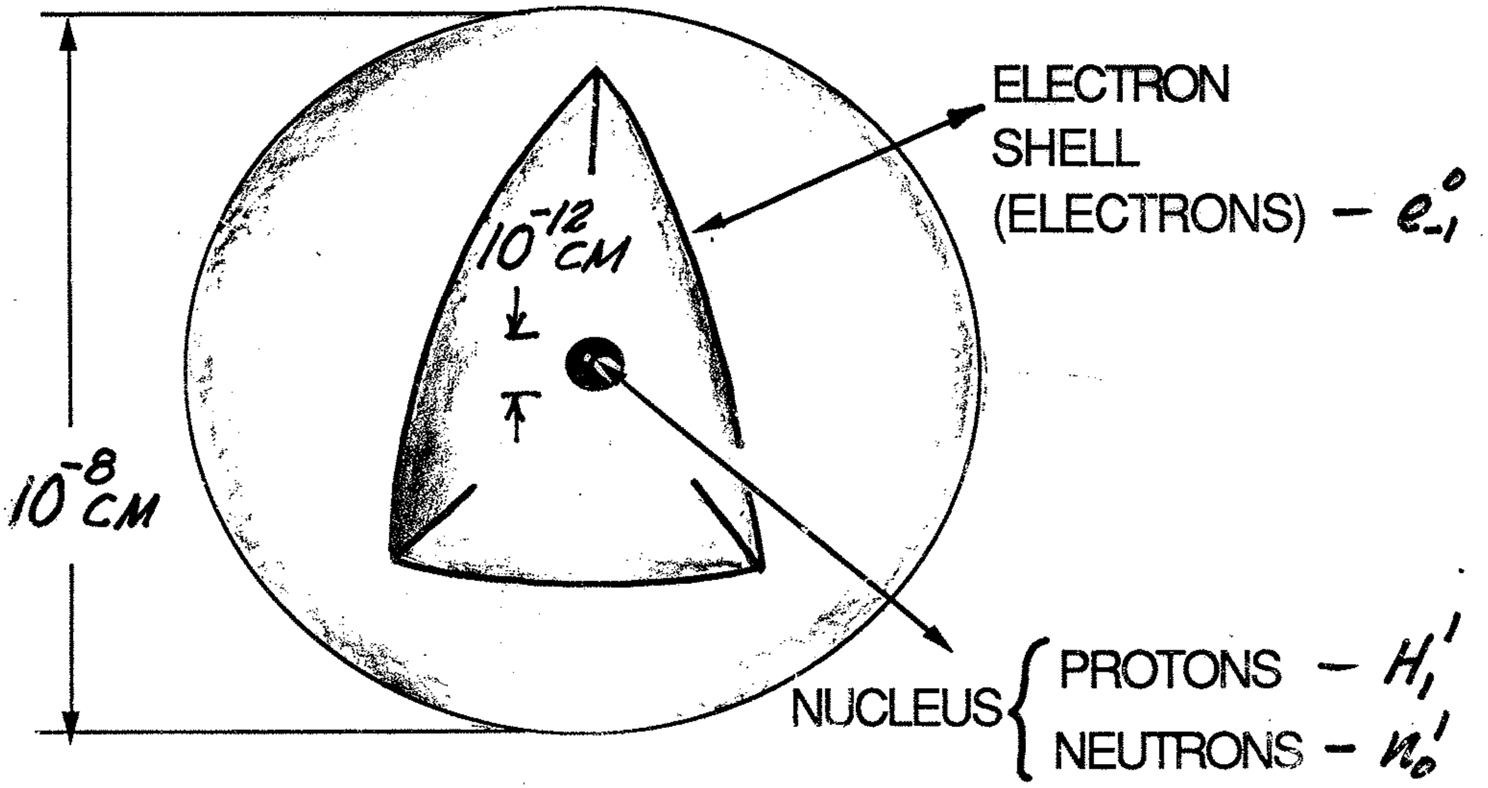
THE ATOM



BINDING ENERGY

ELECTRONS – 0.1 e.v. to 100 e.v.

NEUTRONS & PROTONS – 2 to 9 million e.v.

PRIMARY ENERGY SOURCES

1. CHEMICAL REACTIONS

-Rearranging Electrons

e.g. $C + O_2 \rightarrow CO_2 + 2$ e.v.

2. NUCLEAR REACTIONS

-Rearranging Protons & Neutrons

TYPES:

a. Radioactive decay (1 to 5 Mev)
b. Fission (200 Mev)
c. Fusion (2 to 20 Mev)

e.g. $H_1^2 + H_1^3 \rightarrow He_2^4 + n_0^1 + 18$ Mev

FISSION:	SPLITTING (–DIVISION) OF CERTAIN HEAVY NUCLEI RELEASING ENERGY
RADIOACTIVE DECAY:	SPONTANEOUS EMISSION OF MASS AND ENERGY FROM NUCLEUS
FUSION:	COMBINING (~FUSING) OF LIGHT NUCLEI TOGETHER RELEASING ENERGY

BASIC ENERGY LAW

$E = MC^2$ — EINSTEIN'S EQUATION

Energy (million e.v.) = $931 \times 10^6 \times$ Mass (a.m.u.)

RATIO: $\dfrac{\text{Nuclear Reaction}}{\text{Chemical Reaction}} \approx \dfrac{\text{10 Million}}{1}$

BINDING ENERGY WHICH HOLDS THE NUCLEUS TOGETHER

$\Delta E = C^2$ [MASS (# nts = # protons)-Nuclear Mass]

