39th Annual Conference of the Canadian Nuclear Societyand 43rd Annual CNS/CNA Student Conference
WestinOttawa Hotel, Ottawa, ON, Canada, 2019June 23-26

A REALISTIC LOOK AT THE PATH TO SMR AND ADVANCED REACTOR COMMERCIALIZATION

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Abstract

The professional, societal, and economic rewards for commercializing Small Modular Reactors (SMRs) and Advanced Reactors (ARs) can be significant and daunting. A good technical concept is not enough. This paper is based on first-hand personal experience developing SMR and other new technologies. It will realistically address requirements for bringing SMR and AR technology to successful commercialization.

The labyrinth of challenges addressed will include proof of concept, technical issues, markets & competition, brand recognition, fund raising, prototyping, licensing, personnel, partnerships, intellectual property, legal, accounting, deployment, and others.

The commitment of time and money extends for years; and the end game is uncertain until a unit is successfully deployed and operating as planned. Not every idea will cross the finish line. Many will fail along the way.

This paper focuses on the challenges that technology developers must confront and suggests actions to deal with them. It addresses a broad range of considerations from the entrepreneur's point of view. Technology developers should not rely totally on these insights and opinions but should consult with appropriate legal and financial experts when pursuing their business creation.

1. Introduction

In the context of this paper, "commercialization" means developing new nuclear technology to where a commercial nuclear plant is successfully supplying 100% of its design output capacity (e.g. electricity, steam) for a sustained period as defined by contract or regulation. There are many phases of commercialization addressed in the literature. The focus here is not on phases, but on topical considerations for the entrepreneur. Some will be well known. Hopefully, others will be new thoughts that will inform the entrepreneur in the quest for commercialization.

In a world where carbon emissions are threatening to disrupt civilization as we know it, fossil fueled electric generation continues to be the default source of power because it's generally well developed, available, accepted by the public, and relatively low risk for generating companies. Carbon-less wind and solar sources are expanding; although with economic, availability, and other challenges. The low-emission lifecycle of nuclear power seems ideal for reliable carbon-free generation. However, large light water nuclear projects present challenges driven largely by cost overruns and schedule delays. The Western Hemisphere has seen limited new nuclear development since the 70s and 80s, when more than 100 new nuclear units were placed in service over a 20-year new build period. Since 2001, the industry touted a nuclear renaissance, stimulated by high fossil fuel prices, greenhouse gas emission concerns, and growing electric demand. Greenhouse gas issues remain. However, natural gas prices have plummeted and electric demand growth has slowed. Recent large light water reactor new builds in the U.S. have met with significant cost overruns and schedule delays. The Fukushima accident challenged the safety claims of nuclear power. Regardless of the low, if any human impact of Fukushima's nuclear accident, it was truly a commercial disaster, caused by forces of nature not nuclear operations.

Clearly, the power market needs new technology. It also needs more cost-effective and schedule-effective ways to develop and deploy new nuclear technology. Small Modular Reactor (SMR) and Advanced Reactor (AR) technology may overcome the challenges of traditional large nuclear units. Then again, they may not. Commercializing new nuclear power facilities demands credible cost-effective technology, considerable funding, and many years of effort pursuing a result that is uncertain until operating units prove themselves reliable and sustainable in the actual power market. The process is daunting and may consume even the most deserving technologies. It's not a path for marginally committed or "business as usual" individuals to pursue.

The process to commercialization is complex with many routes, barriers, and tentacles. There is no "one size fits all" process. Unexpected events, both favorable and unfavorable, will occur due to the uncertainties of developing such a complex technology. Raising funds will likely be the biggest challenge. This paper, while not intended to deal extensively with fund raising details, will proceed to address likely development challenges, largely driven by available funds; and will address considerations for financing the enterprise.

