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Summary of “Designing emerging technologies taking into account upscaling.”

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This summary presents the content of the paper entitled “**Designing emerging technologies taking into account upscaling**”, submitted to **Design Science** and still under review.

The content of this paper is summarized in the following abstract, extended with an overview of the results and the references cited in this research.

Abstract

Under the umbrella concepts of upscaling and emerging technology, are examined a wide variety of phenomena partly related to the environmental transition to achieve sustainability. The design literature does not provide an explicit common theoretical and practical framework to clarify the assessment method to handle « an » upscaling. In this nebulous context, designers are struggling to identify the characteristics to anticipate the consequences of emerging technology upscaling. This article therefore first proposes a structuring framework to analyze the literature in a wide range of industrial sectors (energy, chemistry, building, etc). This characterization brought out five prevalent archetypes clarifying the concepts of upscaling and emerging technology and their interactions. Then, a synthesis of invariants and methodological requirements for designers is proposed to deal with upscaling assessment according to each definition/archetype, based on a literature review of existing design methods. This literature review process showed a disparity in treatment for some archetypes, regarding the industrial sector. A discussion is consequently proposed in the conclusion to guide design practices.

Keywords: Keywords: Upscaling, Emerging technology, Integrated Design, Literature review, Absolute sustainability.

The upscaling archetypes

The upscaling of an emerging technology can be decomposed into facets depending on the declared goal, the studied object, and the stated scope (Riondet et al., 2022). Based on a literature review in design and engineering, these facets, also mentioned as “archetypes”, are illustrated in Figure 1. Generic representations have been proposed to narrow the specificities of engineering fields. The spotlight is on the common features (i.e. interdisciplinary invariants) shared by technology upscaling from different sectors such as energy and chemistry.

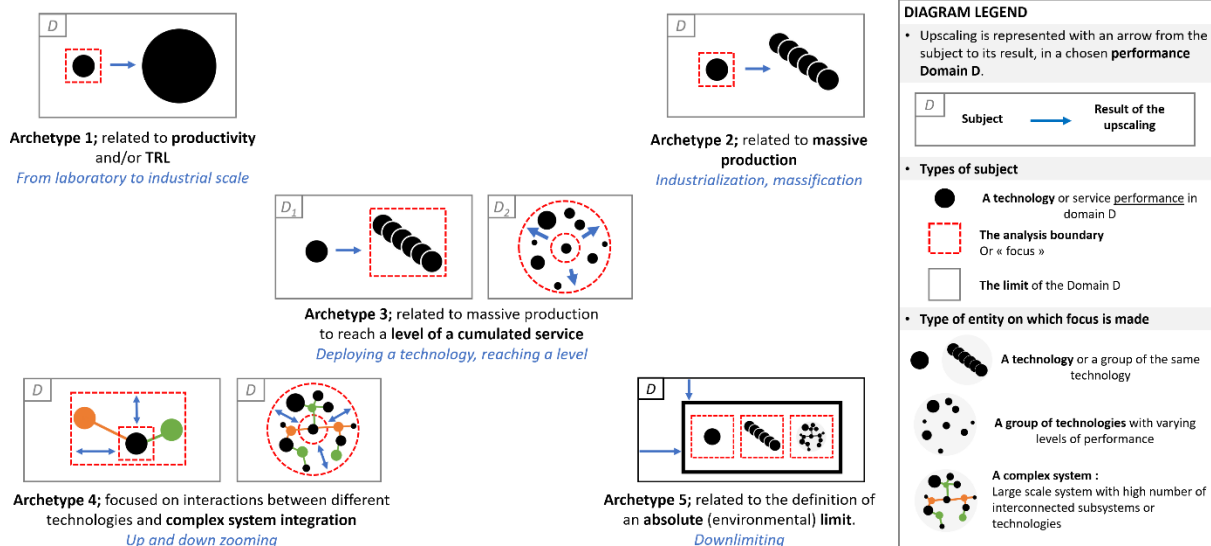


Figure 1- Visual summary of the five identified upscaling archetypes in the design and engineering literature.

Conversely, the matrix archetypes in regard to engineering fields presented in Figure 2 pinpoints the disparity of treatments of upscaling archetypes for nine industrial sectors (chemistry, waste treatment, energy, food, building, electronics, transport, production engineering, bioengineering, and nanoengineering).