CONVENTIONAL FOSSIL-FUELED PLANT

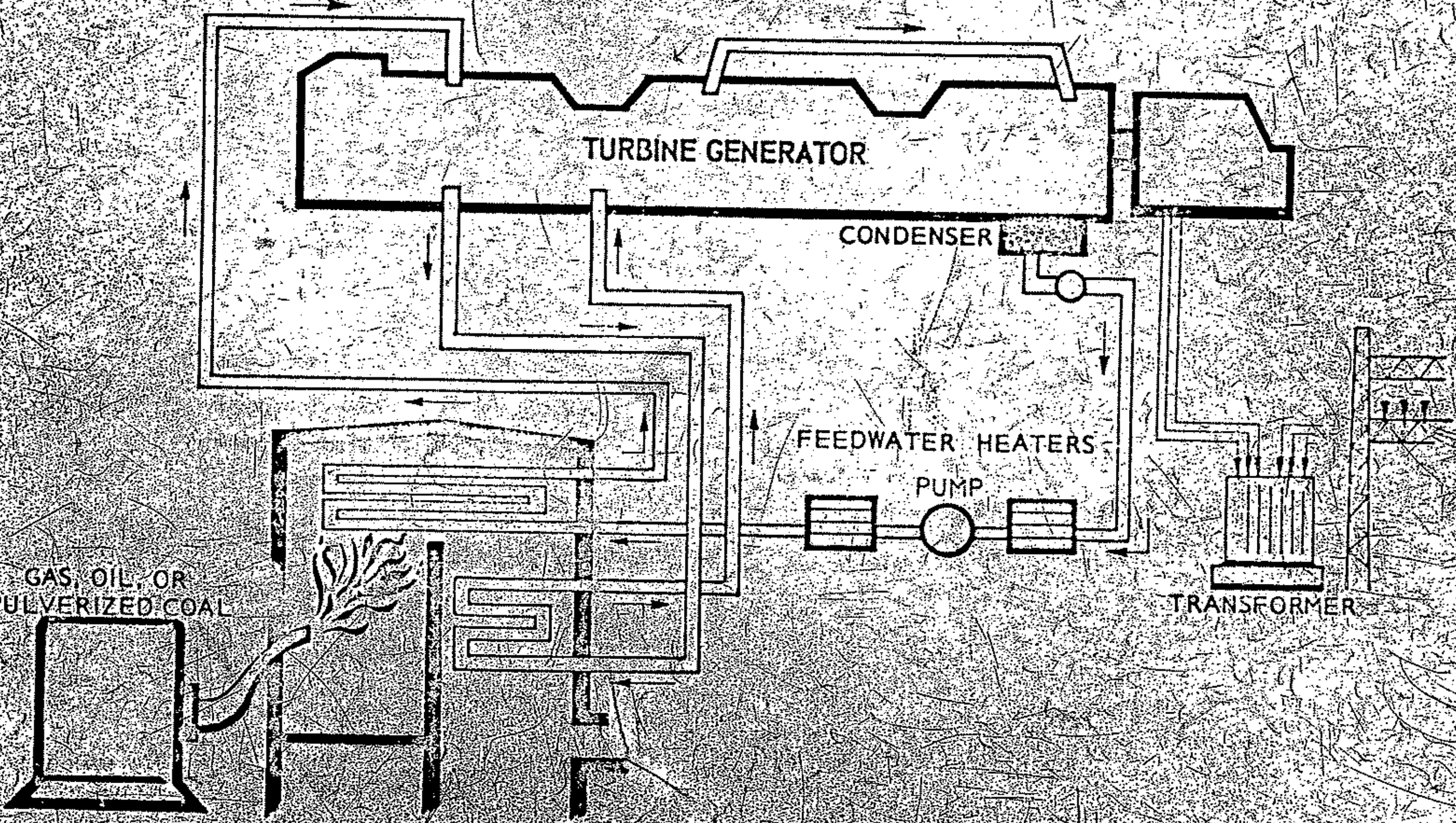


FIGURE 15

BOILING WATER REACTER

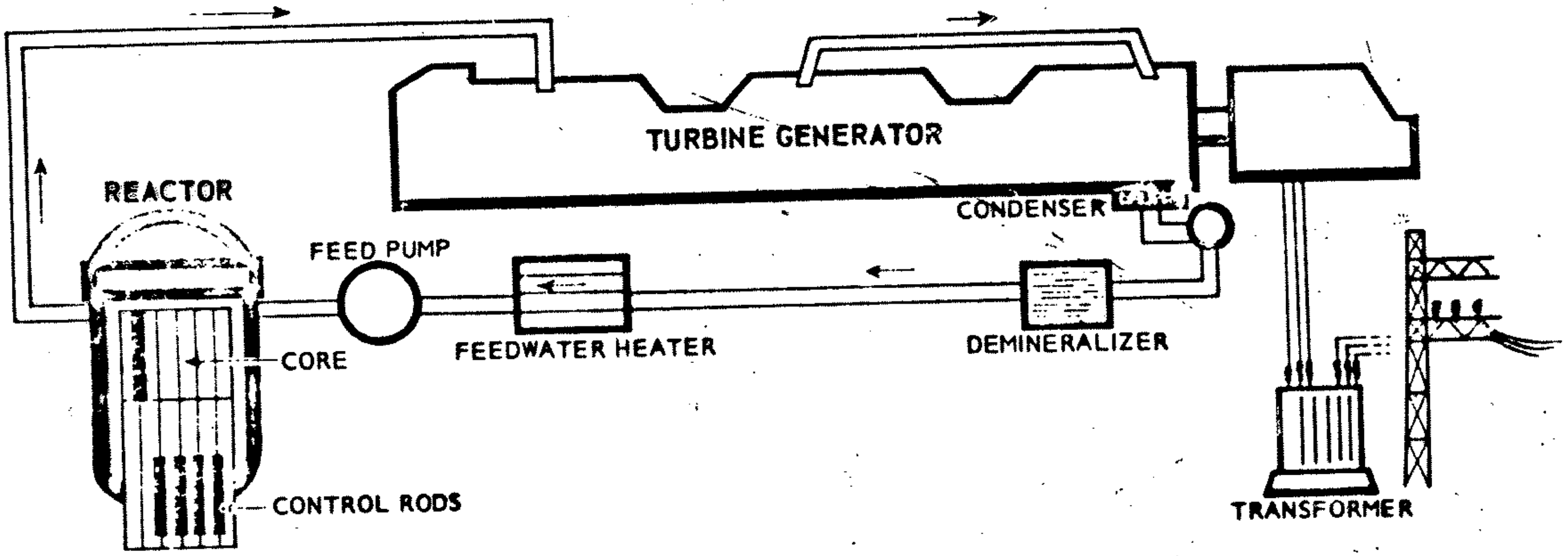


FIGURE 11

CURRENT US ELECTRIC POWER SITUATION (DOE ASSESSMENT)

(2006 DOE-EIA data) Fossil 71.1%, Nuclear 19.4%, Hydro 7.1%,

Others 2.4% (Wood, Waste, Geothermal 1.7%, Wind & Solar 0.7%)

Americans expect electrical power to be
- reliable (available on demand)
- inexpensive (<10cts/kWhr- US average)
- low environmental impact (control Greenhouse gases).

Limited baseload capacity added past decade (2000-2009)

No new US nuclear plant orders since 1979 because

- Coal & nuclear baseload excess capacity ~35% up to 2000
- Unstable NRC licensing discouraged new plant construction.
- Low public support due to TMI-2(1979), Chernobyl (1986) accidents
- No assured means of disposing of spent nuclear fuel.

SIMPLE PROJECTION US ELECTRIC POWER NEXT 20 YRS

U.S. electric average growth ~2.2%/yr as of 2007 (~2.5% in 2008)

Current capacity ~ 700 GWe (2 GWe supports ~1 million US residents)

For growth at 2.2%/yr next two decades (2010 to 2029)

New Electric Power in 2029 = 700 GWe $(1.022)^{20}$ = 1080 GWe

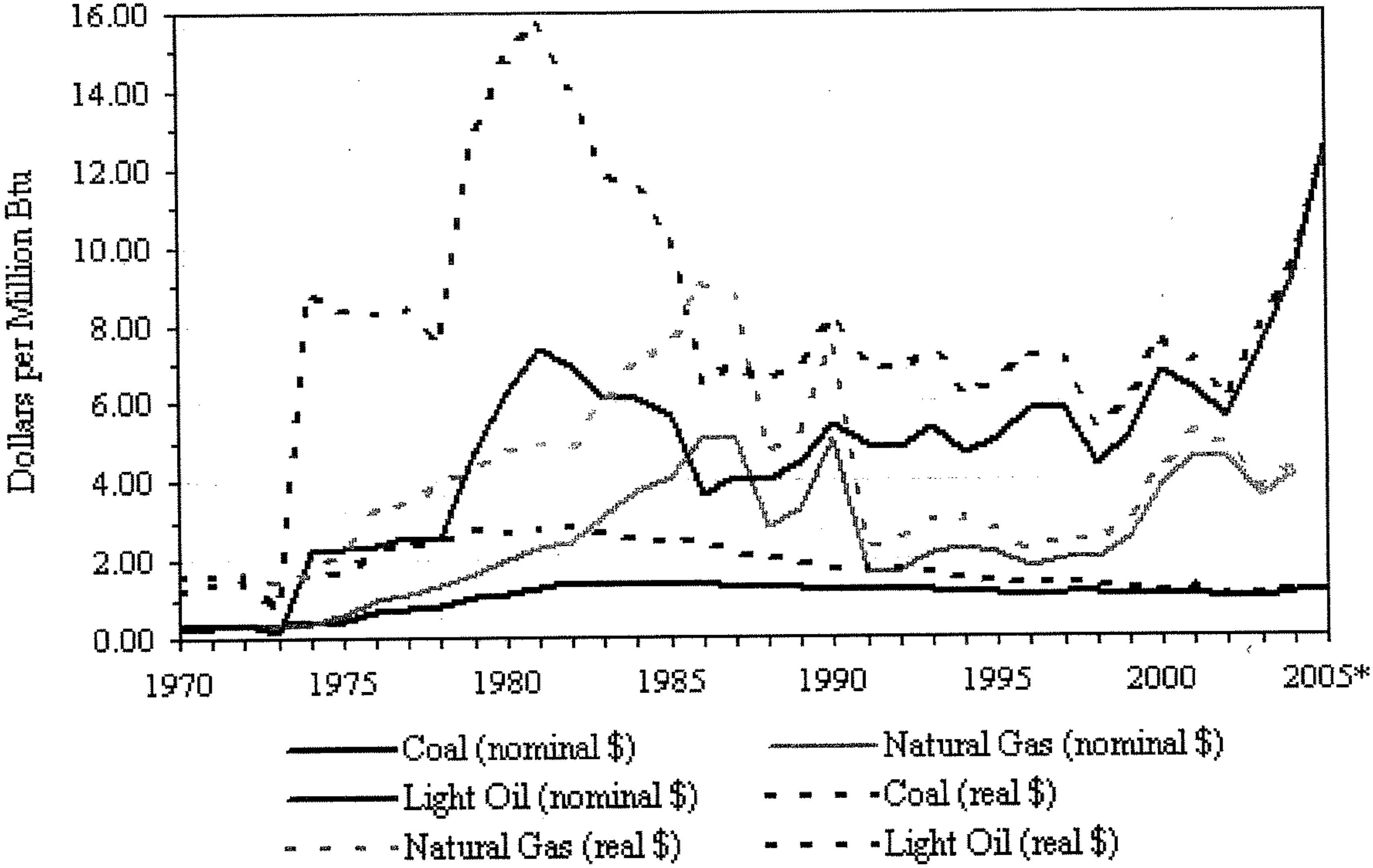
Total needed in 2029 =1080 GWe + 120 GWe (replacement) = 1200 GWe