There are many issues investors consider when putting cash into new ventures of any sort, especially nuclear power technology. These may include:

- A compelling product that has advantages over existing products (e.g. capital cost, levelized cost, load following flexibility, safety, transportability, size, waste, etc.)
- A convincing credible business plan that projects a reasonable approach to commercialization
- Solid intellectual property protection
- First class management team & staff
- Founders' investment ("skin in the game")
- Projected timing and return on investment
- Identified risks and mitigation plans

2. Commercialization process overview

At one extreme, the process required to commercialize new nuclear technology is complex, but less so if funds are reasonably available when needed. In that situation, activities can be planned, budgeted, and executed in an optimized manner with reasonable expectation of the availability funds. Prudency still applies and proceeding deliberately by building on increasing developments can occur without the uncertainty and distraction of fundraising and sub-optimized spending of limited funds.

Most developers are not fortunate to have the likes of Bill Gates or Jeff Bezos as backers for the full process. Therefore, very limited initial funding will likely drive the process timing and scope.

For purpose of this paper, a funding-driven commercialization process by a startup company will be discussed. New technology developed within an established corporation having the financial resources and access to the debt market to propel commercialization is much different and will not be discussed in the paper. However, entrepreneurs should seek alliances, partnerships, investment, and other support from large firms with the balance sheet and strategic interest in the technology.

3. Fund Raising

A significant amount of capital is needed to bring a new nuclear power technology to commercialization. Hundreds of millions of dollars and the long time period before realizing revenue are perhaps the entrepreneur's most significant challenges. This paper is not intended to be a treatise on fundraising. That is left to the specialists. However, a brief review of key considerations is presented below. Certain sources of funding described may not be available or necessary. In the course of commercializing the technology, entrepreneurs can judge the best opportunity and the optimum timing for fund raising. In equity financing, the valuation of the business will determine the equity demanded by investors for a given amount of funding. Therefore, to the extent possible timing of fund raising should be pinned to the status of the technology development and forward-looking risks. (See Technology Readiness Assessment below.)

The first step in commercializing any technology is to describe the concept and develop support for its validity. This may be in the form of technical papers, treatises, white papers, presentations, sketches, and other documents. At this very early stage, a team of "founders" may come together, contributing complementary skills and experience. Costs are relatively low and out-of-pocket expenses are often covered by the individuals. Commercializing new nuclear technology takes years. However, time to market is of the essence and founders must establish a credible position in the crowded emerging SMR/AR development field. Unless the founders have considerable wealth, these "bootstrapping" funds will not last long. The objective of bootstrapping should be the expeditious development of material to support

All entrepreneurs need to be mindful of the obvious fact that commercializing new nuclear technology is not a part time endeavor. It requires belief in the technology, unwavering commitment, dedication, tenacity, and money. Early stage principals should be prepared to dig into savings, mortgage the house and do whatever it takes to be successful. The sooner funding can be in place, the greater the likelihood of success.

external fund raising. Bootstrapping also serves as a self-imposed due diligence on the viability of moving forward.

In the early stage, it is important to address costs sharing, ownership rights and responsibilities. The vehicle for accomplishing this is the corporate formation. The founders should consult an attorney to determine the proper corporate structure for their enterprise and to draft the required papers. By-laws or an operating agreement should also be prepared to describe how the business will be managed, roles and responsibilities, ownership rights, etc. The by-laws or operating agreements will also describe financial matters that will inform certain accounting requirements.

A company bank account should be established, and the founders should each contribute an agreed amount of funds to the account. The contributions could be considered as equity or as loans to be paid back when company funds are available. For personal loans, promissory notes should be executed and filed in the company records. Bank loans may be available to founders who pledge personal assets as capital. Banks rarely take risky investments in early stage companies, preferring to limit their risk by lending to firms that offer a history of successful financial performance and balance sheet collateral. Consider again, the value of aligning with a relatively large corporate partner or high net worth individual(s).

Entrepreneurs should be mindful of the fact that future investors value the fact that founders have put their own funds at risk as equity to advance the business, demonstrating personal commitment and confidence in the business. Additionally, investors are reluctant to pay off founders' loans, taking capital away from actual business advancement.

