Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 122 (2015) 290 – 295

Procedia Engineering

www.elsevier.com/locate/procedia

Operational Research in Sustainable Development and Civil Engineering - meeting of EURO working group and 15th German-Lithuanian-Polish colloquium (ORSDCE 2015)

Technology Assessment in Construction Sector as a Strategy towards Sustainability

Lukasz Nazarko[a]*

[a]Bialystok University of Technology, Faculty of Management, ul. Wiejska 45A, 15-351 Bialystok, Poland

Abstract

The purpose of the article is to present and discuss the concept of Technology Assessment with a special focus on the construction sector and its relation to the notion of sustainability. Technology Assessment is seen in the scientific literature as a powerful strategy of generating the appropriate technologies necessary to achieve sustainable development. It provides information and knowledge on technical systems and their connections with the economic, social, political and environmental implications. Such knowledge is crucial in the evaluation of the existing and new technologies within decision support systems and policy intelligence processes. The paper proposes the principles, stages and methods of Technology Assessment applicable in the process of achieving the sustainability of the construction sector.

Peer-review under responsibility of the organizing committee of the Operational Research in Sustainable Development and Civil Engineering - meeting of EURO working group and 15th German-Lithuanian-Polish colloquium

Keywords: Technology Assessment, sustainability, construction sector

* Corresponding author. Tel.: +48 85 746 9821; fax: +48 85 6631988.
E-mail address: l.nazarko@pb.edu.pl

Peer-review under responsibility of the organizing committee of the Operational Research in Sustainable Development and Civil Engineering - meeting of EURO working group and 15th German-Lithuanian-Polish colloquium
doi:10.1016/j.proeng.2015.10.038

1. Introduction

Study of emerging technologies and the potential results of their implementation are of high importance to today's economies, societies and companies. Such studies are a basis for critical decisions regarding the R&D priorities, technological risk management, intellectual property management and competition strategies [19]. Various instruments and procedures have been developed over last decades to understand, anticipate and shape the future technological developments. It has been acknowledged that technology and society co-evolve. Inquiries into technological developments and their implications cannot be based on purely technical considerations but needs to adopt more complex perspectives [2]. Technology Assessment is an approach that follows the recommendation stated above. It can be defined as *a systematic attempt to foresee the consequences of introducing a particular technology in all spheres it is likely to interact with* [1].

With the accelerating pace of Earth's resources exploitation, growing global population, increasing energy needs and pervasive social inequalities, the idea of sustainability appears to be a major guiding concept for the long term development of the human civilisation. New technologies may be seen as a solution for achieving the *development that meets the needs of the present without compromising the ability of future generations to meet their own needs* [16] but also as phenomena that bring about new unknown threats to sustainable development.

Construction sector constitutes a significant segment of national economies all over the world, both in developed in and in the developing countries. For example, in 2013 it amounted to 5,7% of the European Union's gross value-added (not counting related production and services). At the same time, the built environment has implications for social interactions, culture creation and, last but not least, for the natural environment (resources consumption, air emissions, water consumption, land use, acidification, toxicity, waste creation, energy consumption being the major issues to consider). It is therefore no surprise that the construction industry is, or at least should be, increasing concerned with improving the social, economic and environmental indicators of sustainability [15]. In this paper an argument is made for a more extensive use of Technology Assessment in the construction sector as a strategy towards its sustainability.