New capacity (1200 – 700) GWe = 500 GWe or 500 GWe/20 yr = 25 GWe/yr

Requires annual construction

- 28 - 1 GWe nuclear plants (at 90% capacity) - Cost $5000/kWe
  28 Nuclear Plants x $5 billion each = $140 billion
  Land area required @ 100 acres each = 2800 acres = 4 sq miles
- 42,000 - 2 MWe Wind Turbines (at 30% capacity) - Cost $2000/kWe
  42,000 Wind turbines x $4 million each = $168 billion
  Land area at 100 acres each = 4.2 million acres = 6500 sq miles
- 500 sq km – Solar Collectors (at 20% efficiency) - Cost $18,000/kWe
  500 million sq m x $1000/sq m = $500 billion
  Land area at 2 sq km/1sq km-collector = 1000 sq km = 380 sq miles

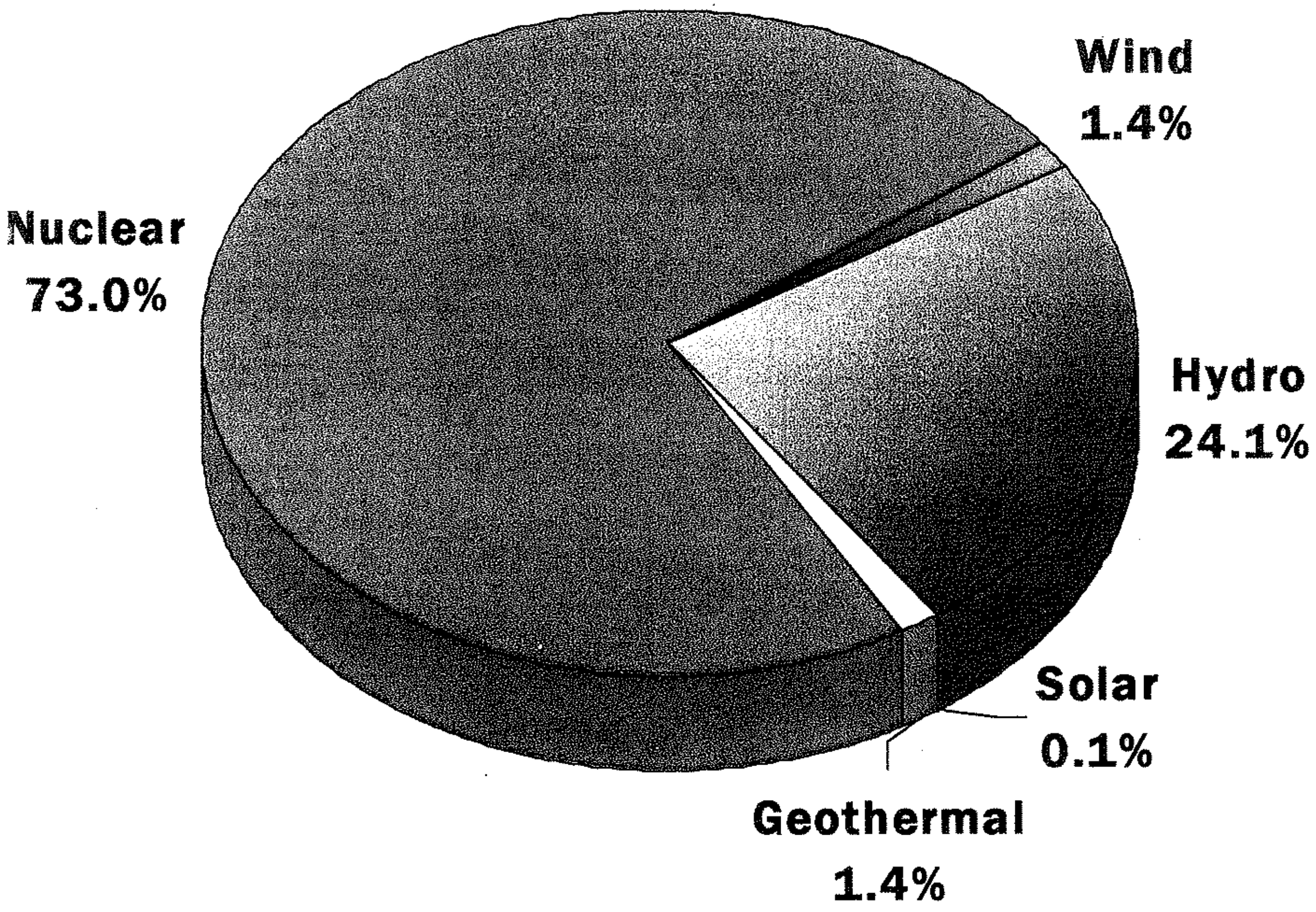
Figure 5.3 - Cost of Fuel to Generate Electricity in Utah, 1970-2005



Evaluation of Reactor Designs for NTD Potential

Design	Supplier	Size and Type	Key features
ABWR	GE	1,350 MWe BWR	Advanced evolutionary LWR, design certified by NRC and built and operating in Japan.
SWR 1000	ANP Framatome	1,013 MWe BWR	Advanced BWR design; to meet European Requirements
ESBWR	GE	1,380 MWe BWR with passive safety features	Based on earlier passive SBWR design, but higher in capacity and decreased in physical size per installed KWe.
AP600	Westinghouse	610 MWe PWR with passive safety features	Advanced passive PWR, design certified by NRC
AP1000	Westinghouse	1,090 MWe PWR with passive safety features	Higher capacity version of AP-600; not yet certified
IRIS	Westinghouse	100-300 MWe PWR	Integral primary system plant design; eliminates classic LOCA accidents.
PBMR	ESKOM	110 MWe modular pebble bed gas-cooled reactor	Modular direct cycle helium-cooled pebble bed design, currently planned for construction in South Africa.
GT-MHR	General Atomics	288 MWe prismatic graphite moderated gas-cooled reactor	Modular direct cycle helium-cooled reactor being licensed for construction in Russia, for power production and disposition of excess Russian weapons-grade plutonium.

Sources of Emission Free Electricity



Source: Global Energy Decisions / Energy Information Administration

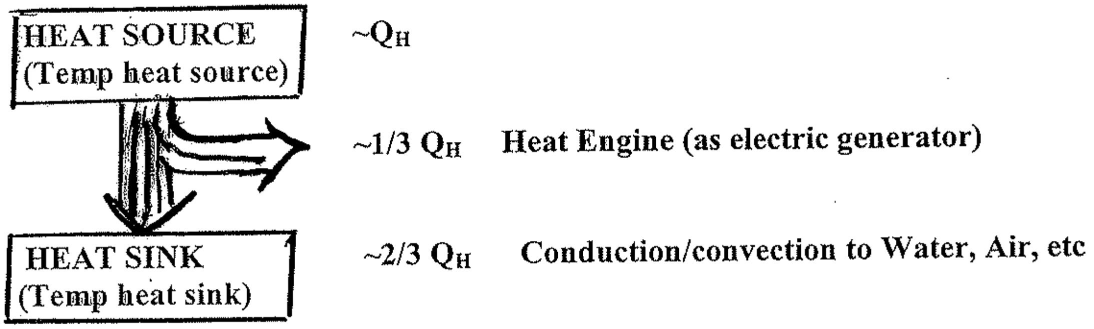
1000 MW (or 1GW) ELECTRIC POWER PLANT
Electric power for 500,000 people

COAL	NUCLEAR
40% efficiency 11,000 BTU/lb (Bituminous) 1/2% sulfur C + O2 -> CO2 + 2 ev	32% efficiency 3% enriched U-235 fuel Light Water Reactor (PWR/BWR) U-235+n ->FP+nts+200 million ev
FUEL	
10,000 tons/day - coal (One hundred 100 ton RR cars) 22,000 tons/day - oxygen (110,000 tons/day or 9 cubic miles/yr)	8.3 lbs/day - U-235 (1 lb U-235 equal to about 1000 tons of coal
WASTE PRODUCTS	
30,000 tons/day - CO2 1200 tons/day - ash 500 tons/day – NOx 200 tons/day – SOx 50 tons/day – toxic hydrocarbons 200 lb/day – toxic trace elements (As,Be,Cd,Se,Hg,Pb,Sn,Sb,Cr, etc) 100 lbs/day –naturally occurring U, Th, K-40, C-14, Radon, Thoron	8.3 lbs/day – fission products (FP) 3.7 lbs/day – transuranics (Pu, etc) 15 lbs/day – low level activity (Resins, coolant residues, etc)
HEALTH EFFECTS	
25 death in public (AMA estimate) 2 worker deaths	0.02 deaths in public (extrapolated) 1 worker death
DISPOSAL	
PRESENT OPTION 31,000 tons/day – air release (CO2, NOx, SO2, Rn, etc) 1200 tons/day ash & trace mat'ls	**NO PROCESSING OPTION** 12 lbs/day HLW, TRU mat'ls 30 MT/yr as spent fuel-10,000 yr 3 MT low-level waste
CLEAN COAL TECHNOLOGY 30,000 tons/day –air release 2000 tons/day–solids(always toxic)	**REPROCESSING – MOX** 2 MT/yr fission products-1000 yr 4 MT/y low-level waste
CARBON SEQUESTRATION(Ca) 70,000 tons/day CaCO3 (seven hundred – 100 ton RR cars) 1200 tons/day ash & trace mat'ls	