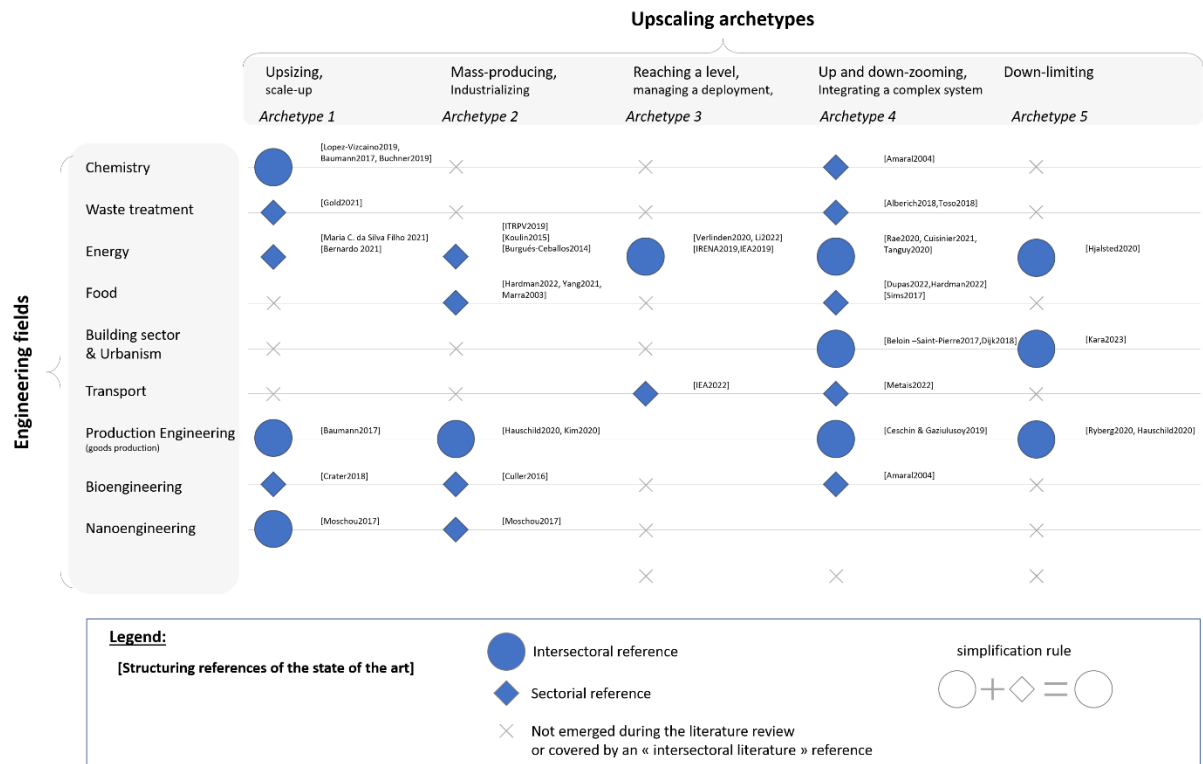


Figure 2- Visual summary of the disparity in treatment in the scientific literature for upscaling archetypes regarding the related engineering fields.

Figure 2 matrix is built on an extended literature review of techno-economic assessments per archetype of upscaling conducted from March 2021 to January 2024. The matrix displays the main references founded that best characterize one or more engineering field(s) archetype assessment. The engineering fields cited on the first column may be extended or detailed in the future. The intersectoral references have the potential to cover several fields. Those references may therefore support designers from different sectors in assessing the archetype of upscaling they are dealing with.

Archetype 1 main references: *Baumann and Lopatnikov, 2017; Buchner et al., 2019; López-Vizcaíno et al., 2019; Moschou and Tserepi, 2017*

Archetype 2 main references: *Hauschild et al., 2020; Kim et al., 2020*

Archetype 3 main references: *IEA, 2020; IRENA, 2019; Verlinden, 2020*

Archetype 4 main references: *Beloin-Saint-Pierre et al., 2017; Ceschin and Gaziulusoy, 2019; Cuisinier et al., 2021; Rae et al., 2020; Tanguy et al., 2020*

Archetype 5 main references: *Hjalsted et al., 2021; Kara et al., 2023; Ryberg et al., 2020*

This matrix is not exhaustive and is intended to be completed over time and additional research work.

