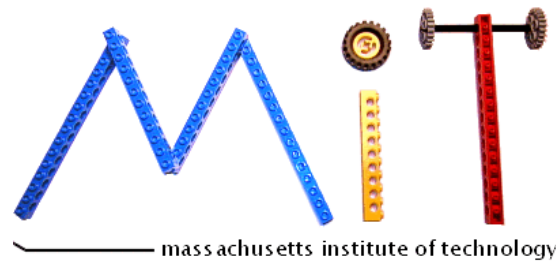


PROSPECTS FOR NEW NUCLEAR GENERATING UNITS IN THE U.S.

Paul L. Joskow



AEI

October 6, 2006

NUCLEAR POWER IN THE U.S.

- U.S. has 100 GW of nuclear capacity (20% of U.S. electricity generation)
- Performance has improved dramatically over time in all dimensions
- It is economical to extend the life of the existing fleet and “uprate” some units to increase capacity (3+ GW more)
- Growing interest in the U.S. in promoting investments in new nuclear capacity but economics, waste disposal, and public acceptance are uncertain
- Changes in licensing process and efforts to resolve waste disposal issues support new investment
- 2005 Energy Act contains financial incentives (production tax credits, other subsidies) to encourage “first-movers” to build new plants
- 6 GW of nuclear capacity additions plus 3.2Gw uprates forecast between 2015 and 2030 by EIA
 - 311 Gw total generating capacity additions forecast by 2030
 - 34 Gw of new nuclear in “low construction cost” sensitivity case
 - 70 Gw of new nuclear in “vendor cost goals” sensitivity case
- Several companies have announced that they will start the licensing process for new plants but no firm orders have been made yet