Data Sheet on Usage of US Water Resources

I- All thermal electric power cycles controlled by Second Law of Thermodynamics

(Heat flows naturally from high temperature sources to low temperature sinks)



$$\text{Efficiency} = \frac{\text{Work (electrical power) Output}}{\text{Heat Input (combustion or fission)}} = 1 - \frac{\text{absolute Temp (heat sink)}}{\text{absoluteTemp (heat source)}} \sim 1/3$$

****

II TYPICAL THERMAL PLANT EFFICIENCIES

Coal plant efficiencies	30 to 40%
Natural gas efficiencies	35 to 40%
Nuclear LWRs (<1980)	33%
Nuclear Adv LWRs(~2005)	36+%

****

III US Water Consumption (source: USGS)

Electrical Power Generation (all sources)	3.3%	~ 2 liters/kWhr or 5 gals/person-day
(Nuclear portion of electrical power)	(0.7%)	~ 1 gal/ person-day
Residential (3 member family)	6.7%	~ 100 gals/ person-day
Irrigation (Agricultural)	81.3%	~ 1200 gals/ person-day
Other	8.7%	~ 130 gals/ person-day
Total	100%	

****

IV Cooling water requirements (avg US ~2005) Liters/kWhr (Nat'l Energy Tech Lab-DOE)

TYPE		withdrawal	consumption	C sequestration (total consumption)
Nuclear	Once through	160	1.5	
	Recirculation (pond)	3.0	2.1	
	(tower)	3.6	2.5	
Coal	Once through	130	1.1	~2
	Recirculation (pond)	1.7	1.5	
	(tower)	1.7	1.8	~3

****

V Total US Electrical Generation from 1950 – 2006 (DOE – EIA) for US population @ 300 million

Fossil fuels	73%	220 million people (electrical power)
Nuclear	14%	42 million people (electrical power)
Renewables	~11%	33 million people (electrical power)
Hydro	11%	
Wind	0.11%	300,000 people (metropolitan SLC - electrical power)
Solar	0.01%	30,000 people (U of U campus population)
Others	2%	

Hydroelectric is the largest consumer of fresh water of all electrical power generation sources due to evaporation of water from dam sites (Lake Powell, Lake Mead, Grand Cooley Dam, etc).

Data Source: Gary M Sandquist 6/17/2009

New Nuclear Plants Global Status (*Jan 2008*)

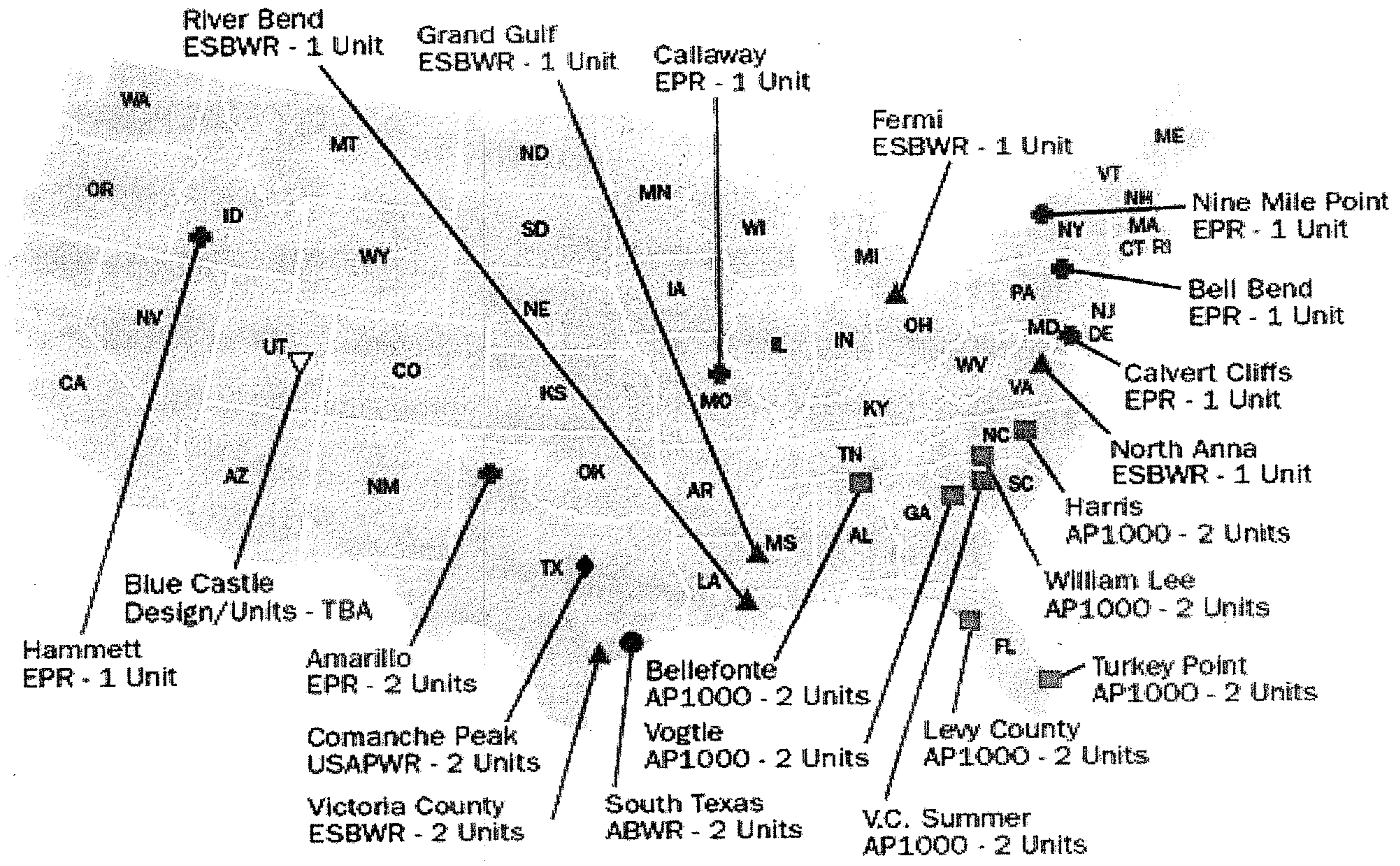
- 35 plants under construction ~ 28 GW
- 93 plants on order or planned in 18 countries
  - Expected to be in operation by 2017
- 200 projects under consideration in 27 countries
  - Statement of intent/proposal
- Media reports US Navy production expansion to two Virginia class submarines per year in 2012
  - Reactor equipment orders in 2010
  - Additional equipment orders for nuclear aircraft carriers periodically

