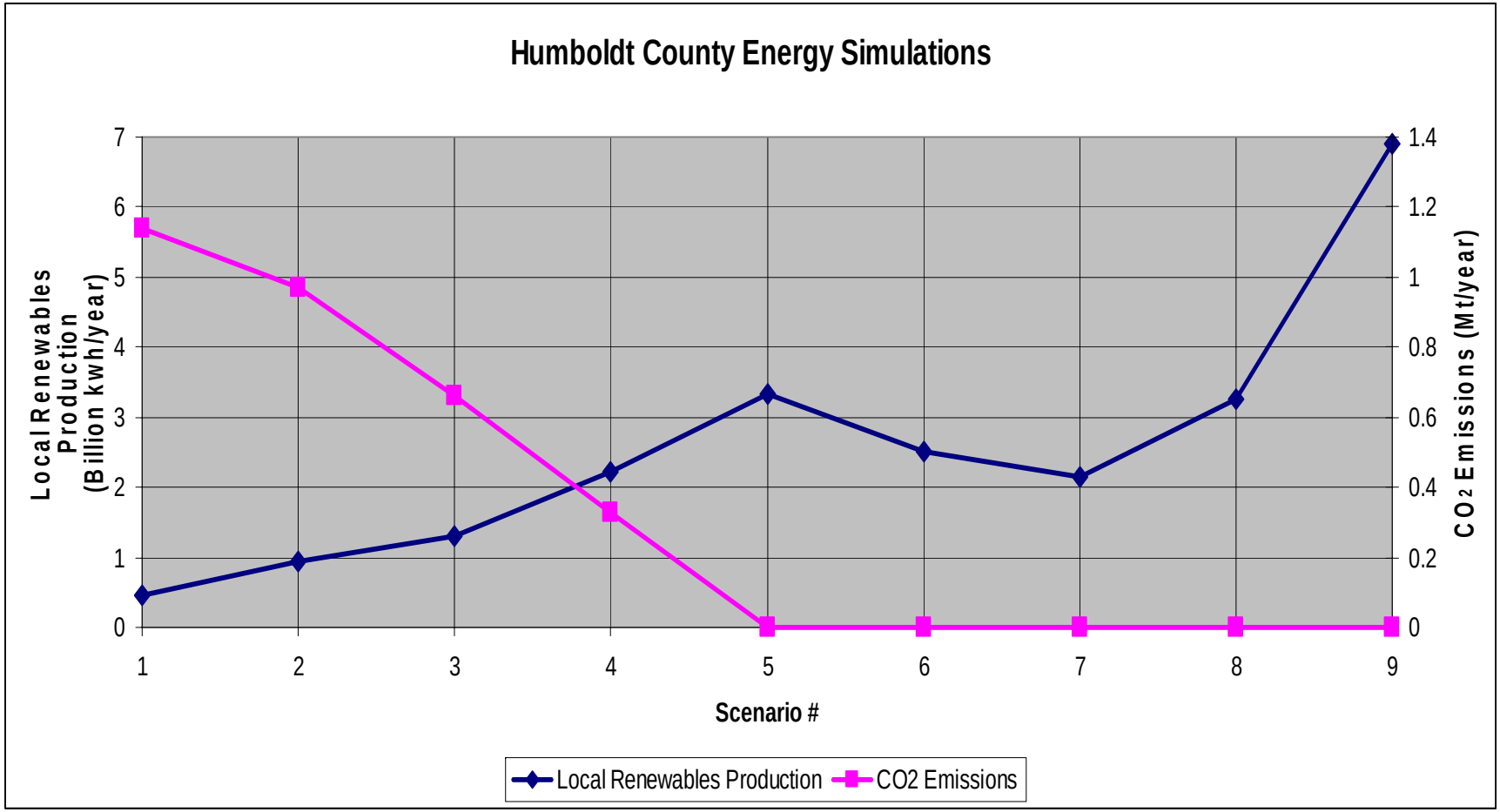
Scenarios	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Technologies	2007 Status Quo	100% Local Renewables for Electricity	Heat Pumps, Smart Grid	Plug-in Gasoline Hybrids	Plug-in H_2 ICE Hybrids	Plug-in H_2 Fuel Cell Hybrids	Battery Vehicles	Maximum Local Renewables	Unlimited Transmission line
Energy Storage				Vehicle Batteries	Vehicle Batteries H_2	Vehicle Batteries H_2	Vehicle Batteries		
Flexible Demand			Heat (space,H_2O) Refrigeration Water Pumping						



Scenarios	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Technologies	2007 Status Quo	100% Local Renewables for Electricity	Heat Pumps, Smart Grid	Plug-in Gasoline Hybrids	Plug-in H_2 ICE Hybrids	Plug-in H_2 Fuel Cell Hybrids	Battery Vehicles	Maximum Local Renewables	Unlimited Transmission line
Energy Storage				Vehicle Batteries	Vehicle Batteries H_2	Vehicle Batteries H_2	Vehicle Batteries		
Flexible Demand			Heat (space,H_2O) Refrigeration Water Pumping						