2. Technology Assessment as an analytical form of Future-Oriented Technology Analysis

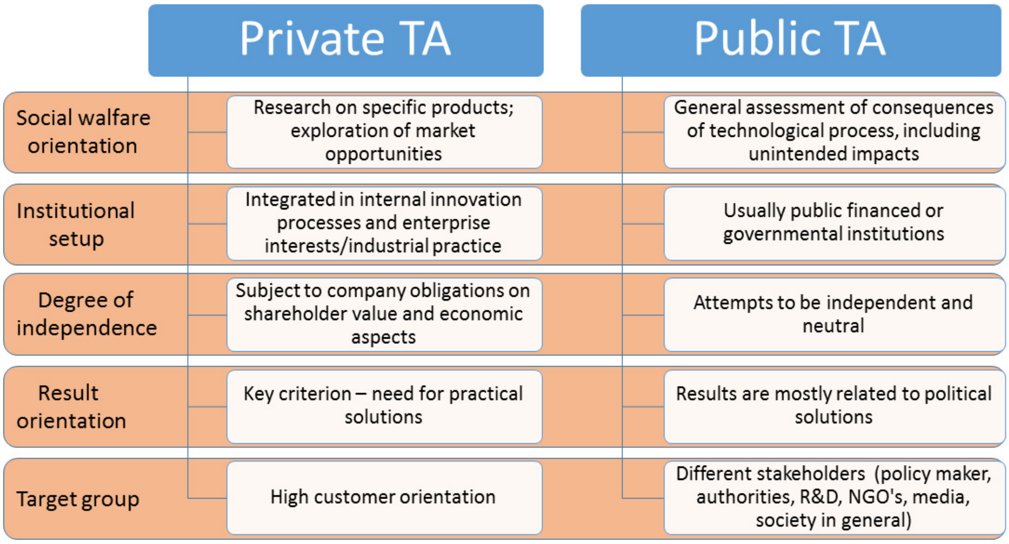
Technology assessment is a term that doesn't have a single, sharply defined meaning in the scientific literature. Most broadly, it may be understood as an evaluation of a technology according to given criteria [1]. It may be regarded as: (i) the examination of the properties of existing technology options or (ii) as the examination of the impact that an introduced or developed technology may have on society, environment and economy. The latter approach is consistent with the considerations presented in this paper. Technology Assessment (TA) is treated here as a specific analytical form of Future-Oriented Technology Analysis (FTA). FTA is an umbrella concept covering a broad range of technology-oriented "futuring" methods and practices that include technology forecasting, technology foresight and technology assessment (table 1) [2] [6]. In this context, the essence of TA is well captured in an enduring definition which states that TA is *the systematic study of the effects on society, that may occur when a technology is introduced, extended, or modified with emphasis on the impacts that are unintended, indirect, or delayed* [3]. It may be as well defined as *a scientific, interactive and communicative process which aims to contribute to the formation of public and political opinion on societal aspects of science and technology* [18].

Table 1. Technology Assessment as an analytical form of Future-Oriented Technology Analysis (FTA)

Future-Oriented Technology Analysis (FTA)	Technology forecasting	Attempt to predict the future characteristics of useful technological machines, procedures or techniques. It does not have to state how these characteristics will be achieved. [7]
	Technology foresight	Process which aims to build visions of the long-term future of science, technology, economy and society by identifying strategic areas of science and technology to ensure the maximum economic and social benefits [14]
	Technology Assessment	Examination of the impact that an introduced or developed technology may have on society, environment and economy.

The concept has its origins in the 60s in the US and is linked to the perceived need of the Congress to create its own information gathering service independent from the executive branch of the government as an aid to the democratic control of scientific and technological innovations. That resulted in the creation of the Office of Technology Assessment (OTA) of the US Congress in 1972. Similarly, on the other side of the Atlantic, Science and Technology Options Assessment (STOA) panel – a committee of European Parliament members – was inaugurated in 1987. In 1990 the European Parliamentary Technology Assessment (EPTA) - a network of technology assessment institutions advising the parliamentary bodies in European countries was established. Nowadays, we also encounter so called private TA i.e. initiatives carried out by private enterprises to assess different technology options. Differences between "private" and "public" TA are presented in figure 1.

