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RIC 2010: Increasing Interest in Small Modular Reactors

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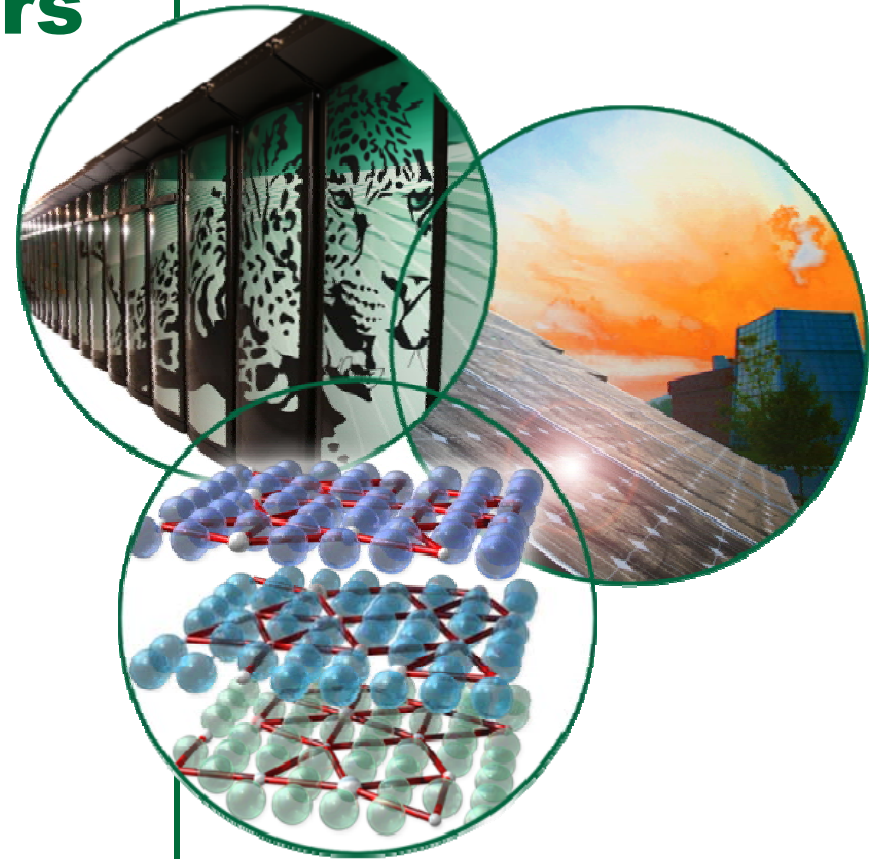
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March 11, 2010

An Economic Case For Small Modular Reactors

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Regulatory Information Conference
March 9-11, 2010