nuclear
manufacturing
outreach

Source WNA Jan 2008

New Reactor Designs

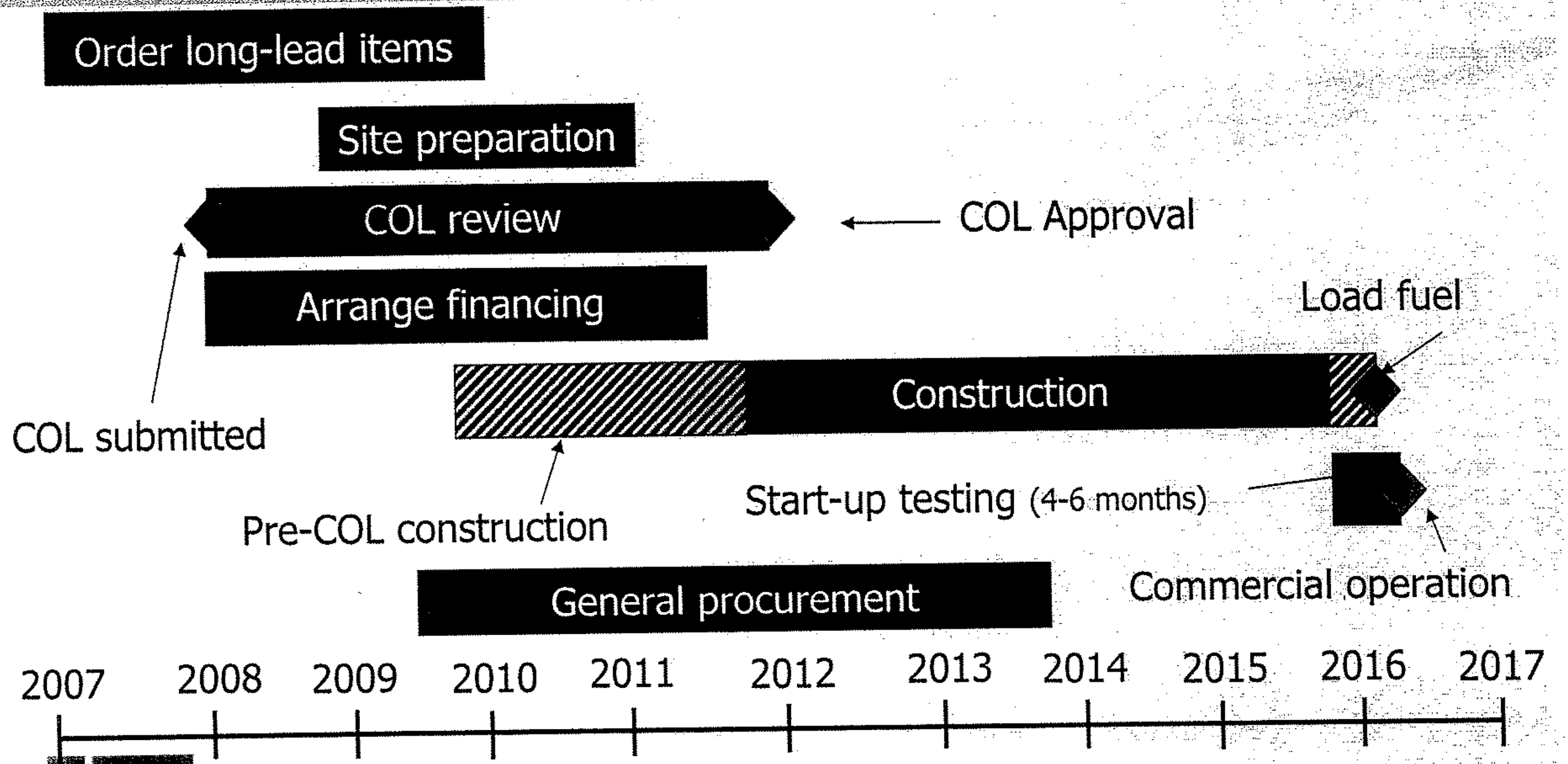
Reactor Design	Vendor	Approximate Capacity (MWe)	Reactor Type	Certification Status
AP600	Westinghouse	650	PWR	Certified
AP1000*	Westinghouse	1117	PWR	Certified
ABWR*	GE et al	1371	BWR	Certified
System 80+	Westinghouse	1300	PWR	Certified
ESBWR*	GE	1550	BWR	Undergoing certification
EPR*	AREVA NP	1600	PWR	Pre-certification
PBMR	Westinghouse, Eskom	180	HTGR	Pre-certification
IRIS	Westinghouse et al	360	PWR	Pre-certification
US APWR	Mitsubishi	1600	PWR	Undergoing certification
ACR Series	AECL	700-1200	Modified PHWR	Pre-certification
GT-MHR	General Atomics	325	HTGR	Research prototype planned
4S*	Toshiba	10-50	Sodium-cooled	Potential construction



You may click on a design name to view the NRC's Web site for the specific design.

● ABWR ▨ AP1000 ✚ EPR ▲ ESBWR ◆ USAPWR ▽ Design/Units - TBA

Short-Term



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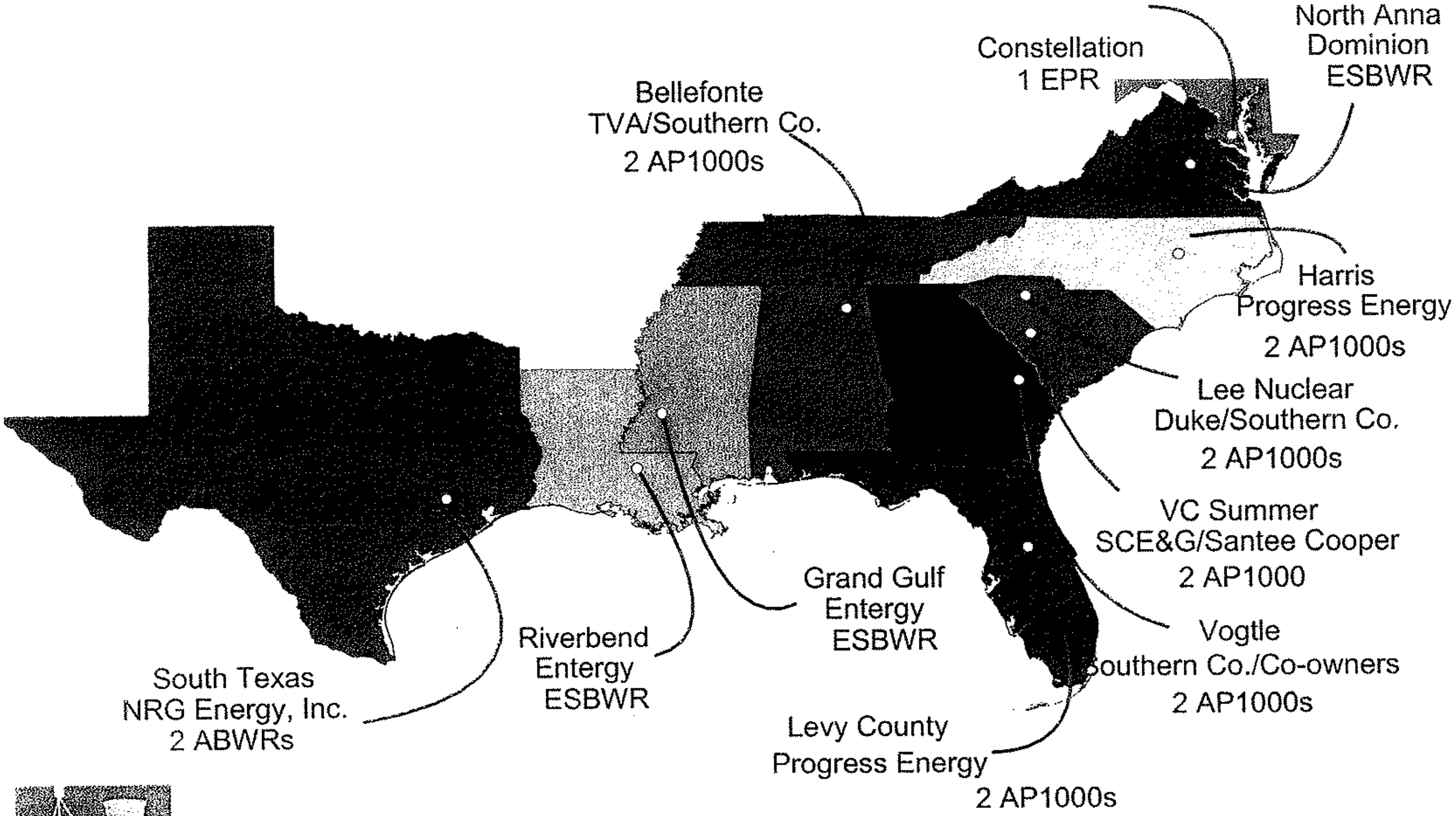
US Commercial Outlook to 2020

- First 4 – 8 plants expected to start commercial operations in 2016
  - Others under construction
  - Building rate and projects adjusted based on the success of the first few projects
- Potential for new plants
  - 15 - 20 in 2020; 35+ in 2030
  - If first projects are successful