It's not too early to protect the underlying intellectual property (IP), including patents and trademarks. If the IP is registered to an individual, a solid assignment to the company should be executed and recorded. The IP assignment should be broad and durable to avoid concerns by investors regarding company ownership of the rights. The principals may agree for the IP assignment to revert to original owner (inventor to whom the IP was originally issued) if, after a period of time, a defined event does not occur. For example, the full intellectual property rights revert to the inventor if after x years the company has failed to generate at least $xxx in revenue.

In the bootstrapping phase, a business plan should be developed. Business plans are not always used by emerging technology companies. However, a good business plan will aid in raising funds from friends, family and possibly angel investors. Many angel investors and venture capitalists prefer a relatively short PowerPoint "pitch" dealing with key elements of the business for a "first look". However, a comprehensive business plan informs the pitch presentation, provides backup for pitch assertions; and helps the founders develop a roadmap for future requirements. It can be a very conceptual, but useful tool for pursuing commercialization. At this very early stage, a business plan is very preliminary. Too much detail at this stage will likely get into the realm of uncertainty and create more confusion than information for external readers. However, for internal planning purposes, good reflection and transcription of path forward details (perhaps in an undistributed version) would be helpful in planning near term activities with a long-term objective in view. A business plan also aids in creating talking points for dialog with external industry and financial parties. The following topics should be considered for a Business Plan:

- Description of the technology
- Addressable market and estimated size

- Marketing & sales strategy
- Competition analysis (comparative features table)
- Management team roles and qualifications
- High level estimate of overnight capital cost and levelized cost of electricity (LCOE).
- Funding requirements, possible deal structures, target sources, and off ramps
- Level 1 draft plan/schedule for commercialization
- Supply chain sourcing plan
- Manufacturing approach
- Planned approach to detailed engineering, procurement & construction (EPC).
- Financial Projections (five-year income & cash flow statements with some detail of planned expenses; longer period view can be at a high level but should be indicative of the road ahead. To the extent possible, benchmarking similar companies may be helpful.)

Use of assumptions in developing the business plan is unavoidable; but the bases for assumptions should be documented. External sources of information should also be referenced.

Bootstrapping alone will not support advancing engineering, design, analysis, testing, staffing, branding, license preparation, etc. to a level that would support institutional investment. However, it will start the ball rolling. The next source may be friends and family (F&F). Asking friends and family for investment is delicate. The risks of early stage investment are high, fraught with uncertainty and high probability of failure. Nuclear technology risks are aggravated by the length of time before return on investment, the regulatory hurdles, and the myriad of technical challenges encountered, including first-of-a-kind (FOAK) cost-effective deployment and operational performance. Nonetheless, friends and family financing may be the only alternative to bring the technology development to a point where more professional investors will come in.

Friends & family investors may consider similar factors as do more sophisticated investors; but they will not likely have industry knowledge to assess the technology or the market. They are likely influenced by the relationship and a perception of technology as presented. Depending on the investor's finances, individual investments from between $10,000 to $100,000 are in the ball park. Entrepreneurs must present a candid picture of the business and risks; and document all information provided. A business plan or a Power Point "pitch" presentation could serve as such documentation.

Solicitation of investments may be governed by laws or regulations. Details of fund-raising laws will be left to the specialists. However, it's useful to know that individual investors may have to be "accredited". That is, they meet certain financial criteria such as net worth and income. Formal subscription agreements, rights of the parties, and detailed statements about business risks may be appropriate. While it may be expedient and tempting to overlook these when working with family and close friends, DON'T. Such rules may be primarily intended to protect the investor; however, the firm is also protected in when communications and details of the deal are in writing. People's attitudes, perspectives and financial position may change

prompting disputes if the business fails or if the business is wildly successful and investors want more of the pie.