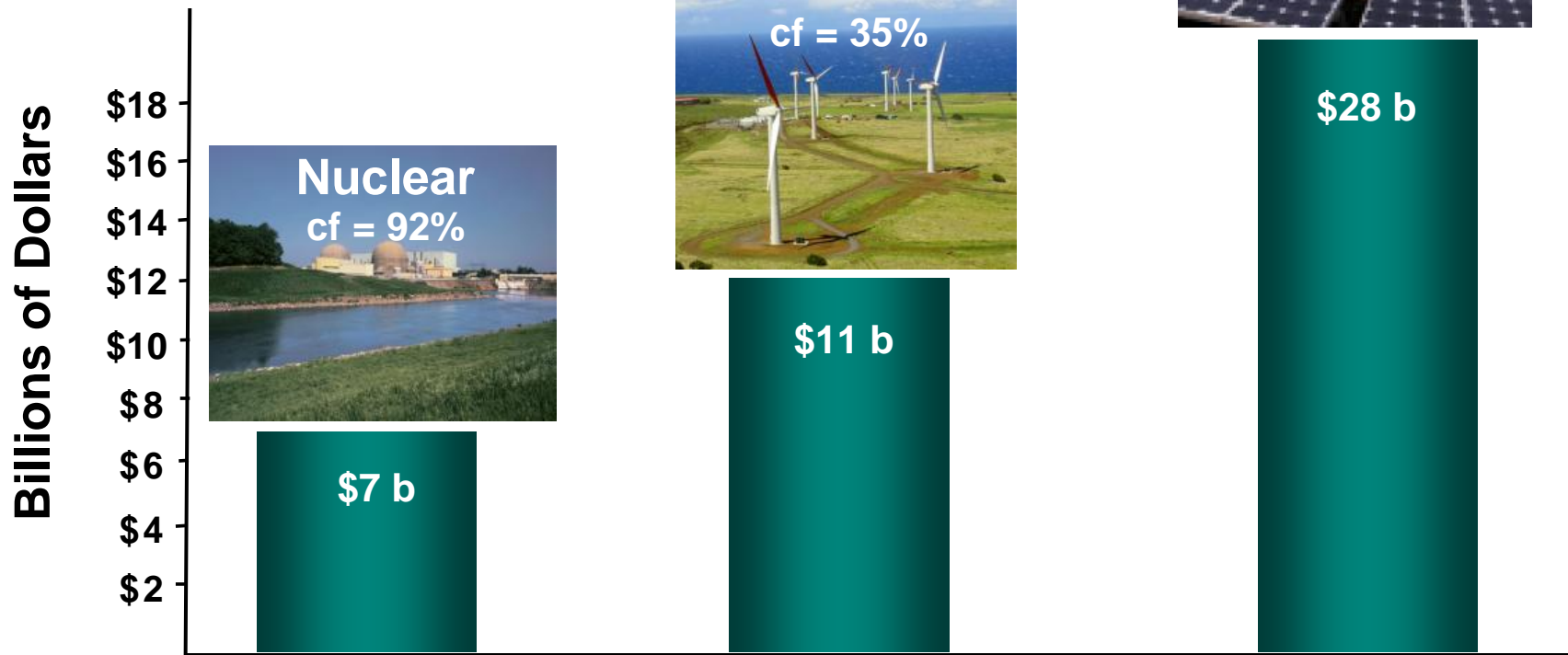


Interest in Smaller Sized Reactor Designs Are Beginning To (Re)Emerge

- Benefits
 - Enhanced safety
 - Improved fabrication and construction logistics
 - Greater operational flexibilities
 - Favorable economics
- Applications
 - Countries with small or limited electrical grid infrastructure
 - Smaller private utilities in large-grid countries
 - Special power applications such as remote sites
 - Non-electrical energy supply

Myth: Nuclear Energy Costs Too Much

How much does it cost to build a plant that will produce 470 billion kWhr over its lifespan?



2009(\$) Construction Costs to produce similar power

Includes: land price, plant components, financing costs, construction, labor, regulatory fees and fuel