The Demand for Nuclear Power AP1000 in the US

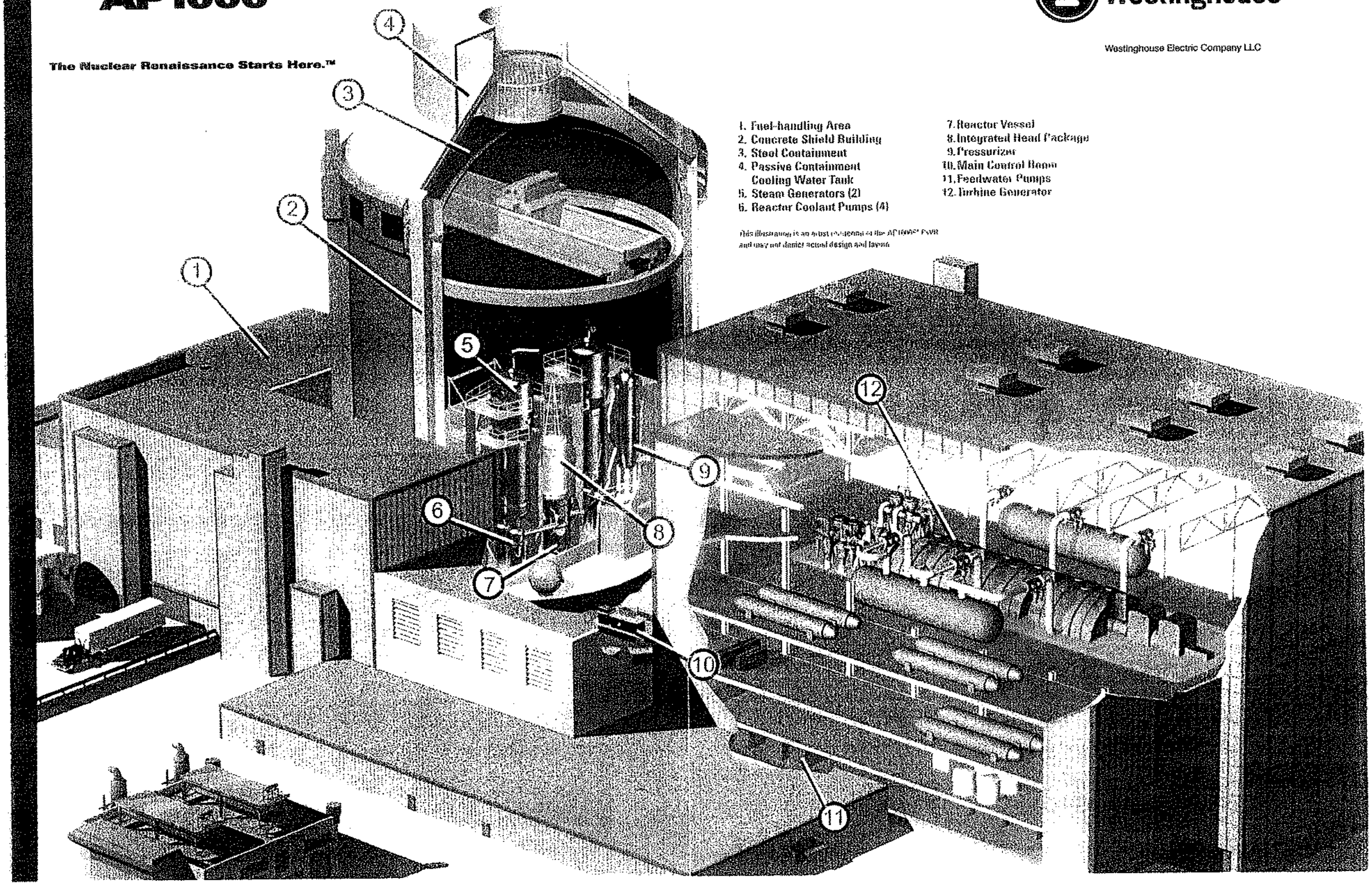


AP1000™

The Nuclear Renaissance Starts Here.™

Westinghouse

Westinghouse Electric Company LLC



1. Fuel-handling Area
2. Concrete Shield Building
3. Steel Containment
4. Passive Containment Cooling Water Tank
5. Steam Generators (2)
6. Reactor Coolant Pumps (4)
7. Reactor Vessel
8. Integrated Head Package
9. Pressurizer
10. Main Control Room
11. Feedwater Pumps
12. Turbine Generator

This illustration is an artist rendering of the AP1000™ PWR and may not depict actual design and layout.

Toshiba 4S (Super Safe, Small and Simple) NUCLEAR REACTOR

"nuclear battery" reactor design

requires minimal operating staff

simple technical specifications unique in nuclear industry.

reactor located in sealed, cylindrical vault 30 m (100 ft) underground

control building above ground 22 x 16 x 11 m (72 × 50 x 36 ft) in size.

Provides 10 Megawatts of power.

neutron reflector panels around core maintain neutron density.

reflector replaces complicated control rods,

Shuts down nuclear reaction in case of emergency.

utilizes liquid sodium as coolant so reactor 200 F hotter than water.

steam pressure at this temperature > 2000 psi

electric costs 5 and 13 cents/kWh in Galena, Alaska (operating costs only).

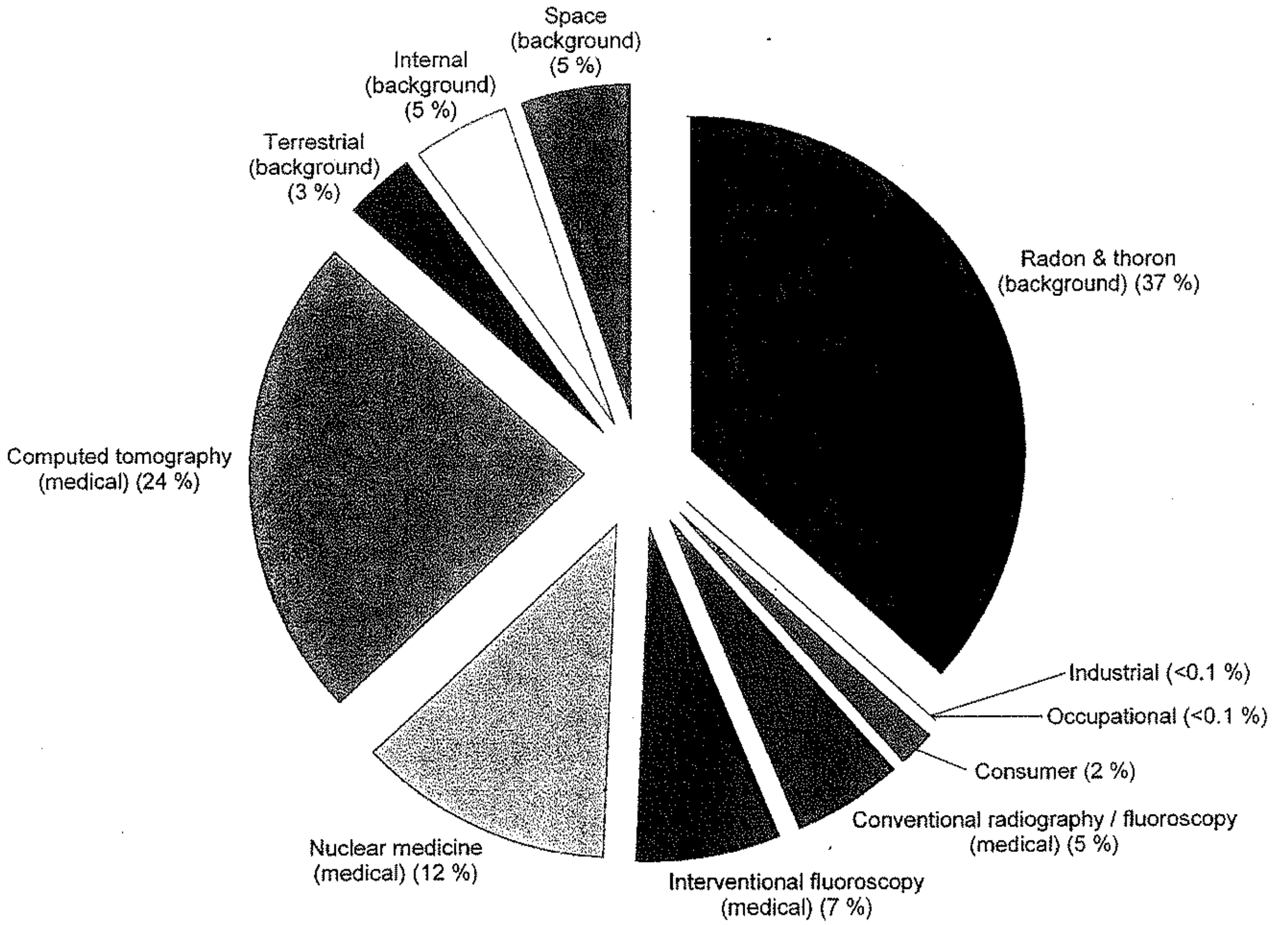
reactor operates for 30 years without refueling.

Toshiba 4S Nuclear Battery proposed power source for Galena Nuclear Power Plant in Galena, Alaska.

For immediate release:
March 3, 2009 (12:00 PM)

NCRP 1929
2009

All Exposure Categories
Collective Effective Dose (percent), 2006



A limited number of prepublication copies of Report No. 160 will be available during the NCRP annual meeting on March 2-3, 2009. The final Report will be available from the NCRP website, http://NCRPpublications.org, in both soft- and hardcopy formats. For additional information contact David A. Schauer, ScD, CHP at schauer@NCRPonline.org, 301.657.2652 (x20) or 301.907.8768 (fax).

