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# Small Modular Reactors in Poland: Financial risks and constraints in a radically innovative megaproject

## Introduction

In 2022, the Polish government incorporated Small Modular Reactors (SMRs) in the national energy policy.[1] Two projects are currently on the table, which will be further labelled by the names of the respective technologies involved, i.e. VOYGR and BWRX-300. Project VOYGR is a joint-venture between the Polish mining company KGHM and the U.S.-based company NuScale Power. Project BWRX-300 is a more complex joint-venture, where the national Polish oil and gas company PKN Orlen S.A.[2] teams up with a private company Synthos Green Energy, and they both partner with the GE-Hitachi consortium.

The Polish SMR programme is a megaproject. In terms of the power announced to be installed – nearly 500 MW in the VOYGR project and more than 5 GW in the BWRX-300 one – both ventures are likely to be true game changers for the national economy of Poland and its power system. The existing literature allows guessing a capital cost of construction around $ 27.61 bln in the BWRX-300 project, and

[1] *Energy Policy of Poland until 2040 (EPP2040)*, Ministry of Climate and Environment, https://www.gov.pl/web/climate/energy-policy-of-poland-until-2040-epp2040; *Nuclear Power and Secure Energy Transitions*, IEA, June 2022, https://www.iea.org/reports/nuclear-power-and-secure-energy-transitions [accessed: 13.06.2023].

[2] S.A. – *spółka akcyjna*, Polish for joint-stock company.

some $ 2 bln in the VOYGR project.[3] As a megaproject, the SMR programme in Poland has all the corresponding factors of uncertainty, such as: political ties, likelihood of corruption, as well as inherent discrepancy between deeds and words in the principal decision-makers.[4] As of October 2022, there were 3 SMRs in the world under actual operations, other 3 in construction, 26 SMRs in the phase of basic and detailed designs, and 29 at the stage of conceptual design.[5] Generally, SMR projects across the world are at the stage of optimal site selection.[6]

At the same time, the two projects display very different degrees of institutional development. The VOYGR project seems to be stuck at the level of preliminary formalities, and whatever action is being taken, structurally it stays within the business structure of KGHM. The target capacity to be installed in this project is probably the 6-module version of the VOYGR plant, thus 462 MWe. As regards the BWRX-300 project, in June 2022, PKN Orlen S.A. and Synthos Green Energy S.A. formed a new entity, Orlen Synthos Green Energy, with an initial paid-in equity of PLN 20 mln, 50% from each of the partners. In November 2022, Synthos Green Energy S.A. and GE Hitachi Nuclear Energy International LLC formed a new entity, BWRX Europe, with an initial paid-in equity of PLN 2 mln, 50% from each of the partners. In March 2023, GE Hitachi Nuclear Energy (GEH), Tennessee Valley Authority (TVA), Ontario Power Generation (OPG) and Synthos Green Energy (SGE) announced they are forming a consortium to advance the global deployment of the GEH BWRX-300 small modular reactor. On April 21, 2023, Orlen Synthos Green Energy sp. z o.o.[7] formed 19 affiliate entities, each as a limited liability partnership, and each with an initial paid-in equity of PLN 500 000, for the purposes of developing 19 local installations of the BWRX-300 technology. Three regional locations are named (Kujawy, Pomorze, and Warta), as well as 16 specific hosting cities: Tarnobrzeg, Stalowa Wola, Krakow-Nowa Huta, Ostrołęka, Połaniec, Bełchatów, Dąbrowa Górnicza, Grudziądz, Kozienice, Łaziska, Łódź, Poznań, Rybnik, Stawy Monowskie, Warszawa, Włocławek.

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3 A. Asuega, B.J. Limb, J.C. Quinn, *Techno-economic analysis of advanced small modular nuclear reactors*, "Applied Energy" 2023, vol. 334, 120669, https://doi.org/10.1016/j.apenergy.2023.120669.