Source: J. Conca, Carlsbad Environmental Monitoring and Research Center

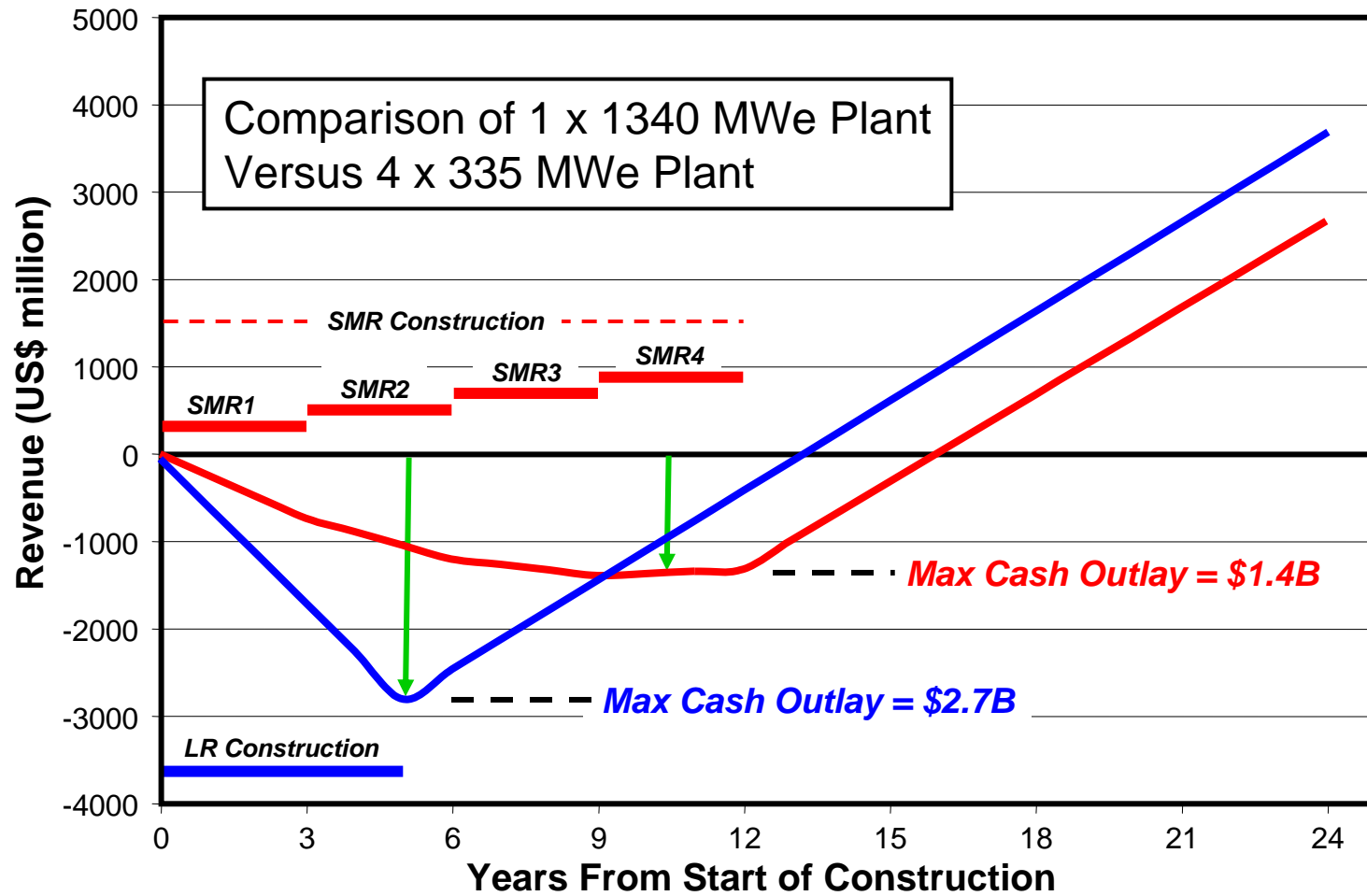
Economic Benefits of SMRs

- Total project cost
 - Smaller plants are cheaper per unit
 - Improves financing options and lowers financing cost
 - May be the driving consideration in some circumstances
- Investment risk
 - Maximum cash outlay is lower and more predictable
 - Lower investment risk even for the same generating capacity
- Cost of electricity
 - Economy-of-scale works against smaller plants
 - Can be mitigated by other economic factors

IAEA Project on Economic Competitiveness of Small and Medium-Sized Reactors

- Initiated in 2008 by V. Kuznetsov to address overcoming the economy-of-scale for SMRs
- Evolved into broader study of economic competitiveness and financing considerations
- Included:
 - Development of economic models to compare SMRs with large plants
 - Case studies of SMR economic viability in individual countries
- Publications:
 - Final report is in publication phase
 - Summary available: V. V. Kuznetsov and N. Barkatullah, "Approaches to Assess Competitiveness of Small and Medium-Sized Reactors," Proceedings of 17th International Conference on Nuclear Engineering (ICONE17), July 12-16, 2009, Brussels, Belgium