Fig. 1. "Private" versus "Public" Technology Assessment

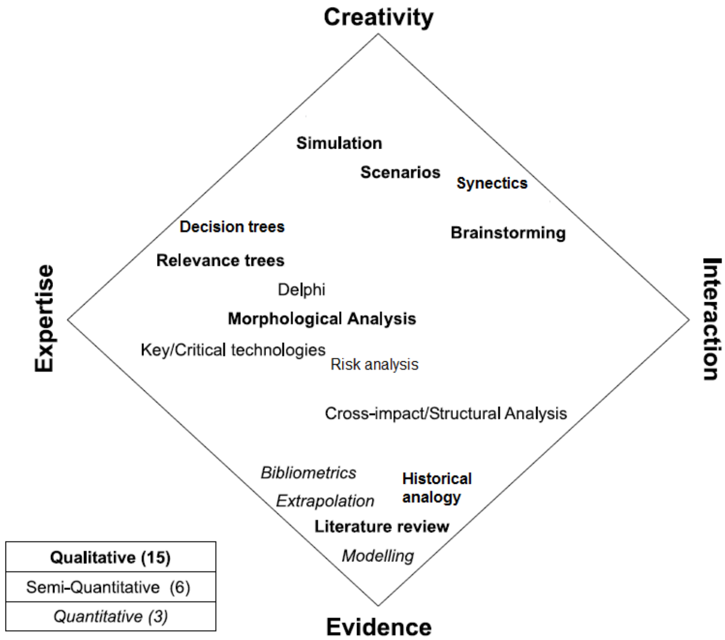


In view of the significant differences outlined in figure 1 a separate term should be– in author's view –assigned to private initiatives (for example "technology portfolio assessment"), whereas "proper" Technology Assessment should be a domain of public entities and its policy intelligence systems. Functions of public Technology Assessment may be defined as follows [20]:

- analysis of the state of an existing or emerging technology and its possibilities,
- estimation of the direct and indirect technical, economic, health, environmental, human, social and other consequences of a technology,
- evaluation of these consequences in light of the defined goals and values,
- recommendation of possibilities for action and design,
- facilitation of informed decision making by appropriate bodies.

There is no rigid formula as to how Technology Assessment should be performed and what methods should be applied. Each case must be considered separately taking into account the specific context, needs and resources available to conduct a study. Popular TA methods are presented in figure 2. They have been located inside a Popper's diamond [17] to indicated four key aspects of TA methods: creativity, evidence, expertise, interaction. Presented methods have also been divided into quantitative, qualitative and semi-quantitative.

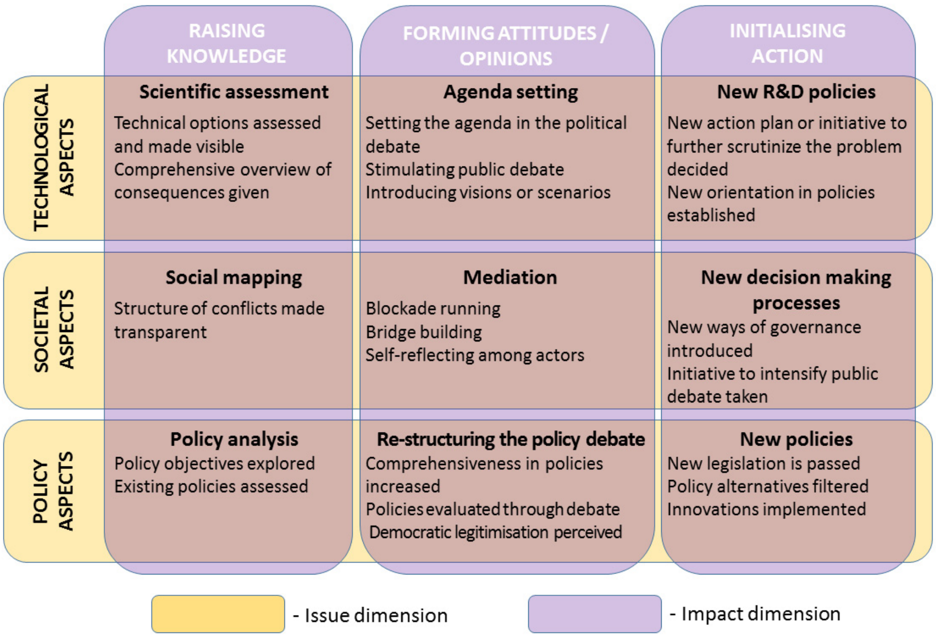
Fig. 2. Technology Assessment methods



Source: [8] [17]

Questions about the results and impact of Technology Assessment projects are of key importance as decision makers need to be convinced that it is worthwhile to publicly finance these kind of activities. Impact of TA is defined as any change with regard to the state of knowledge, opinions held and actions taken by relevant actors in the process of societal debate on technological issues [18]. A synthetic typology of TA impact is presented in figure 3.