4 B. Mignacca, G. Locatelli, T. Sainati, *Deeds not words: Barriers and remedies for Small Modular nuclear Reactors*, "Energy" 2020, vol. 206, 118137, https://doi.org/10.1016/j.energy.2020.118137.

5 *Global number of small modular reactor projects by status of development, 2022*, IEA, 30.06.2022, https://www.iea.org/data-and-statistics/charts/global-number-of-small-modular-reactor-projects-by-status-of-development-2022 [accessed: 13.06.2023].

6 Y. Liu *et al.*, *Development of an optimization-aided small modular reactor siting model – A case study of Saskatchewan, Canada*, "Applied Energy" 2022, vol. 305, 117867, https://doi.org/10.1016/j.apenergy.2021.117867.

7 Sp. z o.o. – *spółka z ograniczoną odpowiedzialnością*, Polish for limited liability company (LLC).

The deployment of SMR is likely to generate windfall gains, which can destabilize the national financial system, and lead to suboptimal decisions in lending and investment.[8] The more risk the corporate decision makers ascribe to their strategy, the more liquid financial assets they accumulate, yet, in the presence of the same systemic risks, companies with disparate qualities of corporate governance accumulate cash in similar ways and proportions.[9] Allocation of funds to the projects studied happens in the internal capital markets of the companies involved, which moderate investment decisions, as long as there is a stream of income to claim; in the absence thereof, decisions might become irrational[10]. The future operators of SMRs in Poland are unlikely to meet significant direct competition in the national market of energy, and alleviating the competitive constraint can push them beyond the limits of rational optimism.[11] Megaprojects are known for periodically falling into financial distress.[12] In the absence of clearly predictable future cash flows from selling energy, maintaining abnormally high cash balances seems the most prevalently used strategy.[13]

Cash management seems to be the key factor of financial risk and the key financial constraint in the emergence and adjustment of business structures in the two SMR projects studied. Therefore, the working hypothesis of the research presented further is that uncertainties relative to those projects make them prone to adopting an opportunistic strategy, where business structures accumulate and hold significant amounts of cash without clear immediate purpose.

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8 T. Beck, S. Poelhekke, *Follow the money: Does the financial sector intermediate natural resource windfalls?*, "Journal of International Money and Finance" 2023, vol. 130, 102769, https://doi.org/10.1016/j.jimonfin.2022.102769.

9 P. Couzoff, S. Banerjee, G. Pawlina, *Effectiveness of monitoring, managerial entrenchment, and corporate cash holdings*, "Journal of Corporate Finance" 2022, vol. 77, 102258, https://doi.org/10.1016/j.jcorpfin.2022.102258.

10 L.R. Kabbach-de-Castro, G. Kirch, R. Matta, *Do internal capital markets in business groups mitigate firms' financial constraints?*, "Journal of Banking & Finance" 2022, vol. 143, 106573, https://doi.org/10.1016/j.jbankfin.2022.106573; C. Iskenderoglu, *Managerial discretion and efficiency of internal capital markets*, "Journal of Corporate Finance" 2021, vol. 70, 102061, https://doi.org/10.1016/j.jcorpfin.2021.102061.

11 N.P. Kell *et al.*, *Simulating offshore wind contract for difference auctions to prepare bid strategies*, "Applied Energy" 2023, vol. 334, 120645, https://doi.org/10.1016/j.apenergy.2023.120645.

12 L. Johnman, F.M.B. Lynch, *The road to Concorde: Franco-British relations and the supersonic project*, "Contemporary European History" 2022, vol. 11, no. 2, pp. 229–252, https://doi.org/10.1017/S0960777302002035.

13 N. Aydin *et al.*, *Prediction of financial distress of companies with artificial neural networks and decision trees models*, "Machine Learning with Applications" 2022, vol. 10, 100432, https://doi.org/10.1016/j.mlwa.2022.100432; R.F. Brenes, A. Johannssen, N. Chukhrova, *An intelligent bankruptcy prediction model using a multilayer perceptron*, "Intelligent Systems with Applications" 2022, vol. 16, 200136, https://doi.org/10.1016/j.iswa.2022.200136.