Staggered Build of SMRs Reduces Maximum Cash Outlay



Based on simplified model

Source: B. Petrovic, Georgia Institute of Technology



Politecnico di Milano Is Developing an Open Model for SMR Deployment Strategies

INCAS: Integrated Model for the Competitiveness Assessment of SMRs

- The Investment Model simulates an investment strategy in the deployment of a reactor fleet at country level
 - Performs a Discounted Cash Flow analysis of the investment project
 - Provides quantitative information on the financial performance of the investment strategy
- The financial performance depends on the specific technology design, size of the NPPs (LR vs SMRs), deployment strategy, financing strategy (public/private investor)

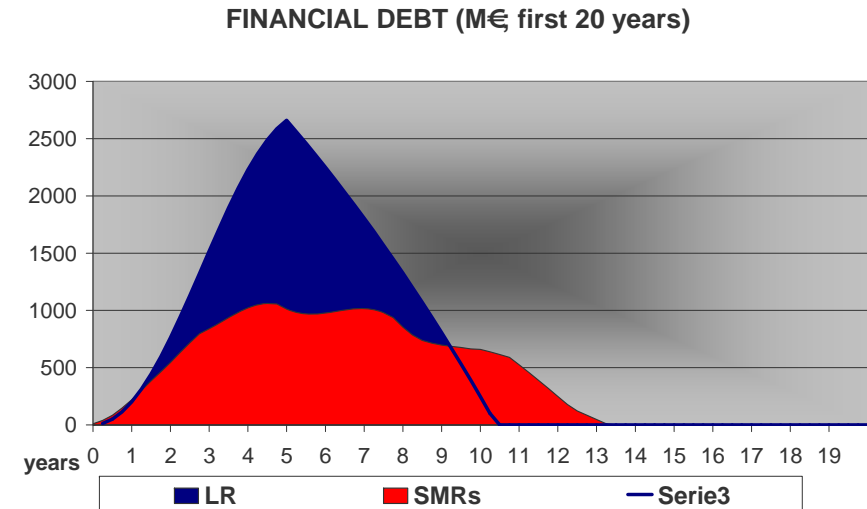
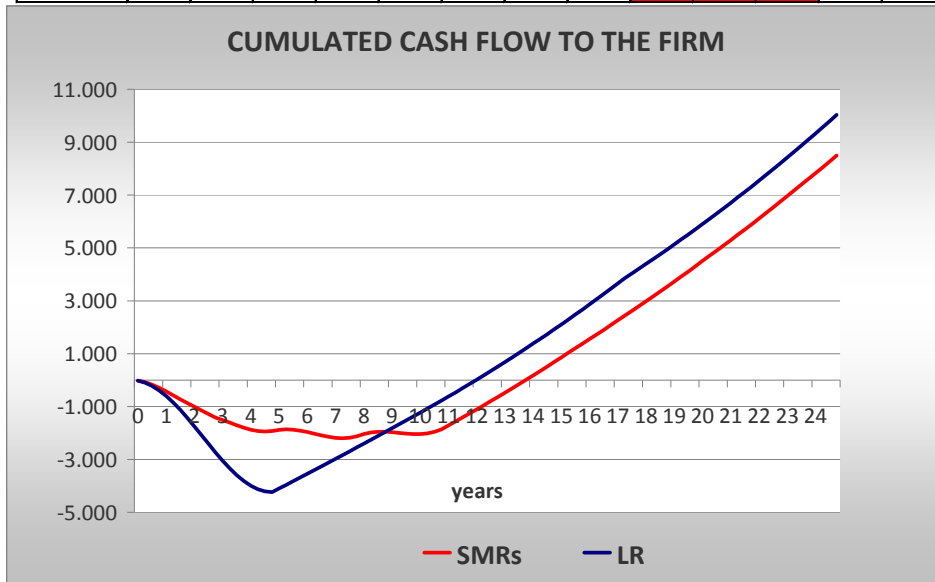
OUTPUT OF THE INVESTMENT MODEL