Scenarios	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Technologies	2007 Status Quo	100% Local Renewables for Electricity	Heat Pumps, Smart Grid	Plug-in Gasoline Hybrids	Plug-in H_2 ICE Hybrids	Plug-in H_2 Fuel Cell Hybrids	Battery Vehicles	Maximum Local Renewables	Unlimited Transmission line
Energy Storage				Vehicle Batteries	Vehicle Batteries H_2	Vehicle Batteries H_2	Vehicle Batteries		
Flexible Demand			Heat (space,H_2O) Refrigeration Water Pumping						



Scenarios	1	2	3	4	5	6	7	8	9
Technologies	2007 Status Quo	100% Local Renewables for Electricity	Heat Pumps, Smart Grid	Plug-in Gasoline Hybrids	Plug-in H_2 ICE Hybrids	Plug-in H_2 Fuel Cell Hybrids	Battery Vehicles	Maximum Local Renewables	Unlimited Transmission line
Energy Storage				Vehicle Batteries	Vehicle Batteries H_2	Vehicle Batteries H_2	Vehicle Batteries		
Flexible Demand			Heat (space,H_2O) Refrigeration Water Pumping						

Key Technologies

- Wind Turbines
- Wave Generators
- Smart Grid
- Heat Pumps
- Flexible Demand
- Plug-In Hybrid Electric Vehicles
- Hydrogen
- Fuel Cells

Wind Turbines

- Cost-competitive with coal and natural gas at best sites
- High annual growth rate
- Major electricity source in Denmark and Germany
- Intermittent output perceived as barrier
- Large wind potential in Humboldt County (up to 1 Billion kwh/year)

Wave Generators

- Prototypes exist in Europe
- DG Energy proposing large system (60 MW) for Humboldt County
- PG&E doing multi-year wave energy analysis off our coast
- Resource in Humboldt County up to (5 Billion kwh/year), enough to meet all County energy needs

Electric Grid (Structure)

1. Transmission and distribution lines move electricity from generators to end users
2. Flow of current is two-way (Alternating Current)
3. Flow of energy is one-way (limited exceptions)
4. Grid controlled by Cal ISO (Independent System Operator)
5. No electricity storage; energy used as it is generated
6. No real-time information on individual end-users

Electric Grid (End Users)

- Independent
- Can take any quantity of energy at any time without advance notice

Electric Grid (Cal ISO)

- Controls generator output and energy flow to meet end-user demands

Electric Grid (future smart grid)

- PG&E and other utilities have begun implementing “Advanced Metering Infrastructure (AMI)”
- AMI will allow PG&E to do remote meter reading
- AMI will be two-way and could allow PG&E to monitor and control end-user equipment
- PG&E likely to implement near real-time electric rates (some utilities already have)

Heat Pumps

- Move heat from cold to warm (opposite direction of spontaneous flow)
- Allow replacement of Natural Gas with electricity for heating
- Heat Pumps are the most efficient form of electric heating
- In widespread commercial use

Flexible Demand

- Many end uses need electricity during a period of time; not at a precise time
- Grid operator can send electricity to flexible end uses when supply > demand
- Reduced independent demand improves grid balance
- Allows grid operator to adjust to:
  - changing output from intermittent renewables
  - changing demand from end users

Flexible Demand (examples)

- Space heating and water Heating (especially with hot water storage)
- Refrigeration and air conditioning (especially with ice & chilled water storage)
- Water and wastewater pumping (especially with water storage)
- Ventilation (minimum ACH & CO_2)

Plug-In Hybrid Electric Vehicles

- Much larger battery packs than existing hybrids
- Could run up to 60 miles on batteries alone
- Batteries mostly recharged by plugging into grid
- Could store excess electricity from intermittent renewables
- Could run on electricity or fuel (gasoline, Diesel, Natural Gas, H_2)
- Prototypes exist; GM promising production in 3 years

Hydrogen

- Could store excess electricity from intermittent renewables
- Could replace gasoline/Diesel in plug-in hybrids
- Better than batteries for large-scale, long-term storage
- Could be used with ICE's or fuel cells
- Not cost effective until fossil fuels much more expensive

Fuel Cells

- Like a battery with an external fuel supply
- H_2 combined with O_2 from the air to produce electricity
- High efficiency, very low pollution
- Cost & lifetime need to significantly improve

Conclusions:
Benefits of Proposed Systems

1. Allow up to 100% renewables (up to 70% from intermittent sources)
2. Lower overall cost of energy
3. Allow greater use of local energy sources
4. Increase effective capacity of transmission lines
5. Prevent grid overloads and blackouts
6. Provide backup for end users when grid is down
7. Increased information for users
8. Increased energy security

Conclusions

- Humboldt County has renewable resources great enough to meet **all** our energy needs
- Integrating electricity, heating and transportation into a single energy system would enable us to eliminate fossil fuel use and net electricity imports
- Energy Storage, Flexible Demand and a Smart Grid are needed to operate an integrated system
- An integrated system would have many benefits for our county:
  - Economic
  - Environmental
  - Security