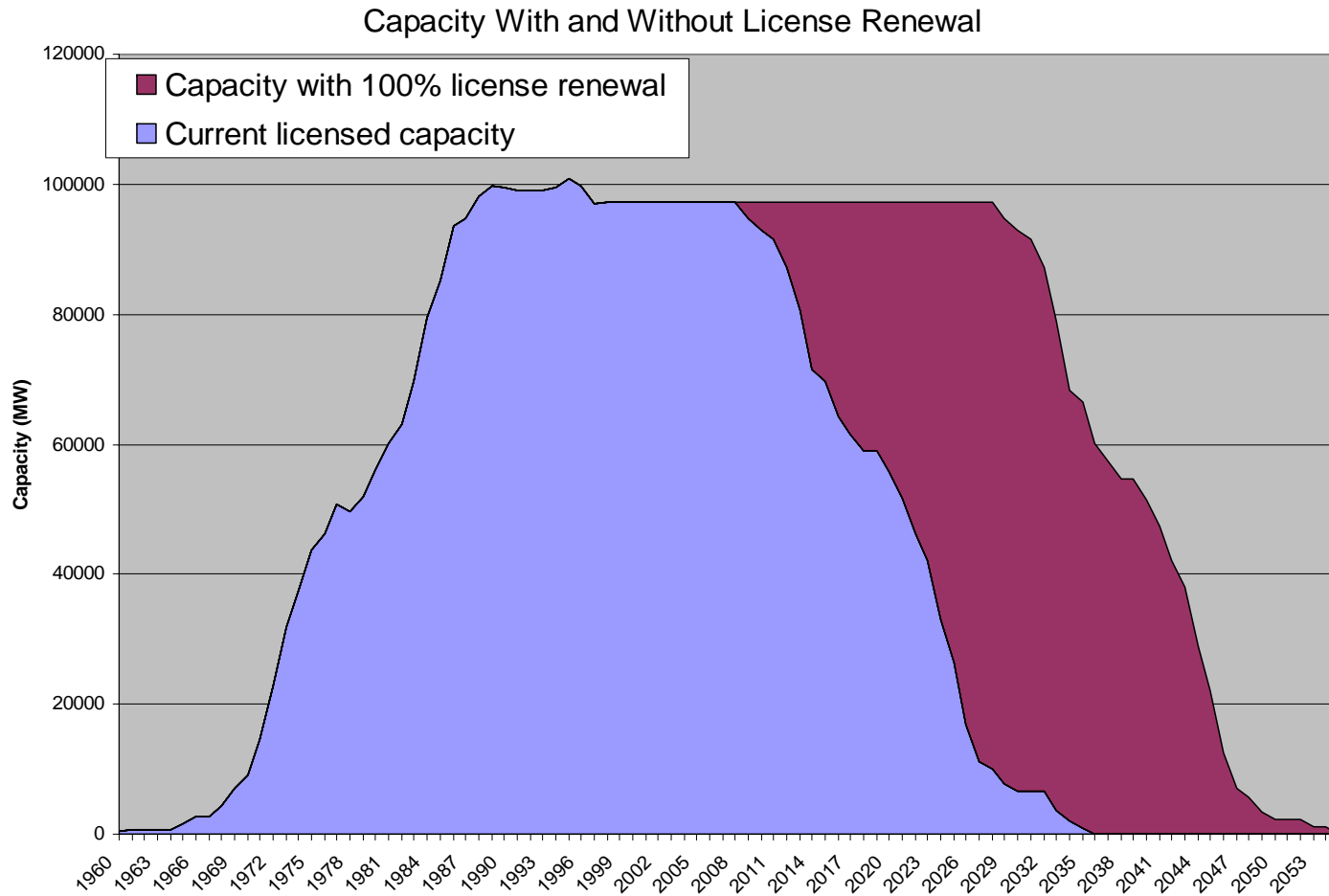
BACKGROUND CONSIDERATIONS

- Need to distinguish existing fleet of plants from investments in new plants
- Economics is only one consideration for viability of investment in new nuclear plants
 - Public and political acceptance
 - Effectiveness of new licensing process
 - Waste disposal policies
- CO₂ policies, natural gas prices, coal prices, government subsidies and competitive/contractual/regulatory framework are important drivers of comparative economics of investments in new nuclear plants for private sector investors

Prospects for Expanding/Extending Capacity of Existing U.S. Fleet

- License renewals/extensions (as of September 1, 2006)
 - 44 units approved
 - 8 units under review
 - 26 letters of intent (multiple units)
- Power uprates
 - Additional 3.2 GW forecast by EIA
- Refurbishment:
 - Browns Ferry 1 on track for 2007
 - 1,280 MW plant
- Capacity factors:
 - Further improvement will be difficult

Without New Investments U.S. Nuclear Capacity Declines Quickly After 2030



Source: Dominion Resources, 2005

WHAT IS NEEDED TO STIMULATE SIGNIFICANT NUCLEAR INVESTMENT IN THE U.S.?

- Stable regulatory, competitive and commercial framework that will support capital intensive projects with relatively long construction expenditure cycles
- Stable and efficient nuclear plant licensing framework
- Achieve credible \$1500/kW (\$2002) (or \$1700/kW in \$2006) overnight cost including all relevant owner's costs, 5-year construction period and \geq 85% life-time capacity factor
- Placing a significant "price" on carbon emissions helps a lot
- Realize credible and economic nuclear waste disposal policy

CONSTRUCTION AND FINANCING COSTS

- No new nuclear plants completed in the U.S. for over 10 years
- There are few new nuclear plants under construction in the world
 - Mostly in less developed countries
- Recent credible construction and cost data are limited
- Competitive, regulatory and contractual environment is very uncertain and varies widely across the U.S. (and the world)
- The U.S. has not adopted policies to place a price on CO₂ emissions

CONSTRUCTION COST ESTIMATES

- Construction cost estimates should include all costs, including engineering, construction management and owner's costs (~ 20%)
- The best estimates are drawn from actual experience rather than engineering cost models
- Construction cost estimates for PC and CCGT can be verified from actual experience
- Publicly available data on recent nuclear plants completed suggest that \$2,000/Kw (\$2002) or \$2,300/kW (\$2006), including all owner's costs, with a 5-year construction period is a good base case cost estimate
- Competitive power markets induce truthful revelation of costs and associated uncertainties
 - Need to convince investors not me

RECENT CONSTRUCTION COST EXPERIENCE (\$2002)

Genkai 3	\$2,818/kW (overnight)
Genkai 4	\$2,288/kW (overnight)
Onagawa	\$2,409/kW (overnight)
KK6	\$2,020/kW (overnight)
KK7	\$1,790/kW (overnight)
Yonggwang 5&6	\$1,800/kW (overnight)
Browns Ferry RESTART	\$1,280/kW (overnight estimate)
Finland EPR (AREVA-Seimens contract only)	\$2,300/kW (nominal estimate 2005) (before cost of delays)
Bruce RESTART	\$1,425/kW (nominal estimate 2005)
Flammanville 3 (EDF)	\$2,600/Kw (nominal estimate 2006)