- Key financial indicators
- Simulation tool to test different scenario conditions / deployment strategies
- Sensitivity analysis to the variation of key parameters

POLIMI INCAS Model: Cash Flow Profiles

CONSTRUCTION SCHEDULE

YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13
LR													
SMR #1													
SMR #2													
SMR #3													
SMR #4													



- Cash flow profile of SMRs is smoother due to the dilution of construction period
- Despite staggered deployment of SMRs, Debt Duration and Pay Back Time are comparable

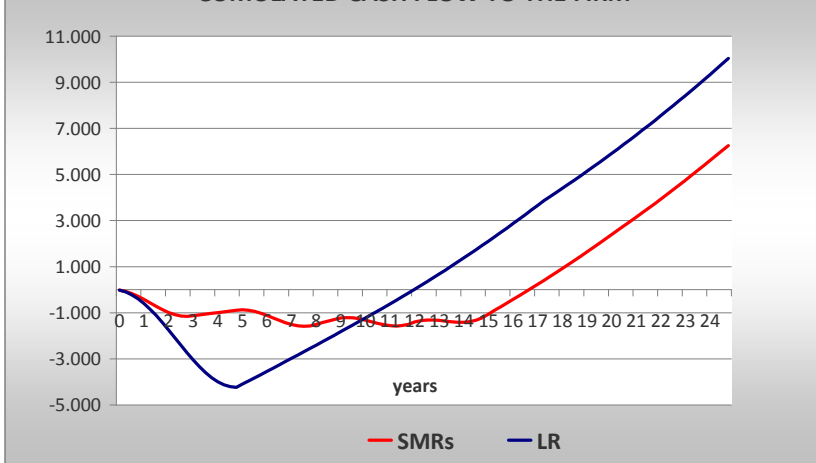
Source: S. Boarin, Politecnico di Milano

POLIMI INCAS Model: Cash Flow Profiles

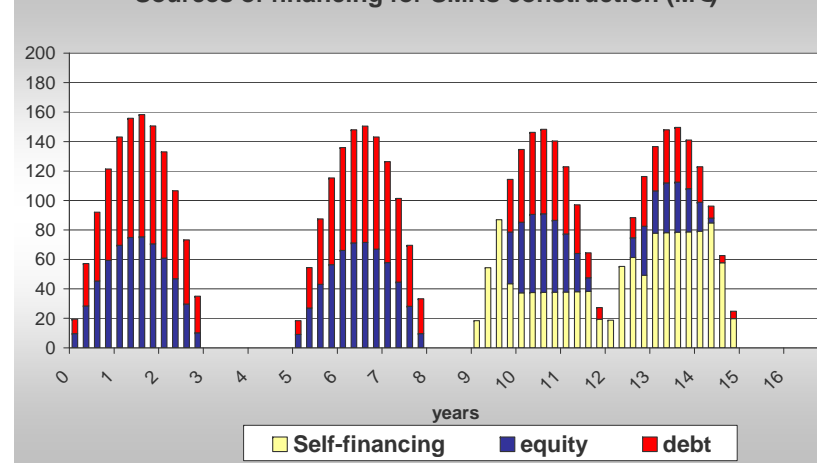
CONSTRUCTION SCHEDULE

YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
LR															
SMR #1															
SMR #2															
SMR #3															
SMR #4															