Entrepreneurs should be familiar with "Technology Readiness Level" (TRL). It's a tool used by some industries and government agencies use to indicate the maturity of a technology on a scale ranging from basic research to full launch and operations. It may be helpful for attracting some investors to present a Technology Readiness Level assessment and developers should be familiar with the concept if it arises. The TRL will not be discussed here as there are numerous sources of information available. [1] [2]

F&F money dries up very quickly and founders must be prepared to seek other funds. Angel Investors are individuals who will invest perhaps $50,000 to $1 million. Some are very sophisticated. Some are not. Most, but not all, will conduct a due diligence assessment of the business in varying degrees of detail. Angels often will form syndicates with other angels, pooling funds for a larger investment.

Venture Capital (VC) is another source of funding, usually less than $15 million. However, most VC funds focus on specific technologies such as biotech and clean technology. VCs usually seek to exit with profit in 5+/- years. They often take a management or mentoring role to nurture their investment (the company) to a successful exit point. Very early stage businesses are usually off the table unless there is a compelling interest and very attractive business prospects.

Grants may be available to help with early stage financing. Universities are very familiar with sources of grant money. Contacts and affiliation with universities may produce a path to such funding, especially if the university gets funds for related research. The U.S. National Science Foundation (www.nsf.gov/funding/) provides USD$100,000 to USD$2 million grant money to attractive early stage technology companies. The Canadian Foundation for Innovation (www.innovation.ca) provides research funds to institutions. Local, provincial, and private funding sources may also be available.

Some large energy corporations have corporate venture funds that focus on areas of interest, including energy related technologies. These include BP, Shell, Constellation (Exelon) and others. [3] Considering the increasing global concern for climate change and the evolving advocacy of SMR and AR roles in a carbon free generation mix, venture investment in these technologies may become available.

It takes hundreds of millions of dollars to bring a new nuclear technology to commercialization. There are many attractive SMR and AR technologies in the pipeline. Not all will get funded. And traditional sources of technology startup funding are not likely to move the needle significantly. Large firms for which SMRs and ARs have strategic value to their core business (strategic investors) are potential white knight saviors. Consider the Fluor Corporation investment in NuScale. Fluor not only provides funds. It adds considerable credibility and confidence in the technology's future. It's global network also provides access to governments, potential customers and other investors. Other similar strategic investors are in the wings, some have already made early investments. Consider NB Power's association with Moltex and ARC Energy. Success in full SMR or AR commercialization will likely find a path leading through large companies with interest in synergistic strategic interests.

Ultimately, the startup company shareholders may wish to raise money in the public equity markets through an Initial Public Offering (IPO). The process for IPO is complex, expensive, and time consuming; but can be very financially beneficial for the company and rewarding for individual shareholders. Support from an investment banking firm may be necessary to guide the business through IPO.

4. Business scope and structure

When traversing the path to commercialization, the company needs to decide how it will be structured to approach the market. Considerations include whether the company will be fully integrated and perform full engineering, procurement, and construction/construction management (EPC, EPCM) for the entire plant or only supply the nuclear steam supply system (NSSS). A hybrid may be appropriate where the company provides the NSSS system and the entire plant engineering & design along with major Balance of Plant components in modular form. The company may choose to provide plant operation services directly or through a dedicated operations partner. What about long-term service agreements and training? Will the company market the product directly or through strategic partners and intermediaries? These and other strategic matters must be addressed at some point in the commercialization process and may unfold as the business evolves.

5. Staffing

Eventually significant staffing must occur. In order to obtain a license, detailed design, analysis and testing must be accomplished. A staff of engineers, scientists, specialists and other professionals need to be in place to justify investment and justify the licensing agency's serious consideration of committing resources to evaluate the technology. Bringing new nuclear technology to that point is a significant and costly effort. Talented resources must be convinced to leave current positions and join a technology firm with an uncertain future. Uncertain because the market conditions may change, competition may surpass the technology, or sufficient funds may not be available. In addition, compensation and location have to be acceptable. There is good news for recruiting, however. Entrepreneurial people who will take the risk if they believe in potential success may be excited to join. These individuals usually have the attitude and commitment to help the business succeed. The entrepreneurial recruit's interest is not automatic. It comes from a rational assessment of the business prospects. Those prospects must be created by the existing team. Clearly, a ten-plus year commitment to an uncertain result is difficult. Granting stock options often helps with the decision. Bottom line: the business must present a case for key people to join, who in turn, can attract others. **That business case also includes many issues that are important to recruits as well investors, including:**