Source: MIT and Trade Press

COMPARATIVE BASE LOAD COSTS (MIT REPORT)

(\$2002 cents/kWh)

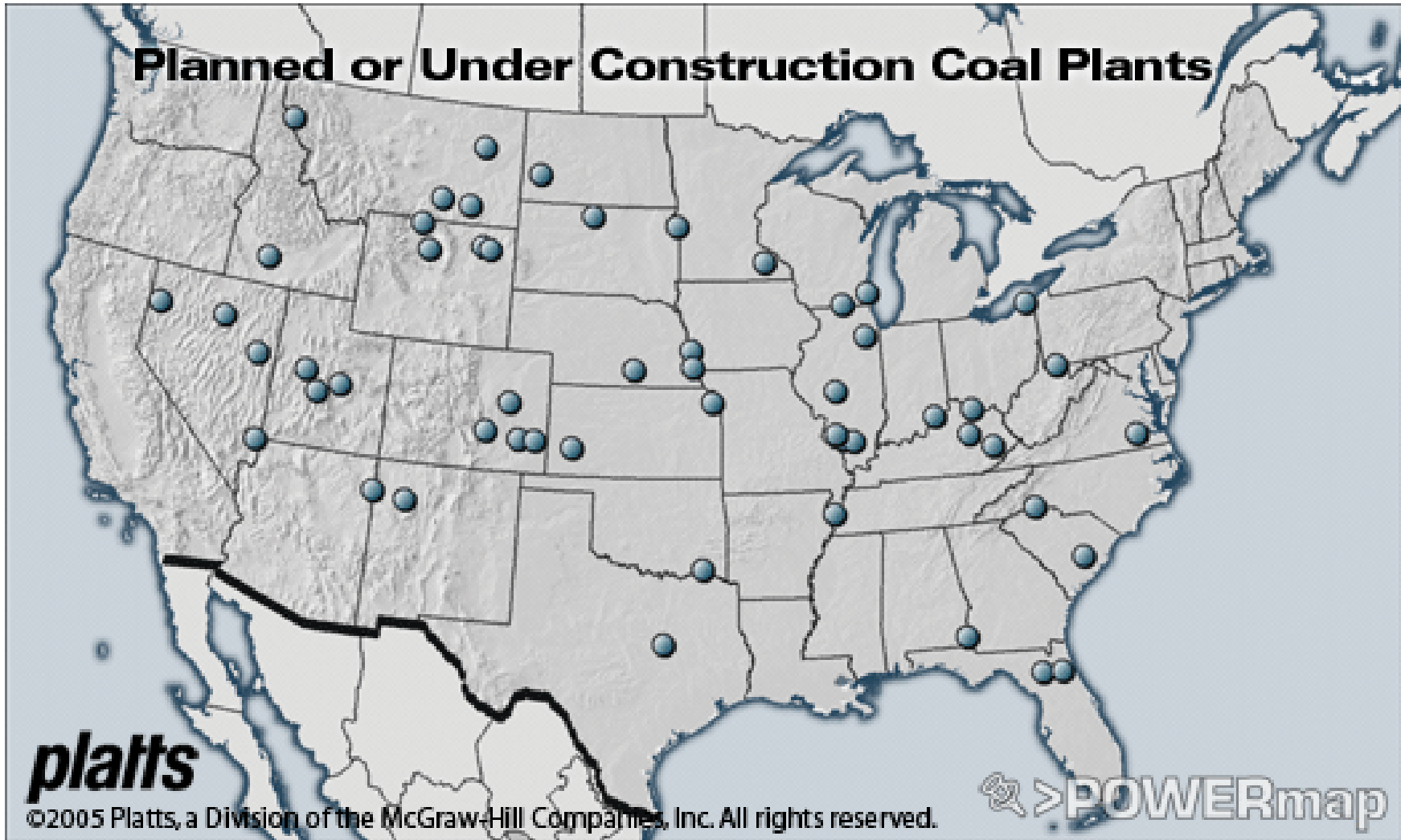
	<u>Merchant</u>	<u>Traditional</u>
Base Case (\$2000/kW)	6.7	5.2
Reduce Construction Costs 25% (\$1500/kW)	5.5	4.4
Reduce Construction time by 12 months	5.3	4.3
Reduce cost of capital (financing cost)	4.2	3.6
Coal-PC	4.2	3.5
Gas-Low (\$3.77/MCF)	3.8	3.6
Gas-Moderate (\$4.42/MCF)	4.1	4.0
Gas-High (\$6.72/MCF)	5.6	5.7