CUMULATED CASH FLOW TO THE FIRM



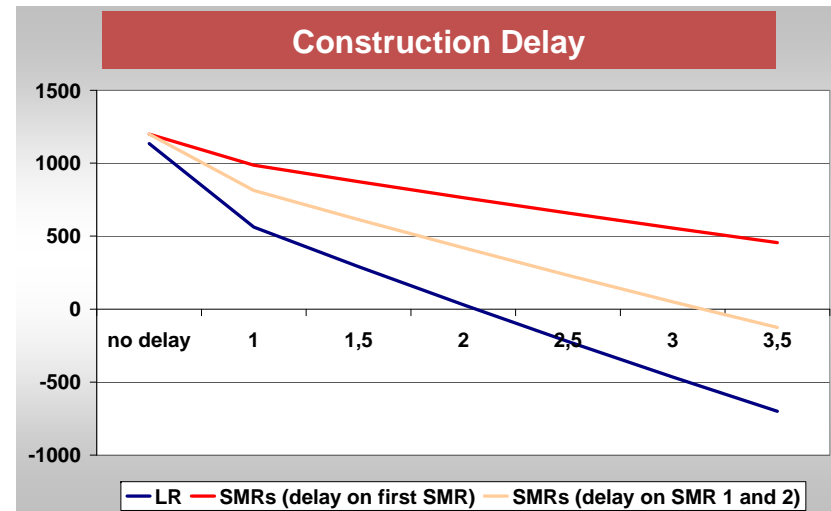
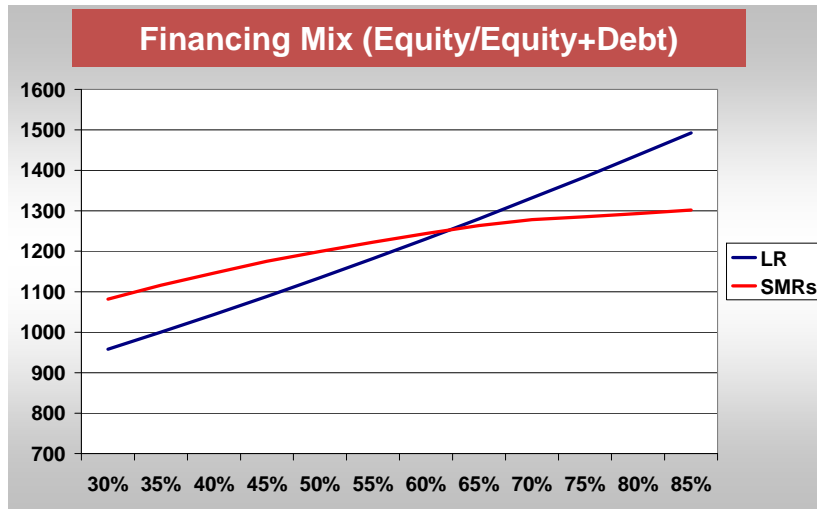
Sources of financing for SMRs construction (M€)



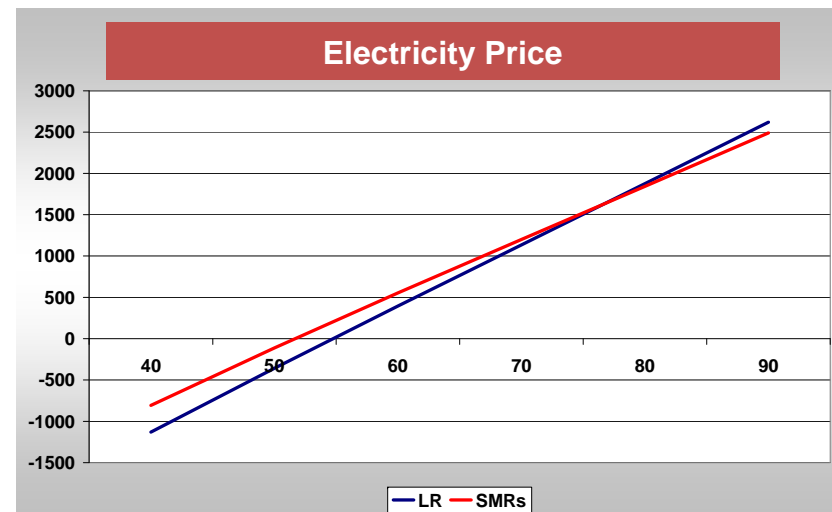
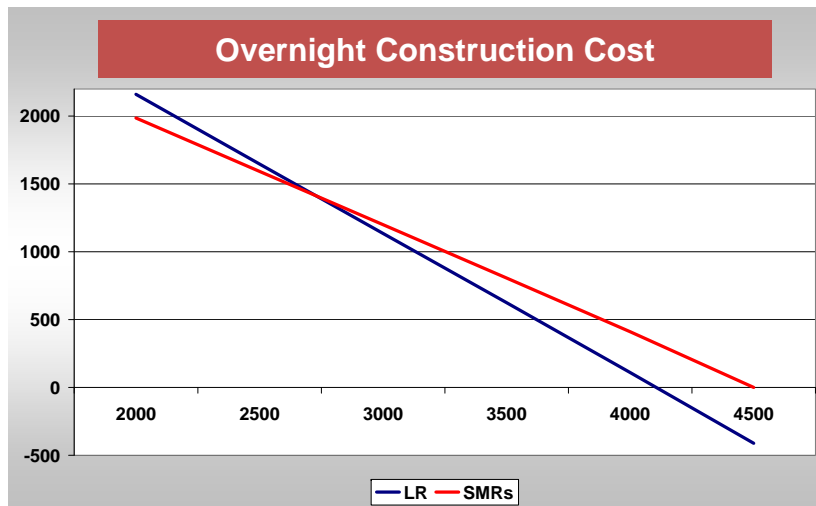
- More staggered construction: increased self-financing (958M€ = 24% of total capital invested)
 - SMRs: Maximum cash outlay is 1,589M€ in 3rd quarter of 7th year
 - LR: Maximum cash outlay is 4,237M€ in 4th quarter of 4th year
- They are not comparable investment options—new power installation rate is very different between LR and SMR cases