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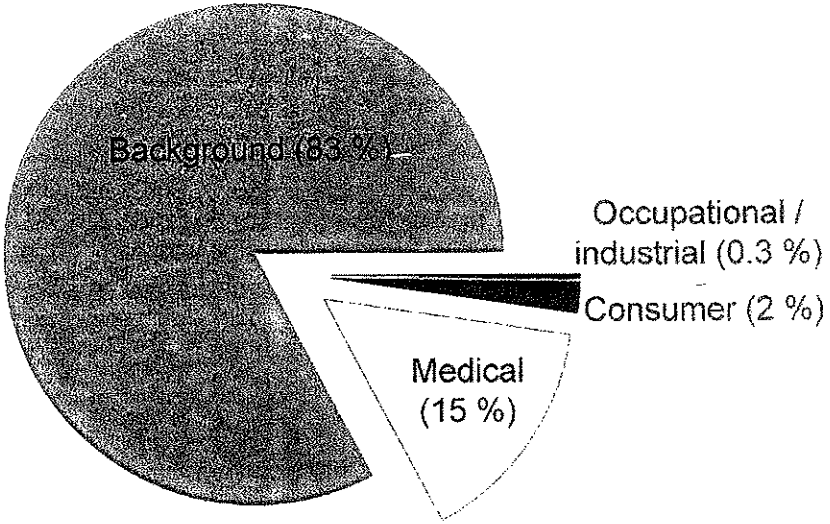
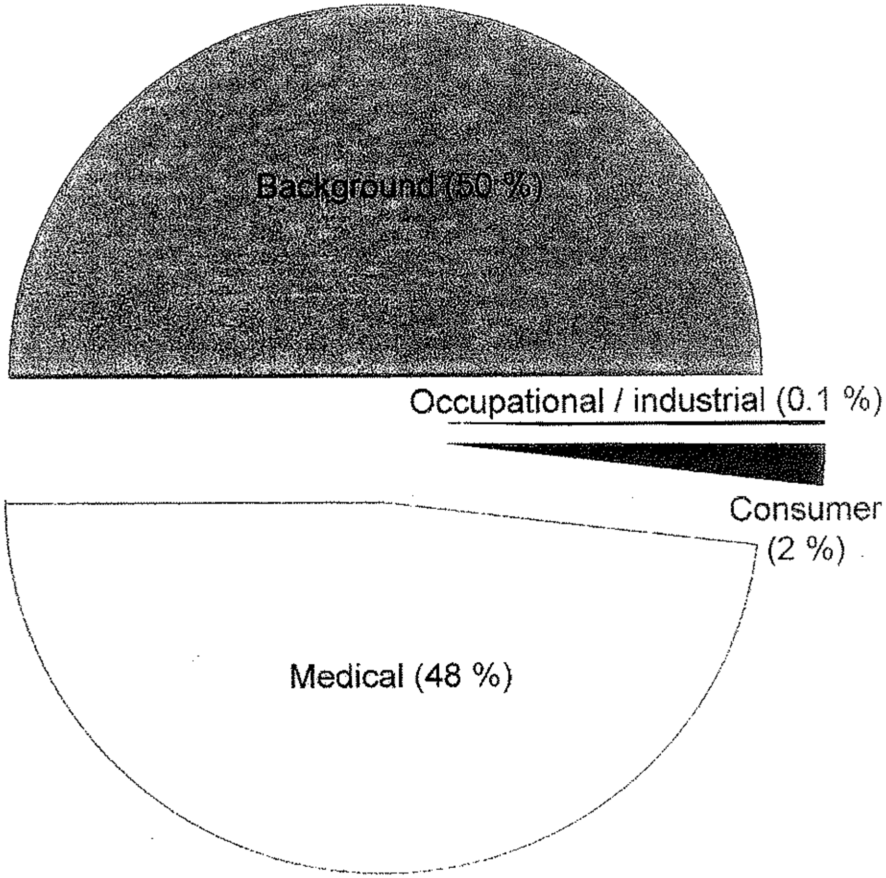
http://NCRPpublications.org

NCRP Report No. 160, *Ionizing Radiation Exposure of the Population of the United States*

Early 1980s



2006



	Early 1980s	2006
Collective effective dose (person-Sv)	835,000	1,870,000
Effective dose per individual in the U.S. population (mSv)	3.6	6.2

Is wind power solution to Utah's future electrical energy need?

Utah consumed 41,300 GW-hr electricity in 2006. Average annual power of 4.7 GW

90% from coal, 8% natural gas, 2% hydro, less than 1% from geothermal, wind and solar.

Utah's future annual electrical energy growth about 3%. Doubles from 4.7 to 9.4 GW by 2030

Impacts of generating 4.7 GW from wind energy only

GE wind turbines produce peak output of 2 MW at minimum cost of $1000/kW

Construction, transmission, distribution totals about $3 million each.

Capacity factor for turbines less than 30% for wind loading and downtime

So 7800 (2 MW) wind turbines needed to provide 4.7 GW by 2030.

7800 wind turbines at $3 million each is $23 billion or $4900 per KW delivered.

New coal plants cost about $1500 to $2000 per KW

New nuclear plants costs estimated at $1800 to $2300 per KW.

Annual cost of fuel must be added to coal and nuclear plants

Impact of massive wind turbine infrastructure and construction effort

Wind towers have 200 foot diameter blades and reach 350 feet above grade

Silhouette similar in size to LDS Church Office Building in Salt Lake City.

7800 wind turbines distributed along 300 mile I-15 and 200 mile I-80

Need a wind turbine every 400 feet along these two interstates.

Wind turbines extract and alter energy from flowing wind because of turbulence and other meteorological conditions to create an artificial mountain range 1 mile wide, 700 feet high (I-15&I-80)

Impact upon seasonal weather and precipitation conditions in Utah.

Utah's water budget depends on mountain snow pack and water recharge zones in Bear, Weber, Jordan, Unita, and Sevier River watersheds along Wasatch Mountain range.

These areas best wind resource areas identified by US DOE.

Would such a massive topological disturbance affect Utah's water storage economy?

Wind towers on mountains would increase capital, transmission, and maintenance costs

Impacts upon Utah's water budget, climate changes, electrical utility costs, and reliability and environmental issues of massive development of wind energy must be evaluated and addressed.

UTAH ELECTRICAL POWER GROWTH @ 2.5% / YEAR

2008	2035 (DOUBLES)	INCREASE
5.2 GW	10.4 GW	~5 GW

EMPLOY WIND FOR 20% (1 GW) BASE LOAD POWER BY 2035

WIND AVAILABILITY ~ 25% OF TIME POWER OUTPUT = $(\text{AIR SPEED})^3$

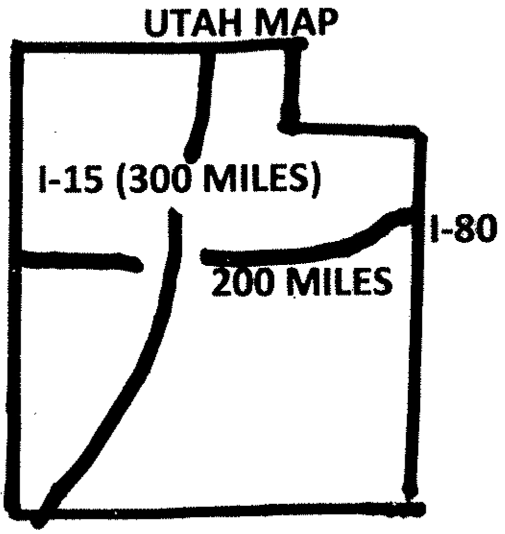
IF AIR SPEED DROPS TO 1 / 2 POWER OUTPUT = $(1/2)^3 = 1/8$

SO FOR 1 GW/.25 = 4 GW WIND TURBINES REQUIRED FOR BASE LOAD

2 MW GE WIND TURBINES 500 FT HIGH - BLADES 200 FT DIAMETER

~THESE GE TURBINES HAVE PROFILE OF LDS CHURCH OFFICE BUILDING

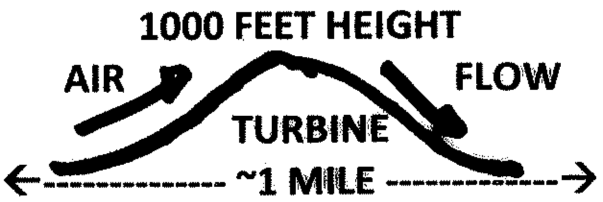
NUMBER OF WIND TURBINES NEEDED	4000 MW/2 MW PER TURBINE 2000 WIND TURBINES => 1 GW BASELOAD