## Material and method

A business structure can be represented as a set of proportions between capital aggregates, possible to reduce to a common denominator which will be further called the peg value. The capital aggregate burdened with the least uncertainty in the case studied is the capital cost of building the reactors strictly spoken. To the author's best knowledge, both technologies are those of LW-SMR type, and the overall capital cost of constructing a small modular reactor at $ 4844 per 1 kW of electrical power. The BWRX-300 reactor has a nominal power of 300 MW, whence a unitary capital cost circa $ 1.45 bln, and a total capital cost of 19 local deployments in the BWRX-300 technology in Poland estimated at $ 27.61 bln. As regards the VOYGR project, the SMR of 462 MW corresponds to $2.24 bln for the reactor alone. There is anecdotal evidence of a lower capital cost in the BWRX-300 case, namely $ 1.18 bln for the first reactor, with a possibility to achieve a lower cost in subsequent constructions.[14] That last figure is to be considered with caution, as it corresponds rather to the capital cost of a Molten-Salt-SMR, not a LW-SMR. It is further assumed that: a) the total capital cost of building the reactors will be the total value of plant, property and equipment, further designated as *PPE(t)*, in the future balance sheets of business entities involved; b) fixed physical productive assets, or *PPE(t)*, take on a non-random proportion to other capital aggregates in the business structure.

The empirical material used in the practical application of the method consists of financial data reported by business entities considered as benchmarks for the two projects. The set of benchmark entities is split in two subsets: the founding entities in each project, and the strictly spoken benchmark ones. The common benchmarks for both projects are:

(a) Tauron Polska Energia S.A., a big Polish generalist in the energy sector, with assets in both the generation and the distribution of energy. According to the current reports published in the VOYGR project, Tauron is supposed to be a technological partner in this venture, although not one of the founding entities.

(b) Energa S.A., a Polish generalist in the energy industry, similar to the above-mentioned Tauron, but different in three respects. Firstly, Energa is smaller than Tauron and relatively more oriented on new sources of energy. Secondly, Energa has a corporate history of ups-and-downs, thus it is a relatively less stable business structure than Tauron. Thirdly, Energa is an affiliate of PKN Orlen, one of the founding entities in the BWRX-300 project.

(c) ZEPAK S.A., a big operator of power plants in Poland, and involved in building a large scale nuclear power plant, together with another benchmark entity, PGE.

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14 P. Rapacka, *Poland: Capital Expenditure On First BWRX-300 SMR Project Estimated At €1.1 Billion*, NucNet, 26.05.2022, https://www.nucnet.org/news/capital-expenditure-on-first-bwrx-300-smr-project-estimated-at-eur1-1-billion-5-4-2022 [accessed: 13.06.2023].

(d) Nuclearelectrica S.A., a Romanian operator in the sector of energy, and participating in the Romanian implementation of the VOYGR technology, together with NuScale Power, the latter being the provider of core technology.

Besides those benchmark entities, the method is applied to the financials of founding entities in the two project, namely:

- KGHM and NuScale Power in the VOYGR project
- PKN Orlen, Synthos Group and GE Hitachi Nuclear Energy in the BWRX-300 project. The latter actor requires some commentary. GE Hitachi is a consortium articulated around many projects rather than a business entity in strict terms. According to the author's best knowledge, the dominant business entity, and the de facto host business structure for this joint venture is General Electric, and more specifically its Power segment. Therefore, the financials taken as empirical material for this specific benchmark are those of GE.