Source: S. Boarin, Politecnico di Milano

POLIMI INCAS Model: Sensitivity of Net Present Value to Economic Factors



POLIMI INCAS Model: Sensitivity of Net Present Value to Economic Factors

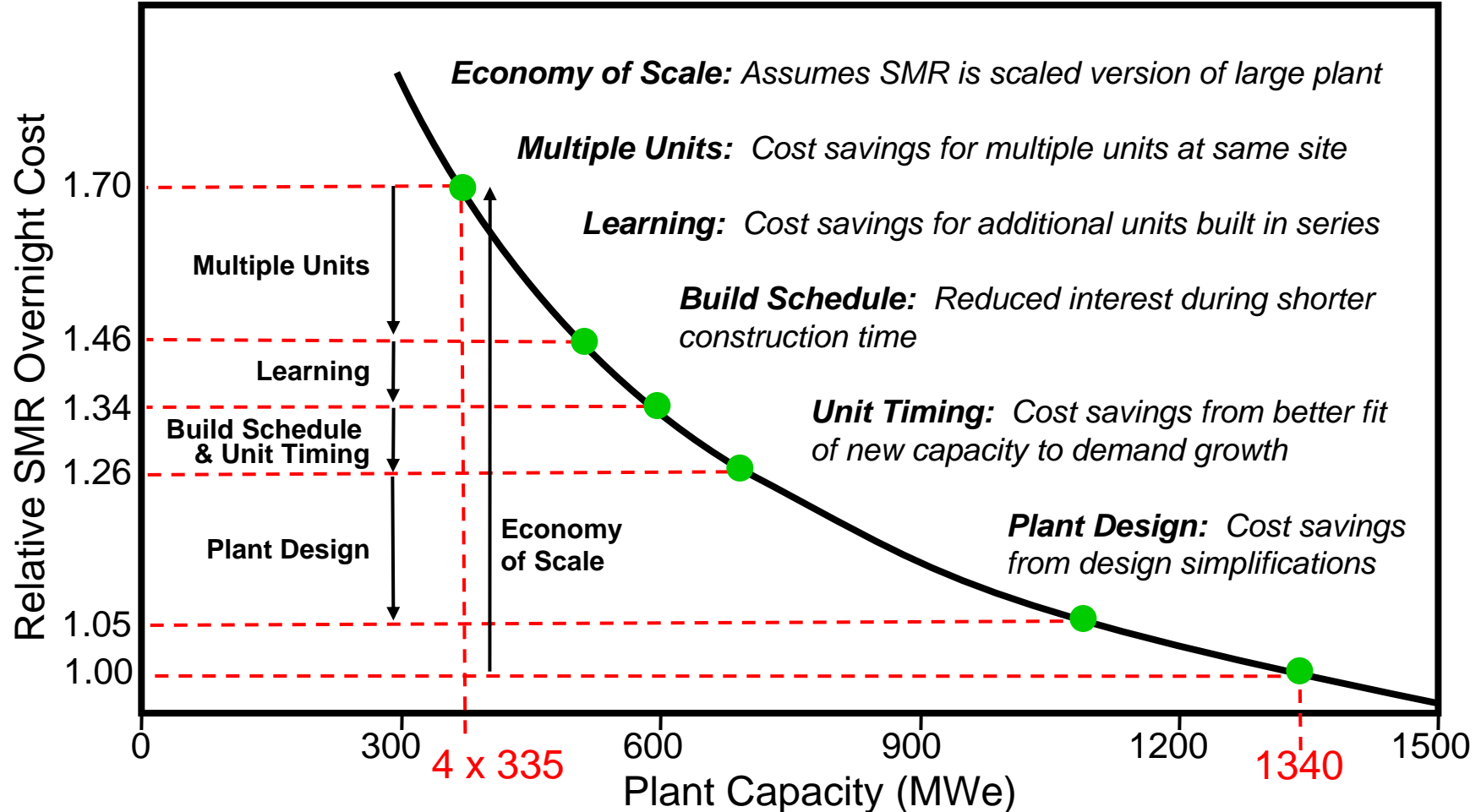


Summary of INCAS Studies

- Incremental capacity reduces the required front-end investment and the Capital-at-Risk
- Lower Interest During Construction compensates higher overnight costs:
- Capital structure is more balanced and risk of default is lower
- SMRs may bear a higher financial leverage during construction
- SMRs are able to absorb construction delay without heavy financial shock
- Profitability is comparable between LR and SMRs in terms of NPV and IRR
- Trade-off: excessively staggered construction delays full site power availability to the grid and lowers NPV of the project (by shifting cash inflows onwards)

Source: V. Kuznetsov, International Atomic Energy Agency

Factors Offsetting the Economy of Scale