Fig. 3. Impact of Technology Assessment



Source: [18]

3. Technology Assessment in the Construction Sector

Technology Assessment has been applied in various research areas. Survey of conduced TA initiatives in Europe and North America points at health technologies and ICT as the most popular technological fields. However, one may also find a number of TA projects related to construction. Material engineering (including nanotechnology), energy, IT systems, transportation and waste are among the construction-related topics under investigation in TA projects.

Taking into account the large variety and wide scope of technological issues linked to construction that could be studied in TA projects one may conclude that there is a relatively low number of construction-related TA initiatives. One of the reason for that may be the existence of alternative approaches that provide a framework for reflection on construction and sustainability. Brief comparison of existing approaches is presented in table 2. Approaches such as Environmental Impact Assessment, Environmental and Social Impact Assessment, Life cycle (sustainability) assessment, Strategic Environmental Assessment and Technology Assessment have been compared according to the object of study, entity performing/commissioning the study and the analytical focus with regards to sustainability. Following M.F. Jischa, environmental sustainability has been defined as *keeping within the limits of the ecosphere so that the natural basic conditions for life be maintained*. Social sustainability is understood as a *high degree of equal opportunity, freedom, justice, and safety*. Economic sustainability is viewed as *efficient allocation of limited goods and resources* [8].

Table 2. Different approaches to sustainability assessment in construction sector

Initiative type	Object of study	Performed or commissioned by	Takes into account:		
			Environmental Sustainability	**Social Sustainability**	**Economic Sustainability**
Environmental Impact Assessment	Construction projects	Investors, supervisory bodies, certification institutions	Yes	No	No
Environmental and Social Impact Assessment	Construction projects	Investors, supervisory bodies, certification institutions	Yes	Yes	Yes
Life cycle (sustainability) assessment	Construction projects	Investors, supervisory bodies, certification institutions	Yes	No	No
Strategic Environmental Assessment	plans, programmes and policies regarding land use and construction	public planning authorities, sometimes private bodies	Yes	Sometimes	Sometimes
Technology Assessment	technologies applied in construction	legislative and governing bodies as well as private bodies (companies)	Yes	Yes	Yes

One may notice from the above comparison that Technology Assessment possesses some unique features distinguishing it from other approaches. First of all it has a comprehensive understanding of sustainability while other approaches usually focus only on the environmental aspect. Secondly, it does not study construction projects (as it is typically the case with other approaches) but focuses specifically on technologies applied in construction. Thirdly, it is an approach especially suitable for legislative bodies and decision makers that deal with technological and innovation policy.

4. Conclusions

Identifying and understanding cause and effect relationships in complex, dynamic socio-technical systems is a tremendous challenge. It is obvious that Technology Assessment cannot describe the future with full certainty but it can, in author's opinion, reduce the uncertainty about the future when used strategically and systematically.

The task of TA is to view technology in its full context, with all its opportunities, possibilities and ramifications for the environment in which it is rooted [1]. It is not about a precise prediction but about spotting vectors of change that point at potential benefits and concerns related to a technological innovation. TA approach assumes that the unintended and undesirable consequences of technical developments may be neutralised or minimised only by technology itself [8].

When conducted with methodological rigour and democratic accountability, TA has the potential to enhance the roles of science, technology and innovation towards achieving cleaner environment, more efficient economy and more just societies [4]. It is a vehicle for exploring the plurality of alternative 'pathways to sustainability' [9] and for assuming collective responsibility for the impact of increasingly more complex technologies. Sustainability may be achieved thanks to the synergy between available technologies, strategies of innovation [12] [13] and the policies of governments [21]. Technology Assessment is a suitable framework to obtain this synergy.