The core variables in this empirical simulation are the proportions between Property, Plant, and Equipment (PPE) on the one hand, and: total assets (PPE_TA), equity (PPE_EQ), total liabilities (PPE_TL), and cash plus cash equivalents, such as liquid financial securities (PPE_Cash). Variables PPE_TA, PPE_EQ, and PPE_TL are crucial for estimating the total financial needs of business structures emerging in the two SMR projects. Besides, all the four variables are significant for predicting the long-term financial stability of business structures.[15]

In each of the entities taken as benchmarks, two snapshots are taken at the above-specified variables: end of 2021, and end of 2022, which makes a total of 20 'company <> year' sets of the proportions PPE_TA, PPE_EQ, PPE_TL, and PPE. The expected capital cost of construction – $ 2237.93 mln in the VOYGR project and $ 27 610.80 mln in the BWRX-300 project – has been divided by said proportions in order to simulate, respectively, total assets, total equity, total debt, and total cash balance held in the two projects. Those simulations of capital aggregates are considered as attractors for the business structures emerging in those projects.

Next, a generator of intelligent Monte Carlo sampling has been constructed in order to estimate the central scenarios of PPE_TA, PPE_EQ, PPE_TL, and PPE_Cash. The initial set of 20 empirical observations has been normalized over the respective maxima of the 4 variables, and then subject to 1600 Monte Carlo samples, which, if the given sampling is reliable for prediction, should produce a clear tendency to stable standard error.[16] The here-used Monte Carlo generator adds the

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[15] N. Sayari, C. Simga Mugan, *Industry specific financial distress modeling*, "BRQ Business Research Quarterly" 2017, vol. 20, no. 1, pp. 45–62, http://dx.doi.org/10.1016/j.brq.2016.03.003; S. Handoyo *et al.*, *A business strategy, operational efficiency, ownership structure, and manufacturing performance: The moderating role of market uncertainty and competition intensity and its implication on open innovation*, "Journal of Open Innovation: Technology, Market, and Complexity" 2023, vol. 9, no. 2, 100039, https://doi.org/10.1016/j.joitmc.2023.100039.

[16] I. Lerche, B.S. Mudford, *How many Monte Carlo simulations does one need to do?*, "Energy Exploration & Exploitation" 2005, vol. 23, no. 6, pp. 405–427.

standard error obtained from each consecutive sample to the normalized empirical values for the next sample. In other words, each consecutive sample is informed by the coherence between previous samples.

Each *j*-th Monte Carlo sample yields $MS_j = X_1*PPE\_TA + X_2*PPE\_EQ + X_3*PPE\_TL + X_4*PPE\_Cash$, where $X_i$ is a random number such as $0 < X_1 < 1, 0 < X_2 < 1, 0 < X_3 < 1, 0 < X_4 < 1$. In order to test additionally the robustness of Monte Carlo sampling, 2 different computations of standard error have been used. The first one, $\varepsilon_1$, sports a standard error which is de facto the half of mathematical distance between the current *MSj* and the previous one, thus:

$$\varepsilon_1 = \sqrt{\frac{(MS_j - MS_{j\text{-}1})^2}{2}}$$

The second type of standard error, $\varepsilon_2$, goes over all the so-far generated samples, and therefore:

$$\varepsilon_2 = \frac{StdDev[\mathrm{MS}_1,\mathrm{MS}_j]}{j}$$

Both standard errors display satisfactory tendency to narrow down, with $\varepsilon_1$ stabilizing around 0.006, and $\varepsilon_2$ at 0.0122.

## Calculations and discussion

Table 1 summarizes the PPE_TA, PPE_Equity, PPE_Debt, and PPE_Cash proportions in benchmark entities for both SMR projects in Poland. PPE_Cash and PPE_Debt. Table 2 and Table 3 present simulations of capital aggregates in, respectively, the VOYGR and the BWRX-300 projects. It is reasonable to predict the total capital base of the two SMR projects – thus their total assets – at more than twice the currently estimated capital cost of construction, i.e. some \$ 4.8–4.9 bln in the VOYGR project, and \$ 59–61 bln in the BWRX-300 project. Different simulations of capital aggregates yield different levels of coherence between the two sides of the balance sheet. Simulations by similarity, i.e. when the new business structures are supposed to emulate internal proportions of their benchmarks, generally yield the sum of equity and debt equal to the sum of assets, to \$ 1 mln close. Simulation in the VOYGR case, by similarity to the capital structure of NuScale Power in 2021, is an exception: the sum of equity and debt is smaller than total assets by \$ 965 mln. Interestingly, that specific business structure (NuScale Power in 2021) is the least stable among all the benchmarks used. In 2021, NuScale Power was not even exactly NuScale Power yet: there was a SPAC (Special Purpose Acquisition Corporation) in place as a prelude to incorporating the definitive business entity.