FOSSIL GENERATION COSTS WITH CO₂ PRICES

(\$2002 levelized cents/kWh - Merchant)

	<u>\$50/tonne C</u>	<u>\$100/tonne C</u>	<u>\$200/tonne C</u>
Coal	5.4	6.6	9.0
Gas (low)	4.3	4.8	5.9
Gas (moderate)	4.7	5.2	6.2
Gas (High)	6.1	6.7	7.7
Nuclear (base)	6.7	6.7	6.7
Nuclear (-25%)	5.5	5.5	5.5
Nuclear (low)	4.2	4.2	4.2

Planned or Under Construction Coal Plants



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 > POWERmap

FINLAND

- Teollisuuden Voima Oy (TVO) is building Olkiluoto 3
 - EUR 3 billion fixed-price contract with Areva and Siemens (~\$2300/kw) [unspecified cost overruns due to delays and cost increases to date but TVO is insulated from them]
 - 1600 MWe
 - Permit application in 2000, construction started September 2005 and commercial operation now forecast for mid-2010 [9-month delay so far]

- Ownership and Long Term Contract Shares

UPM-Kymmene (forestry products via PVO energy company)	25.63%
Stora Enso Oyj (forestry products via PVO energy company)	9.39%
others (forestry products via PVO energy company)	25.18%
Fortum Power & Heat (government controlled power corp)	25.00%
Oy Mankala Ab (city of Helsinki)	8.10%
Etala-Pohjanmaan Voima Oy (distr cos in NW coast of Finland)	6.50%
Graninge Suomi Oy (energy co. in forestry/energy group)	0.10%

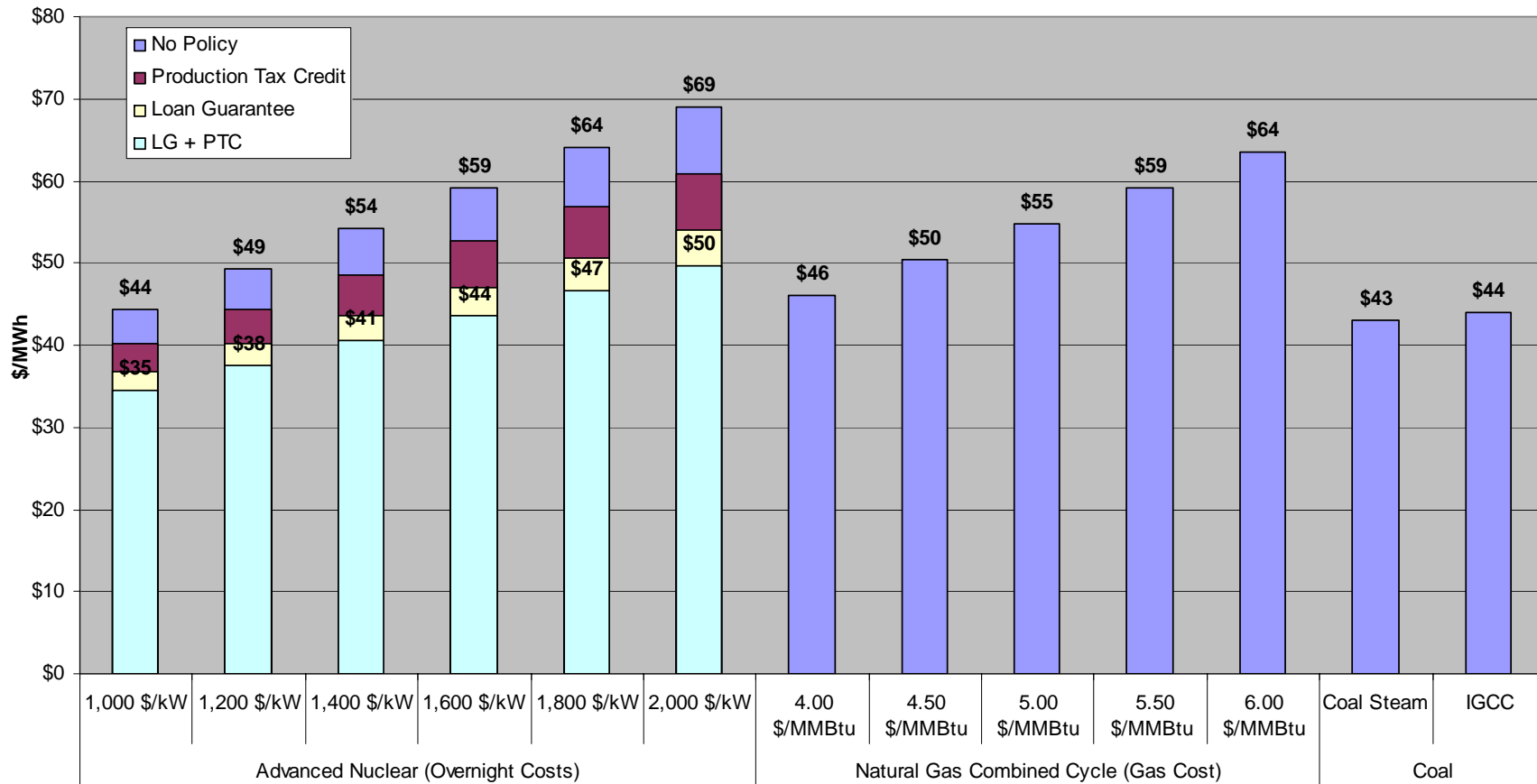
WHAT IS THE U.S. DOING TO ENCOURAGE INVESTMENT IN NUCLEAR?