References

- Baumann, C., Lopatnikov, A., 2017. Scaling Laws: Uses and Misuses in Industrial Plant and Equipment Replacement Cost Estimates. *The MTS Journal* 33, 38–44.
- Beloin-Saint-Pierre, D., Rugani, B., Lasvaux, S., Mailhac, A., Popovici, E., Sibiude, G., Benetto, E., Schiopu, N., 2017. A review of urban metabolism studies to identify key methodological choices for future harmonization and implementation. *J Clean Prod* 163, S223–S240. <https://doi.org/10.1016/j.jclepro.2016.09.014>
- Buchner, G., Stepputat, K., Zimmermann, A., Schomacker, R., 2019. Specifying Technology Readiness Levels for the Chemical Industry. *Industrial & Engineering Chemistry Research* 58, 6957–6969. <https://doi.org/10.1021/acs.iecr.8b05693>
- Ceschin, F., Gaziulusoy, İ., 2019. Design for Sustainability: A Multi-level Framework from Products to Socio-technical Systems, 1st ed. Routledge. <https://doi.org/10.4324/9780429456510>
- Cuisinier, E., Bourasseau, C., Ruby, A., Lemaire, P., Penz, B., 2021. Techno-economic planning of local energy systems through optimization models: a survey of current methods. *Int J Energy Res* 45, 4888–4931. <https://doi.org/10.1002/er.6208>
- Hauschild, M., Kara, S., Ropke, I., 2020. Absolute sustainability: Challenges to life cycle engineering. *Cirp Annals-Manufacturing Technology* 69, 533–553. <https://doi.org/10.1016/j.cirp.2020.05.004>
- Hjalsted, A., Laurent, A., Andersen, M., Olsen, K., Ryberg, M., Hauschild, M., 2021. Sharing the safe operating space: Exploring ethical allocation principles to operationalize the planetary boundaries and assess absolute sustainability at individual and industrial sector levels. *J Ind Ecol* 25, 6–19. <https://doi.org/10.1111/jiec.13050>
- IEA, 2020. Energy Technology Perspectives 2020.
- IRENA, 2019. Future of Solar photovoltaic: deployment, investment, technology, grid integration and socio-economic aspects. A Global Energy Transformation.
- Kara, S., Herrmann, C., Hauschild, M., 2023. Operationalization of life cycle engineering. *Resources, Conservation and Recycling* 190, 106836. <https://doi.org/10.1016/j.resconrec.2022.106836>
- Kim, H., Cluzel, F., Leroy, Y., Yannou, B., Yannou-Le Bris, G., 2020. Research perspectives in ecodesign. *Des. Sci.* 6, e7. <https://doi.org/10.1017/dsj.2020.5>
- López-Vizcaíno, R., Yustres, A., Sáez, C., Cañizares, P., Asensio, L., Navarro, V., Rodrigo, M.A., 2019. Techno-economic analysis of the scale-up process of electrochemically-assisted soil remediation. *Journal of Environmental Management* 231, 570–575. <https://doi.org/10.1016/j.jenvman.2018.10.084>
- Moschou, D., Tserepi, A., 2017. The lab-on-PCB approach: tackling the μ TAS commercial upscaling bottleneck. *Lab Chip* 17, 1388–1405. <https://doi.org/10.1039/C7LC00121E>
- Rae, C., Kerr, S., Maroto-Valer, M.M., 2020. Upscaling smart local energy systems: A review of technical barriers. *Renew Sustain Energy Rev* 131, 110020. <https://doi.org/10.1016/j.rser.2020.110020>
- Riondet, L., Rio, M., Perrot-Bernardet, V., Zwolinski, P., 2022. For an upscaling assessment integration in product design. *Procedia CIRP*, 32nd CIRP Design Conference 109, 89–94. <https://doi.org/10.1016/j.procir.2022.05.219>
- Ryberg, M.W., Andersen, M., Owsianiak, M., Hauschild, M., 2020. Downscaling the planetary boundaries in absolute environmental sustainability assessments - A review. *J Clean Prod* 276. <https://doi.org/10.1016/j.jclepro.2020.123287>
- Tanguy, A., Bahers, J., Athanassiadis, A., 2020. Outsourcing of urban metabolisms and its consequences: A multiscale energy flow analysis of a French port-city. *Resources Conservation and Recycling* 161. <https://doi.org/10.1016/j.resconrec.2020.104951>
- Verlinden, P.J., 2020. Future challenges for photovoltaic manufacturing at the terawatt level. *Journal of Renewable and Sustainable Energy* 12, 053505. <https://doi.org/10.1063/5.0020380>