Simulations based on Monte Carlo sampling systematically display a gap between total assets and the sum of equity and debt: around \$ 1.1 bln in the VOYGR case and \$ 13–14 bln in the BWRX-300 project. Each time, the gap makes around 22–23% of the total simulated assets. If those probabilistic gaps in the capital base are just a computational fluke, equity and debt obtained by simulation can be simply normalized over the total simulated value of assets. That would yield an almost textbook balance sheet with financial leverage just below 50%. Total equity in the VOYGR project would be around $ 2.6 bln, with total debt approximating $ 2.3 bln, whilst the BRX-300 project would sport circa $ 32 bln in equity and a total debt neighbouring $ 28 bln. If, however, that gap has a deeper meaning, we might simply not have any reliable way to predict the exact origins (debt or equity) of 22–23% in the total capital base of those projects.

Monte Carlo sampling suggests the emergence of business structures quite frugal in their cash holdings: around 4% of total assets. This is close to the least cash-pumped benchmarks, e.g. Energa, Tauron or KGHM, and it is much below what is observable in companies such as Tesla or Meta, where cash can easily top 20% of total assets. Simulations by similarity give more interesting insights. In the VOYGR case, any attempt to emulate the business structure of NuScale Power would yield to nothing short of a financial bubble, with a business structure holding several times more cash than needed to finance productive nuclear assets. In both projects, the benchmarks of ZEPAK and Nuclearelectrica offer somehow less outlandish versions of strongly cash-based business structures.

Table 1. Financial proportions in benchmark entities

| | | PPE_TA | PPE_Equity | PPE_Debt | PPE_Cash |
|---|---|---|---|---|---|
| Benchmark entity | PGE 2021 | 0.6836 | 1.2594 | 1.4952 | 9.0327 |
| Benchmark entity | PGE 2022 | 0.6087 | 1.1840 | 1.2528 | 5.4167 |
| Benchmark entity | Energa 2021 | 0.7195 | 1.5370 | 1.3528 | 44.9441 |
| Benchmark entity | Energa 2022 | 0.6381 | 1.5066 | 1.1068 | 15.8055 |
| Benchmark entity | Tauron 2021 | 0.7280 | 1.7656 | 1.2388 | 32.2721 |
| Benchmark entity | Tauron 2022 | 0.6560 | 1.7895 | 1.0357 | 13.7899 |
| Benchmark entity | ZEPAK 2021 | 0.3570 | 2.2552 | 0.4241 | 2.2852 |
| Benchmark entity | ZEPAK 2022 | 0.3804 | 1.4219 | 0.5194 | 1.1648 |
| Benchmark entity | Nuclearelectrica 2021 | 0.6236 | 0.7176 | 4.7621 | 2.1769 |
| Benchmark entity | Nuclearelectrica 2022 | 0.5015 | 0.5615 | 4.6935 | 1.2639 |
| Founding entity | KGHM 2021 | 0.5030 | 0.8902 | 1.1564 | 11.7495 |
| Founding entity | KGHM 2022 | 0.4797 | 0.7975 | 1.2037 | 16.6792 |
| Founding entity | NuScale Power 2021 | 0.0409 | 0.0749 | 0.0939 | 0.0643 |
| Founding entity | NuScale Power 2022 | 0.0137 | 0.0172 | 0.0667 | 0.0178 |
| Founding entity | Synthos 2021 | 0.4640 | 1.6968 | 0.6386 | 18.1357 |
| Founding entity | Synthos 2022 | 0.4582 | 1.4730 | 0.6650 | 22.4375 |
| Founding entity | PKN Orlen 2021 | 0.5188 | 1.0533 | 1.0222 | 13.6907 |
| Founding entity | PKN Orlen 2022 | 0.4364 | 0.8677 | 0.8779 | 4.7892 |
| Founding entity | General Electric 2021 | 0.0785 | 0.3751 | 0.0993 | 0.5561 |
| Founding entity | General Electric 2022 | 0.0771 | 0.3852 | 0.0964 | 0.5821 |