- **Recognition and acceptance**

  Industry recognition can be achieved by creating a team of respected individuals as "Technical Advisors" (TA). The TAs role is to bring their relevant expertise to the company in a manner visible to the industry. They lend their name and endorsement to the business. This does not have to be an exclusive arrangement; but must connote definite support.

  In addition to Technical Advisors, potential end user (customer) involvement would help with recognition. The customers could be structured in a customer forum that periodically meets for development updates, to offer end user perspectives, and provide suggestions on the evolving technology

- **Visibility in the industry**

  An aggressive "branding" strategy needs to be deployed to gain familiarity and credibility in the industry. This will require a recognizable name, logo, presence at industry forums and conferences (including local chapter meetings), university guest lectures, press releases, videos, and a professional website with technical and commercial content. While a self-developed branding strategy may be successful, entrepreneurs should reach beyond their inner circle to seek opinions of focus groups and support from marketing professionals. Websites of related companies can also provide good insights to branding strategy and support.

- **A reasonable path to adequate funding**

  Absent an iron clad contractual commitment from a capable source, future funding will always be a matter of uncertainty. There are too many hurdles and risks involved; as well as a long timeline to success. Past funding success may be supportive of future funding success. Clearly that will depend on the commitment of the earlier investors, their balance sheets, their genuine interest in the technology, and their potential return exclusive of direct financial reward.

- **A team of inspirational leaders**

  An impressive existing team can have a significant impact on recruiting and fund raising. So can an unimpressive team. Entrepreneurs should be mindful of the fact that the early team impressions will influence the quality of the successive team members. Favorable impressions come from individual past performance, peer recognition, education, past startup successes, personality, and image. Opinion of others in the startup company are not out of scope for recruits to seek advice. Most important is the interview process. It should not be perfunctory. Planned interviews with probing questions dealing with technical competence, motivation and commitment should be pre-established.

- **A plan for commercialization**

  Imagine an interviewee or an investor asking the question: "What is your plan for commercialization?" Would different respondents provide different or conflicting answers? The value of a current and consistent plan for moving forward to the finish line is clear.

- **Adequate compensation**

  Startup companies rarely have funds to pay top dollar. Entrepreneurial talent will often value the opportunity to work for a startup company that advances a favored technology and can provide long term reward. Few talented individuals will accept employment with compensation that doesn't support their financial needs. However, some sacrifice may be made if career opportunities and long-term compensation are credible aspirations. Career opportunities can be perceived from the recruit's position in the organization chart and the anticipated growth in the staff. Compensation is usually sweetened by some form of incentive such as cash bonus and equity.

6. Supply chain

Specifying qualified "off-the-shelf" components can reduce the overall cost of the technology and should be done to the extent possible. New nuclear technology, however, will likely require some custom engineered components. Therefore, a startup nuclear company must establish a vendor supply chain. Initial vendors will likely provide specialty **services**; but eventually, as design evolves, **components and material** have to be sourced. To accomplish this, the company needs an experienced nuclear procurement manager to organize a procurement team, establish vendor relations and create a qualified supply chain. The prospect of supplying goods or services for a considerable time may be attractive to vendors, providing negotiating leverage for the company. Some vendors may be willing to provide goods or services at a reduced price in exchange for the prospect of considerable future sales. Some may provide early stage services for an equity share in the business. While vendor exclusivity can be risky, contract language providing exclusivity with appropriate "off ramps" may be advisable to gain early stage price concessions.

