The Economics of Small Modular Reactors (SMR)

James R. Moody & Associates

August 2012

Sources of Information for the Presentation

- ***Small Modular Reactors—Key to Future Nuclear Power Generation in the U. S.***, by Robert Rosner and Stephen Goldberg, The University of Chicago, Energy Policy Institute of Chicago, November 2011.
- ***Economic and Employment Impacts of Small Modular Nuclear Reactors,*** The Energy Policy Institute, June 2010.
- ***Estimating the Economic Impacts of Small Nuclear Reactors,*** by Geoffrey Black, PhD, Department of Economics, Boise State University, May 2012.
- ***A Study of Westinghouse and Ameren Missouri's Economic Impacts of Small Modular Reactor Installation In The United States Economy,*** by Development Strategies, St. Louis, Missouri

Frequently Used Terms

(from University of Chicago study)

- Small Modular Reactor (SMR)—Advanced reactors that are built in modular arrangements at the factory, are less than 600 Mwe, and shipped to the location of use by truck, rail, or barge.
- (First of a kind) FOAK or LEAD Plant—First modular plant to show that design is commercially viable and to faciliate the optimization of construction of a manufacturing plant for SMR.
- (Nth of a kind) NOAK—Subsequent plants after the FOAK or LEAD plant. Cost is lowered as more are built.

Overview of the Presentation

- SMR represents an unprecedented opportunity for Missouri to lead in a new industry, developing affordable energy while creating jobs.
- Dr. Black from Boise State estimates that SMR is an industry that could generate over $25 billion of economic activity *annually* between 2019 and 2030. Missouri needs to insure that it can get a major share of that industry.
- The Westinghouse/Ameren Alliance and Missouri are well positioned to compete in the development of an industry by being on the leading edge.

Employment Ranking of Major Missouri Manufacturing/Information Businesses

Company	Missouri Employment Rank
Boeing	**3**
Cerner	**10**
ATT	**17**
Ford Motor	**23**
Source: MERIC Ranking of 50 Top Employers	

Comments on SMR --**John E. Kelly,** Deputy Asst. Secretary for Nuclear Reactor Technologies, U. S. Dept. of Energy

SMR Benefits—

Enhanced safety and security

Reduced capital cost makes nuclear power feasible for more utilities

Shorter construction schedules due to modular construction

Improve quality due to replication in factory-setting

Meets electric demand growth incrementally

Re-establish U. S. technical leadership

Expand/create economic opportunities and jobs

The Large Scale Nuclear Dilemma

- Development of large scale nuclear plants is very time intensive and very expensive.
- Capital and the cost of capital are a major issue.
- How and who pays for the capital cost during construction is very much an issue.
- Missouri needs long term sustainable power, but the only nuclear plant here was opened in the 1980s.

Potential Cost vs. Annual Revenues Of Large Investor-Owned Nuclear Utilities

(Data and quote from University of Chicago Study, Figure 1)

- The average annual revenue of investor-owned nuclear utilities is about $13 billion.
- The cost of building a large scale nuclear plant approaches $12 billion.
- "This analysis… is consistent with Moody's Investor Service opinion that "we view nuclear generation plants as a 'bet the farm' endeavor for most companies, due to the size of the investment and length of time to build a nuclear facility."

Capacity of University of Chicago Study SMR Sites

- A theoretical LEAD or FOAK Plant—600 Mw, from six reactors of 100 Mw each.
- As designs are developed by companies, actual module capacities may very. For example, Westinghouse module design is 225 Mw.

The SMR Construction Cycle Concept

- Build the LEAD modular reactor on site, in the ground.
- As subsequent SMR's are developed, possibly on-site, transition fabrication of modules to factory (or factories)
- When mature, competely transition initial fabrication to manufacture factor(ies).

University of Chicago Estimates of Cost of Electricity for SMR's by Development Stage

Stage of Development	Leveled Cost (real 2011 $ per MWh)
LEAD/2	$123.60
LEAD	$91.17
NOAK-4	$71.15
NOAK	$60.95
From Table 2, University of Chicago Rosner/Goldberg Study	

The Arguments For SMR

(From University of Chicago EPIC Study)

- SMR's have lower pre-completion risk due to shorter construction schedules (24-36 months as compared with 48 months)
- SMR's have lower market risk because there is significantly less power that needs to be sold as compared with GW-level plants.
- The modular nature of SMRs affords the flexibility to build capacity on an as-needed basis.

Where Is The Energy Consumer In This Process?

- Public Service Commission will not approve non-market price energy purchases.
- Early SMR power (which will have higher generation costs) will need subsidy from either the manufacturer or the federal government.
- If large scale SMR deployment is successful, in the long term the consumer benefits from lower risk, lower capital cost to produce energy, and a reliable source.
- Consumer is aided by an effective alternative to aging fossil fuel plants.

Estimated SMR Direct Cost (in millions)

(From University of Chicago EPIC Study)

	NOAK	FOAK-4	LEAD	LEAD-2
Site Improvement and Structures	$400	$440	$549	$549
Power Unit Equipment	$1,600	$1,789	$2,288	$1,259
Direct Costs	$2,000	$2,229	$2,837	$1,808

Posing The Two Sides of the Question—What Is The Economic Break-even Point For SMR?

Can SMR Be Developed Cost Effectively?

- Cost is reduced as more NOAK facilities are built.
- First facilities will not be cost competitive per KWh and will need some form of subsidy.
- Can modularly manufactured SMR's create demand?
- Effective alternative to early retirement of coal fired generation.

What About Investing In Other Energy Alternatives?

- Who is smart enough to predict the cost of natural gas in ten years?
- Wind and solar alternatives are struggling and not baseload. Nuclear can be utilized with both.
- Can coal powered alternatives meet environmental standards at a cost effective price?
- Last large nuclear plant in Missouri was Callaway in the 1970s. Risk and capital costs are very high.

Assumed Market Share For U. S. Manufacturers

(Energy Policy Institute, 2010)

- 50% of the domestic market
- 20% of the international market

Estimated Fiscal Impact Of Moderate and High Nuclear Adoption 2030

(Energy Policy Institute, 2010)

- 215,000-255,000 jobs
- $40-$48 billion in sales
- $19-$23 billion in value-added

Boise State Estimate of SMR Economic Impacts 2019-2030

- $283 Billion in sales
- $99 billion in payroll
- 1,878,848 in job years

Sales From Top Missouri Agricultural Businesses

Product	2007 $ Market Value
Corn	$1,909,026,000
Soybeans	$1,768,763,000
Cattle and Calves	$1,676,632,000
Poultry and Eggs	$1,265,166,000
Hogs and Pigs	$725,738,000
Source: MERIC Economic Research Brief, Farm and Agribusiness	

Missouri Goals For SMR Development

- Be a leader in LEAD or FOAK SMR plant construction

But More Importantly

Build The Manufacturing Plant!!