- “First mover” financial incentives
- Streamline licensing process
- Resolve waste disposal deadlock
- “Moral support” for nuclear investment

Energy Policy Act of 2005

- Loan guarantees for up to 80% of project cost
 - Valid for all GHG-free technologies
 - Higher leverage, lower debt cost reduces overall project cost
- Production tax credit of \$18 per MWh for 8 years for new nuclear capacity through 2021, subject to 2 limitations:
 - \$125 million per 1,000-MW per year
 - 6,000-MW eligible, allocated among available capacity
- Insurance protection against delays during construction and until commercial operation caused by factors beyond private sector's control
 - Coverage: \$500 million apiece for first two plants, \$250 million for next four
 - Covered delays: NRC licensing delays, litigation delays

The Energy Policy Act of 2005 Reduces Costs for First Movers



Source: Berger and Parsons (MIT CEEPR 2005)

NEW NUCLEAR PLANTS UNDER CONSIDERATION

<u>Company</u>	<u>Site</u>	<u>Early Site Permit</u>	<u>Design</u>	<u>File Construction/ Operating License</u>
Dominion	North Anna	Under Review	ESBWR	Pending (2007)
TVA (NuStart)	Bellefonte	N/A	AP1000 (2)	Pending (2007)
Entergy (NuStart)	Grand Gulf	Under Review	ESBWR	Pending (2007)
Entergy	River Bend	N/A	ESBWR	Pending (2008)
Southern	Vogtle	Submitted	AP1000	Pending (2008)
Progress Energy	Harris + TBD	N/A	AP1000 (2)	Pending (2007/08)
SCE&G	Summer	N/A	AP1000 (2)	Pending (2007)
Duke	South Carolina	N/A	AP1000 (2)	Pending (2007)

Source: Nuclear Energy Institute

NEW NUCLEAR PLANTS UNDER CONSIDERATION

<u>Company</u>	<u>Site</u>	<u>Early Site Permit</u>	<u>Design</u>	<u>File Construction/ Operating License</u>
Exelon	Clinton	Under Review	ND	ND
Constellation (Unistar)	Calvert Cliffs or Nine Mile Point	N/A	EPR (5)	Pending (Q4-07)
FP&L	Florida (TBD)	N/A	ND	ND
Duke	North Carolina	ND	ND	ND
Duke	South Carolina	ND	ND	ND
NRG	South Texas Proj	N/A	ABWR(2)	2007
TXU	ND	N/A	ND	2008

Source: Nuclear Energy Institute

ATTRIBUTES OF ACTIVE U.S. PROJECTS

- Companies with good nuclear operating experience (consolidation in the U.S.)
- First movers are likely to be on existing sites
- Energy Policy Act subsidies have stimulated a lot more interest
- Projects are primarily in states that have not deregulated
 - What will the regulatory framework be?
 - Construction cost caps and operating performance incentive mechanisms are likely
- No firm commitments have been made to build a new plant
 - Companies are buying options at the moment
 - Uncertainty about the competitive, regulatory, and contractual framework is a major issue

In Best Case Scenario, First New Plants
Would Be Online Around 2015 (on
existing sites)