Particular attention must be paid to long lead time items to ensure they will be available when needed. The timing of "need" is driven by the realistic expectation of a new build; in other words, a sufficiently detailed and realistic schedule that can project material delivery dates. Clearly, such projections will include uncertainty. However, skilled procurement management may be able to negotiate a fair deal that minimizes risk to the company and the vendor.

Perhaps the largest procurement will be for integrated manufacture and assembly of the final nuclear steam supply system (NSSS). Many, if not most SMRs and advanced reactors in today's pipeline expect factory assembly for a good portion or for all the NSSS. The selection of this vendor is critical to the success of the business and may be leveraged in several ways. First, the vendor responsible for assembly stands to realize substantial economic benefit. Second, a customer may be enticed to build an SMR or AR in the region where the assembly facility is located. Utilities often fashion themselves as strong economic development advocates. Local, regional, state or provincial governments may offer incentives for the assembly facility; one such incentive may be economic support for the new nuclear plant. Regardless, the primary selection criterion for choosing an assembly vendor is, of course, the quality and value accruing to the technology developer.

7. Verification and prototyping

The process for licensing new nuclear technology requires rigorous analysis and testing. Some processes, such as core performance and system thermal hydraulics may require sophisticated software systems, and well-documented bases of analysis. In turn, calculations and software analytics may require verification by physical testing. A unique test facility that simulates the parameters in question may have to be constructed; or may be available at a university, laboratory, or industrial facility. In some cases, material properties must be verified to be appropriate for application. Laboratories or supplier shops may be able to fulfil these needs. Individual component testing may best be carried out by the component supplier and be included in the procurement specifications. These activities cost money and time and must be factored in planning and budgeting.

Throughout the entire technology development process, contemporaneous documenting of the bases of all conclusions will save time and avoid repeated efforts.

8. Licensing

Licensing new nuclear power technology can be a rigorous, costly, time-consuming, and uncertain process. Demonstrating the ability license a technology is an important element in the commercialization process. It raises the confidence of investors, employees, suppliers, and other stakeholders.

Experience with the regulator is invaluable to succeed in the licensing process. In fact, the technology developer should hire a senior individual familiar with the regulator and the licensing process to be the primary contact. Applicants must not wait too long before engaging the regulator. Early interface, detailed discussions regarding the technology and regulatory considerations will benefit both parties. Preliminary document submittals are also beneficial and often stimulate feedback from reviewers.

"Licensability" can be tested by requesting a pre-license Vendor Design Review (VDR) by the CNSC. "This review can provide early identification and resolution of potential regulatory or technical issues in the design process, particularly those that could result in significant changes to the design or safety analysis. The objective of a pre-licensing review is to increase regulatory certainty while ensuring public safety." [4]

9. Intellectual Property

Comprehensive and timely intellectual property (IP) protection is essential as the business proceeds. This is not only prudent to protect the business proprietary technology. IP ownership has value. If the venture does not succeed to full commercialization, rights to the patented subject matter may be licensed to another party, providing a source of income.

Protecting intellectual property can be expensive, especially in the nuclear power industry, where the market is global and there are global players who may not hesitate to adopt unprotected technology. International protection becomes a necessity. Entrepreneurs are well served to have competent patent attorneys, who understand the technology and are proficient in domestic and international IP protection.

10. Customers

Acquiring the first customer for new nuclear technology is a challenge to say the least. Potential customers may not be inclined to contract for a plant until the initial facility is operating successfully. What can the developer do to obtain the first customer? Stand in the shoes of a prospective customer. What would drive you to commit your company to an expensive new technology without guaranteed capital cost in an industry notorious for cost overruns (see the "Deployment" section below), without reasonably certain lifecycle cost and unproven operational performance?

The new wave of SMRs and ARs are addressing such key issues by designs that intuitively are easier to construct and operate. Nonetheless, risk-adverse buyers want more certainty. There are several ways to move the prospect closer to the commitment:

- Engage potential customers early in the design and development stage by creating a customer advisory board that meets periodically to input their needs, concerns, and suggestions. Include public entities and end user groups such as indigenous peoples

in a common or separate board. An advisory board can be valuable in seeding early customer interest.