TOTAL INTERSTATE
300 MI (I-15) + 200 MI (I-80) = 500 MILES

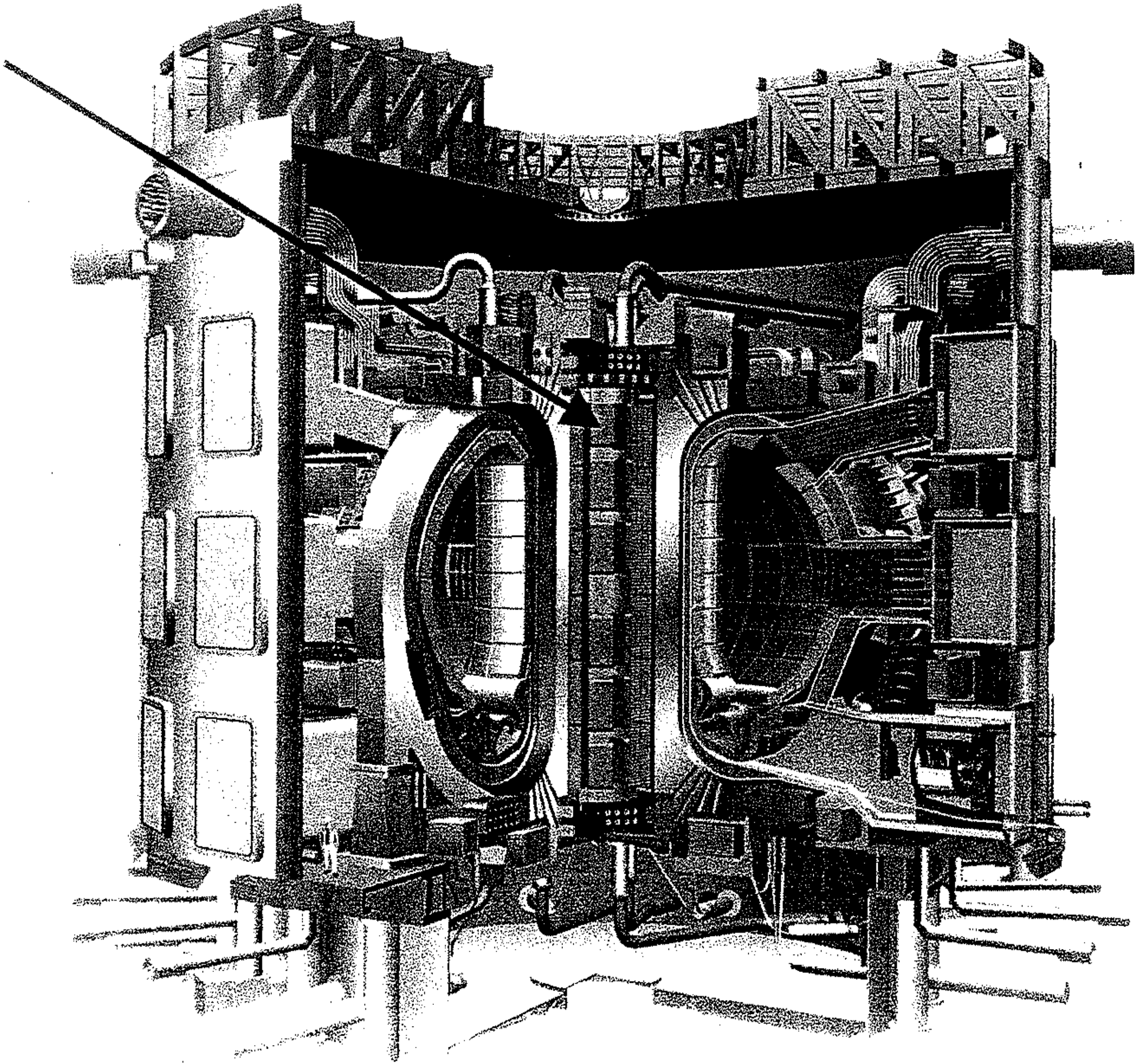
2000 TURBINES OVER 500 MILES INTERSTATE
= 4 TURBINES/MILE OF INTERSTATE

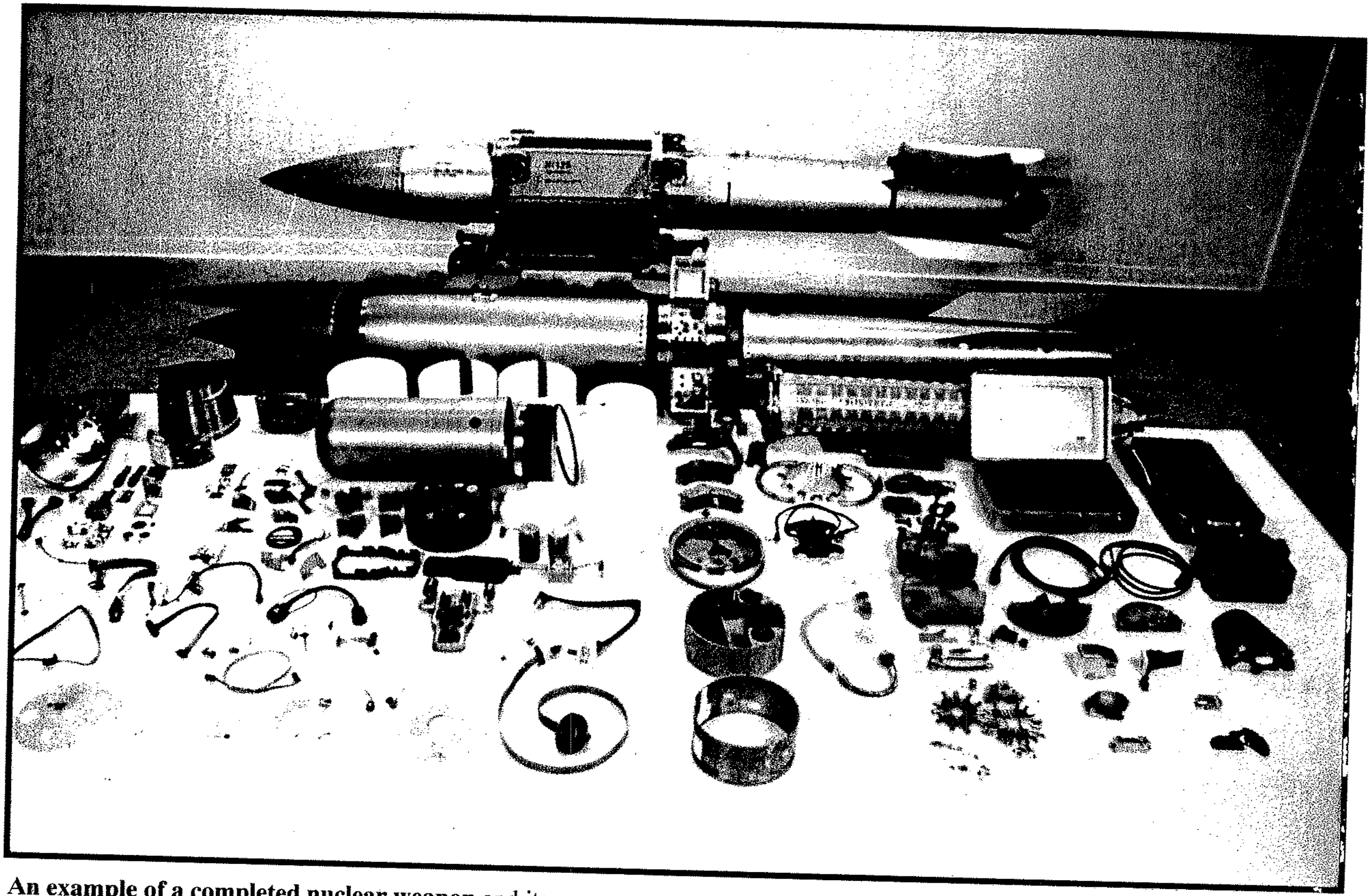
WIND FLOW DISTURBANCE



CREATED A NEW ARTIFICIAL LOW MOUNTAIN RANGE SPANNING UTAH
UNKNOWN IMPACT ON AIR FLOW AND PRECIPITATION (SNOW PACK)
UTAH WATERSHEDS (WEBER, UNITA, BRIAN HEAD, ETC)
UTAH IS SECOND DRIEST STATE (AFTER NV) IN US. **CONCERN!!**

International Thermonuclear Experimental Reactor (ITER)





An example of a completed nuclear weapon and its component parts. At top, an intact B-61 nuclear bomb. At bottom, the assemblies and subassemblies that comprise this weapon. Dozens of facilities across the country engage in different processes and contribute specific parts to the production of nuclear weapons.