Notice: The preparation of the paper was funded in the framework of the project „National Foresight Programme – Results Implementation", contract No DS-621/NPF/20111 from 5 November, 2011

References

[1] E. Braun, Technology in Context. Technology assessment for managers, Routledge, 1998.
[2] C. Cagnin and M. Keenan, Positioning Future-Oriented Technology Analysis, in: C. Cagnin, M. Keenan, R. Johnston, F. Scapolo, R. Barre (Eds.), Future-Oriented Technology Analysis, Springer, 2008, pp. 1-13.
[3] J.F. Coates, Technology Assessment – A Tool Kit, Chemtech 1976 (June), 372-383.
[4] A. Ely, P. Van Zwanenberg, A. Stirling, Broadening out and opening up technology assessment: Approachesto enhance international development, co-ordination anddemocratisation, Research Policy 43 (2014) 505-518. doi: 10.1016/j.respol.2013.09.004
[5] S. Gressler, A. Gazsó, Nano in the Construction Industry, NanoTrust-Dossier No. 032en, August 2012, http://epub.oeaw.ac.at/ita/nanotrust-dossiers/dossier032en.pdf (accessed; 31.08.2015)
[6] K. Halicka, P.A. Lombardi, Z. Styczynski, Future-oriented analysis of battery technologies, 2015 IEEE International Conference on Industrial Technology (ICIT), 1019 - 1024, doi: 10.1109/ICIT.2015.7125231
[7] C. Huang, C.Kuo, Y. Kao, H. Lu, P. Chiang, Forecasting the Internet of Things Market by Using the Grey Prediction Model Based Forecast Method, International Conference on Economic Management and Trade Cooperation (EMTC 2014). doi:10.2991/emtc-14.2014.57
[8] M.F. Jischa, Sustainable Development and Technology Assessment, Chemical Enigneering & Technology 21(8) (1998) 629-636. doi: 10.1002/(SICI)1521-4125(199808)21:8<629::AID-CEAT629>3.0.CO;2-Q
[9] M. Leach, I. Scoones, A. Stirling, Dynamic Sustainabilities: Technology, Environment, Social Justice, Routledge 2010.
[10] Les freins réglementaires a l'innovation en matière d'economies d'energie dans le bâtiment: le besoin d'une thérapie de choc, Office parlementaire d'evaluation des choix scientifiques et technologiques, Paris, 9 July 2014
[11] B. Ludwig, The concept of Technology Assessment - an entire process to sustainable development, Sustainable development, 5 (1997) 111-117.
[12] J. Nazarko, Kształtowanie polityki proinnowacyjnej regionu np. foresightu technologicznego «NT FOR Podlaskie 2020», Optimum. Studia Ekonomiczne 52(4) (2011) 241-251.
[13] J. Nazarko, N. Brzostowski, J. Ejdys, E. Glińska, A. Gudanowska, K. Halicka, A. Kononiuk, A. Kowalewska, E. Krawczyk-Dembicka, W. Łojkowski, Ł. Nazarko, W. Urban, J. Paszkowski, A. Pawluczuk, A. Skorek, Anna Wasiluk, Podlaska strategia rozwoju nanotechnologii do 2020 roku. Przełomowa wizja regionu, Oficyna Wydawnicza Politechniki Białostockiej 2013
[14] L. Nazarko, Istota foresightu i jego percepcja w Polsce, Optimum. Studia Ekonomiczne 52(4) (2011) 224-234.
[15] O. Ortiz, F. Castells, G. Sonnemann, Sustainability in the construction industry: A review of recent developments based on LCA, Construction and Building Materials 23 (2009): 28–39. doi: 10.1016/j.conbuildmat.2007.11.012
[16] Our Common Future. Report of the World Commission on Environment and Development, Doc. No. A/42/427, United Nations, 4 August 1987
[17] R. Popper, How are foresight methods selected?, Foresight, 10(6) (2008) 62-89. doi: 10.1108/14636680810918586
[18] Technology Assessment in Europe. Between Method and Impact, Final report of the TAMI project (2002-2003), https://www.ta-swiss.ch/methodik/tami/ (accessed: 31.08.2015)
[19] Technology Futures Working Group, Technology futures analysis: Toward integration of the field and new methods, Technological Forecasting & Social Change 71 (2004) 287-303.
[20] VDI-Richtlinie 3780: Technikbewertung - Begriffe und Grundlagen, Beuth, Berlin 1991.
[21] F.A. Vollenbroek, Sustainable development and the challenge of innovation, Journal of Cleaner Production 10(3) (2002):215–23. doi: 10.1016/S0959-6526(01)00048-8