- Seek out non-traditional nuclear power customers with demand for the product. The size and mobility of SMRs and ARs open opportunities in remote areas and islands where electricity is produced by liquid fueled machines such as diesel generators. Fuel must be trucked or shipped in. Often seasonal conditions prevent delivery and fuel must be stored for use. Industries such as mining are stepping up to advocate nuclear technology that can reliably supply power production year-round without refueling. Developers would be well served to consider the needs of remote aboriginal communities, mining, and oil & gas extraction industries: small, transportable, safe, easy to operate & maintain, proliferation proof, moveable, etc.

- Government facilities and institutions that have political as well as economic interests in deploying new nuclear technology. Consider jurisdictions with solid commitments to reduce greenhouse gas emissions as primary targets.

- Align with a large strategic partner that has favorable relations and access to potential customers in the global market and leverage those relationships to initiate and close sales.

- If possible, offer conditional guarantees to credible early customers that will follow through with owning a new plant.

- Assist in obtaining co-owners and power purchase agreements for the new facility.

- Consider facilitating a major supplier to locate a production facility in the service territory of a prospective buyer.

- Offer qualified and licensed operation and maintenance services to an entity otherwise not capable of performing these functions.

- Consider a "Build-Own-Operate-Transfer" (BOOT) arrangement whereby the developer or a third party takes responsibility and risk for building owning and operating the facility for a period of years and sells the energy to the counterparty until the all costs plus profit are recovered, then transfer the ownership to that party. Such an arrangement is complicated and may require sovereign or other financial backing to execute.

11. Deployment

As mentioned above, the nuclear industry is not noted for on-time and under budget capital deployments. This is not unique to the nuclear industry, however. Large capital projects in many industries throughout the globe suffer from similar problems. The root causes are similar, and **most are avoidable**. *They are many and details are addressed in an earlier paper by the author.* [5]

The most pervasive and significant causes of deployment problems include:

- Poor initial estimates and schedules

- Weak leadership and accountability

- Ineffective and inexperienced management
- Failure to properly structure and execute the project management process
- Limited or ineffective use of modern risk management tools

12. Business Sustainability

The successful launch of an operating unit is not the end of the line. The economics of factory built NSSS modules and unique components become more favorable as the order book grows. A dedicated and optimized assembly line will not likely be created for one module. With proper cost and revenue data, one can calculate the break-even volume that justifies the construction of a customized and optimized assembly facility with efficient material and component storage facilities and delivery infrastructure.

The first customer is the ice breaker. A sustainable backlog of orders and efficient production are intermediate and long-term objectives.

Entrepreneurs must be mindful of the ever-changing power market and embark on a structured continuous improvement program. This need not wait for the first deployment. During the course of 10+/- years of development, new ideas, new demands, and new challenges will arise and must be anticipated. These could be threats or they could be opportunities. Sustainability requires keeping the focus and commitment. When those are gone, it's time to cash out, turn the business to fresh thinkers and move on.

13. Conclusion

Interest in Small Modular Reactors and Advanced Reactors is gaining strength, driven, to a large extent, by economics, safety, siting, and climate change considerations. Interest and the demand are there. The challenges are significant, however.

Commercializing new nuclear technology such as Small Modular Reactors and Advanced Reactors may require hundreds of millions of dollars, more than ten years, and much uncertainty and risk. Markets change and competitive products appear that may alter the attractiveness of the technology.

Traditional sources of new technology financing may be inadequate to reach the finish line. Entrepreneurs need to build a management team that instils confidence in the investment community and in the market place. In addition, industry recognition by effective branding helps cement understanding and confidence in the technology,

Entrepreneurs must also be prepared to give up significant equity and control. Equity can buy good staff, specialty services, and operating capital. It must be prudently managed with the long-term needs in mind.

> *One hundred percent ownership of an unsuccessful venture is worth virtually nothing. Five percent of a successful venture could be very significant.*

14. References

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