Source: author's own elaboration.

Table 2. Simulation of capital aggregates in the VOYGR project

| | | Assets ($ mln) | Equity ($ mln) | Debt ($ mln) | Cash and equivalents ($ mln) |
|---|---|---|---|---|---|
| Benchmark entity | PGE 2021 | 3274 | 1777 | 1497 | 248 |
| Benchmark entity | PGE 2022 | 3677 | 1890 | 1786 | 413 |
| Benchmark entity | Energa 2021 | 3110 | 1456 | 1654 | 50 |
| Benchmark entity | Energa 2022 | 3507 | 1485 | 2022 | 142 |
| Benchmark entity | Tauron 2021 | 3074 | 1268 | 1807 | 69 |
| Benchmark entity | Tauron 2022 | 3411 | 1251 | 2161 | 162 |
| Benchmark entity | ZEPAK 2021 | 6269 | 992 | 5277 | 979 |
| Benchmark entity | ZEPAK 2022 | 5883 | 1574 | 4309 | 1921 |
| Benchmark entity | Nuclearelectrica 2021 | 3589 | 3119 | 470 | 1028 |
| Benchmark entity | Nuclearelectrica 2022 | 4462 | 3985 | 477 | 1771 |
| Founding entity | KGHM 2021 | 4449 | 2514 | 1935 | 190 |
| Founding entity | KGHM 2022 | 4665 | 2806 | 1859 | 134 |
| Founding entity | NuScale Power 2021 | 54 683 | 29 895 | 23 823 | 34 784 |
| Founding entity | NuScale Power 2022 | 163 568 | 130 000 | 33 568 | 125 589 |
| Central scenario – Monte Carlo sampling | Error between the last two | 4900 | 2021 | 1798 | 197 |
| Central scenario – Monte Carlo sampling | Cumulative standard error | 4810 | 1974 | 1721 | 188 |

Source: author's own elaboration.

Table 3. Simulation of capital aggregates in the BWRX-300 project

| | | Assets ($ mln) | Equity ($ mln) | Debt ($ mln) | Cash and equivalents ($ mln) |
|---|---|---|---|---|---|
| Benchmark entity | PGE 2021 | 40 390 | 21 924 | 18 466 | 3 057 |
| Benchmark entity | PGE 2022 | 45 360 | 23 320 | 22 039 | 5 097 |
| Benchmark entity/ founding entity | Energa 2021 | 38 374 | 17 964 | 20 410 | 614 |
| Benchmark entity/ founding entity | Energa 2022 | 43 273 | 18 327 | 24 946 | 1747 |
| Benchmark entity | Tauron 2021 | 37 928 | 15 639 | 22 289 | 856 |
| Benchmark entity | Tauron 2022 | 42 088 | 15 429 | 26 659 | 2002 |
| Benchmark entity | ZEPAK 2021 | 77 344 | 12 243 | 65 101 | 12 083 |
| Benchmark entity | ZEPAK 2022 | 72 581 | 19 419 | 53 163 | 23 705 |
| Benchmark entity | Nuclearelectrica 2021 | 44 277 | 38 479 | 5798 | 12 684 |
| Benchmark entity | Nuclearelectrica 2022 | 55 052 | 49 170 | 5883 | 21 846 |
| Founding entity | Synthos 2021 | 59 506 | 16 273 | 43 233 | 1522 |
| Founding entity | Synthos 2022 | 60 263 | 18 745 | 41 518 | 1231 |
| Founding entity | PKN Orlen 2021 | 53 225 | 26 214 | 27 011 | 2017 |
| Founding entity | PKN Orlen 2022 | 63 269 | 31 819 | 31 450 | 5765 |
| Founding entity | General Electric 2021 | 351 789 | 73 608 | 278 181 | 49 648 |
| Founding entity | General Electric 2022 | 358 128 | 71 672 | 286 456 | 47 431 |
| Central scenario – Monte Carlo sampling | Error between the last two | 60 458 | 24 934 | 22 181 | 2431 |
| Central scenario – Monte Carlo sampling | Cumulative standard error | 59 349 | 24 352 | 21 229 | 2323 |