Source: C. Mycoff, Westinghouse Electric Company

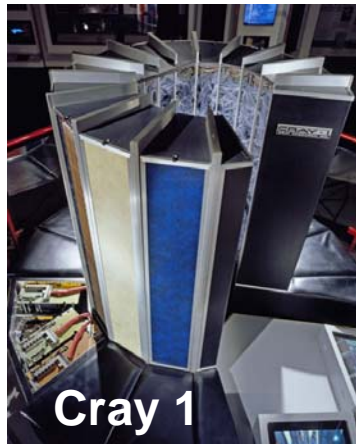
Summary of IAEA Study

- Development of advanced models and software for comparative assessment of investment benefits and risks for sequential deployment
- Case studies that make use of advanced models:
 - POLIMI/ ENEA studies (INCAS)
 - Westinghouse studies
 - A BATAN Study (using G4-ECONS)
- National case studies reflecting positive experience or future prospects for SMRs
 - ROSENERGOATOM Study
 - Two NPCIL Studies, including a study for specific region
 - OKBM Study -- export potential of SMRs
 - RRC KI Study -- cogeneration plants for the Russian north
 - CRIEPI -- Mongolia Study
 - A BATAN study for Kalimantan, including potable water production

Source: V. Kuznetsov, International Atomic Energy Agency

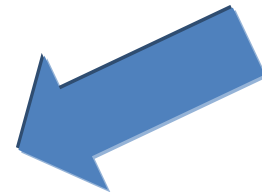
SMRs: Bringing Affordable Power to Market

1 large processor



1 small processor

64 small processors



>224,000 small processors