Source: author's own elaboration.

## Conclusions

The here-presented research offers some tentative insights into the financial size and shape of business structures, likely to emerge as Small Modular Reactors will be deployed in Poland. In the VOYGR project, KGHM currently holds assets worth some $ 12.9 bln, with a cash balance of $ 372 mln, financed with an equity of $ 7.8 bln and a debt of $ 5.16 bln. Most of the financial scenarios sketched for this project seem swallowable for KGHM: financing the VOYGR project will be a big change in their capital base, yet an incremental one. Simulations done for the BWRX-300 project are qualitatively different. Even the relatively conservative scenario obtained by Monte Carlo sampling suggests that PKN Orlen and Synthos, the Polish partners in that venture, would have to double their present, combined assets. Should those less conservative scenarios be consumed in real life, such as the business structure emulated from ZEPAK or General Electric, the current combined capital base of PKN Orlen and Synthos would have to undergo a qualitative leap forward.

Operational readiness of Small Modular Reactors in the two projects studied is planned around 2030, and only a 100% completed and fully operational reactor has unequivocal economic worth. For the next 6 years or so, the circa $ 27 bln of equity, generated via Monte Carlo sampling would have its value based on good faith more than anything else. Apparently overinflated cash balances in some of the simulations presented in earlier sections might have a rational side. In the absence of tangible value in productive assets, financial placements of cash, highly liquid and therefore cash-equivalent, could be a sensible move to give investors some real value for their money.

The two SMR projects in question, although nested in corporate structures, are strongly connected to the overall energy policy of Poland, and said corporate structures are prevalently state-owned. A financial paradox emerges. Running the financials of those projects in strictly corporate lines almost begs for the appearance of corporate slack in the management of exaggeratedly inflated cash holdings. Public funding can solve that problem. Subsidies can be carefully timed in step with technical progress in the deployment of productive assets. Still, public funding relieves much of the constraints which set the limits of strictly corporate decisions.

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*Small Modular Reactors in Poland: Financial risks and constraints in a radically innovative megaproject*

*Abstract*

This article introduces a method of assessing the capital needs of megaprojects in the domain of energy, in the presence of significant uncertainty, and the method is applied for studying two projects of Small Modular Reactors (SMR) in Poland. The working hypothesis is that uncertainties relative to those projects make them prone to adopting an opportunistic strategy, where business structures accumulate and hold significant amounts of cash without clear immediate purpose. The hypothesis is being verified by simulating the business structure of hypothetical entities, supposed to own and manage the productive nuclear assets. Simulation is done by emulating the business structures of incumbent entities, both those founding the two projects studied, and those serving as benchmarks in the same industry. Emulation is done both case by case, and by Monte Carlo sampling. Empirical results of the simulation suggest that significant cash holdings can appear in those projects, if and to the extent that the real business structures created therein emulate firms such as NuScale Power (partner and technology provider in one of the projects studied), i.e. firms with a mission to prepare the deployment of SMR rather than actually conduct it. Monte Carlo sampling, which sets a central financial scenario, seems to contradict the working hypothesis.

Keywords: Small Modular Reactors, business structure, capital base, energy, megaproject