Technology Performance Assessment for Office buildings – A Case Experience from A Knowledge Transfer Partnership Project

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Abstract

The Information and Communication Technology Systems Infrastructure (ICTSI) for commercial buildings in the UK lacks a robust framework for measurement. A taxonomy of characteristics and their key performance measures of ICTSI were developed for an 'availability' report. This report was market tested, developed further, and reviewed again through a stakeholder focus group. The results indicate that the framework is a viable means for standardising an approach to measuring ICTSI requirements in commercial buildings.

Keywords: Technology Performance, surveying, Key Performance Indicators (KPIs)

1. Introduction

Technological performance is a broad term used in this paper to indicate the fulfilment of a claim measured against known standards for ‘science’ based systems within buildings and their infrastructure. Primary ‘science’ based systems in buildings are information and communications products, information, and services. For example, information communication technology (ICT) and the supporting systems infrastructure include computer software, networks, and hardware. ICT also includes products and systems related to wireless, fibre optic and mobile signals (Consoli, 2012; European Commission, 2009; Hashim, 2015; Sin Tan et al., 2009). Further, ICT sets within a wider context, incorporating regulatory and standardized framework and financial environments for their management and use. Buildings provide ICT systems infrastructure that enable organisations to align their need for ICT systems with the provision of ICT systems. The ICT, organisations and buildings are part of a sociotechnical system (Baxter & Sommerville, 2011; Davis, Challenger, Jayewardene, & Clegg, 2014; Leonardi, 2012), in this instance a broad example of a technical system needed to fulfil an organisational function in use (Davis et al., 2014; Geels, 2004; Leonardi, Nardi, & Kallinikos, 2012). However, the classification, taxonomy, and performance of the ICT systems infrastructure in buildings is less well developed, (Davis et al., 2014). A business development project has been funded to develop a broad framework to characterise the ICT systems infrastructure to address this gap in our existing understanding.

This project considered three business development opportunities based on creating a framework for assessing technology performance in commercial buildings within the UK. The first opportunity is the lack of a profiling taxonomy for ICT systems infrastructure. Developing a taxonomy will provide a data framework for the ICT systems infrastructure of a building based on current standards, both technical and market orientated - see an heating, ventilation, and air conditioning (HVAC) example in Marjanovic-Halburd, Korolija, and Hanby (2008). The second opportunity is a source of information for property professionals that enables a standard description of ICT systems infrastructure provision. The real estate industry has a known challenge with asymmetrical information (Garmaise & Moskowitz, 2003; Levitt & Syverson, 2008). This project will provide a standardised framework for ICT systems infrastructure information. The third opportunity is the relevance of this information to the end user. There are a number of aspects to this position. For example, businesses need detailed information to optimise technology investment and subsequent operating costs (T. Lützkendorf, Fan, & Lorenz, 2011; Thomas Lützkendorf & Lorenz, 2006). The level of investment in technology systems is driven not only by business growth strategy planning and availability of capital, but also by the level of technology provisions that exists in the building. In addition, the dynamic nature of ICT driven organisational change is not acknowledged in the facility management literature suggesting longer term issues with aligning changing business demands to existing technology supply (Drew, 2006; Kim, Son, Kim, & Kim, 2015; Mateus, Neiva, Bragança, Mendonça, & Macieira, 2013). The development of a clear, market orientated technical performance framework provides the users and their organisation with an indication of how a building might meet their needs. This paper provides an interim stage report on progress to date in developing a standardised framework for modelling, collecting and analysing ICT systems infrastructures within commercial buildings in the UK.

2. Taxonomy Development for Technology Systems in Buildings

The commercial building is the unit of analysis for developing the taxonomy for this project. The existing commercial building stock is the principle focus as new builds represent only 1-2% of the total stock (per annum) in the UK (Axon, Bright, Dixon, Janda, and Kolokotroni (2012). In addition, for most businesses the quality and demand for commercial buildings have to be accommodated by existing stock (Kincaid, 2003). The initial review of the technical literature provided a number of broad ICT categories and associated performance metrics. However, the gap between an existing commercial building's technology potential and the level or provision required to support business's ICT strategies requires the inclusion of the entire systems infrastructure for that building. For example, most ICT provisions require some type of electrical supply to enable its use. Similarly, heating, ventilation, and air-conditioning are normally required to support the server requirements in terms of heat output. Table 1 below indicates the eleven technology categories that were developed as a basis of this conceptual position. These categories are expanded into four levels of related categories. The categories for levels 1 and 2 are presented in Table 1. For example, ICT Systems have four Level two categories – 1] fibre optic, 2] Wi-Fi, 3] mobile, and 4] telephony. What these categories are responding to is a recognition that the demand for building-related provisioning information differs between the various groups of stakeholders. As mentioned in the discussion of opportunities there are a variety of stakeholders in this process. For example, office space suppliers and estate agents will have increased interest in highly aggregated and easily communicable assessment measures. This affords them competitive advantage through information asymmetries (Levitt & Syverson, 2008). An existing example of a building connectivity assessment tool is WiredScore (2017). In addition, there are conflicting perspectives of what constitutes readiness (ready-to-lease and ready-to-provision occupant/business needs). The taxonomy seeks to address these stakeholder perspectives in order to provide useful information on the ICT systems infrastructure.

Tab. 1: Levels 1 and 2 of the building technology key performance indicators

Level 1	**Level 2**
ICT Systems	fibre optic; Wi-Fi; mobile; telephony
Electrical Power	incoming electric supply, small power
Lighting systems	internal lights; external lights; safety lights
Safety and security	fire safety; building security
Fuel	gas; district scheme; renewables
Heating	primary system; distribution system
Ventilation	natural; mechanical
Air Conditioning	individual units; central ac systems
Water	potable; brown; grey
Spaces and amenities	use class; staircases; toilet provision; floor space; server room; telecommunication room.
Vertical transportation systems	lifts; escalators
Future Technology	

The assessment approach focuses on ICT, telecommunication room, server room and cabinets, electrical power supply for both the building and the occupant's space. The detail for the ICT taxonomy is shown in Table 2.

Tab. 2: ICT systems Levels 2 and 3 categories

Level 2	**Supply and distribution elements**	**Level 3**
Fibre Optic	*Supply System*	provider (cost & contract); capacity; readiness; lead-time; bandwidth external chamber; conduits (depth, slop, material, pathway); intake; fibre distribution
	Distribution System	fibre termination; data cabling; desk-top termination
Wi-Fi	*Supply System*	APs provider/vendor; capacity (cost & contract); readiness
	Distribution System	APs location, cabling, power, coverage, security, congestion
Mobile (2G, 3G,4G,5G)	*Supply System*	provider (cost & contract); capacity; readiness; data; minutes; download speed; upload speed; congestion testing; partitions

	Distribution System	Signal strength; partitions; signal booster; handset; mobile device management, blind spot testing
Telephony	*Supply System*	provider (cost &contact); capacity; readiness
	Distribution System	-Over copper network (mains frame; copper distribution; copper termination; cabling; desk-top termination). -Over VoIP service (cabling and equipment)

One key element indicated in Table 2 is the split between identifying the supply systems and the distribution system within a building. This concept is illustrated in Figure 1 below. Technology provision for the supply is defined at the street or building level. For example, the property either has the connection to the street level optical fibre supply or not. This makes this measure binary. The key construct reported by these measures is that of availability. These measures answer the question: What supply elements of the technology systems are available? The existing distribution systems are then measured within the building as a second element of the availability position. These measures seek the answer the question: What distribution elements of the technology systems are available?

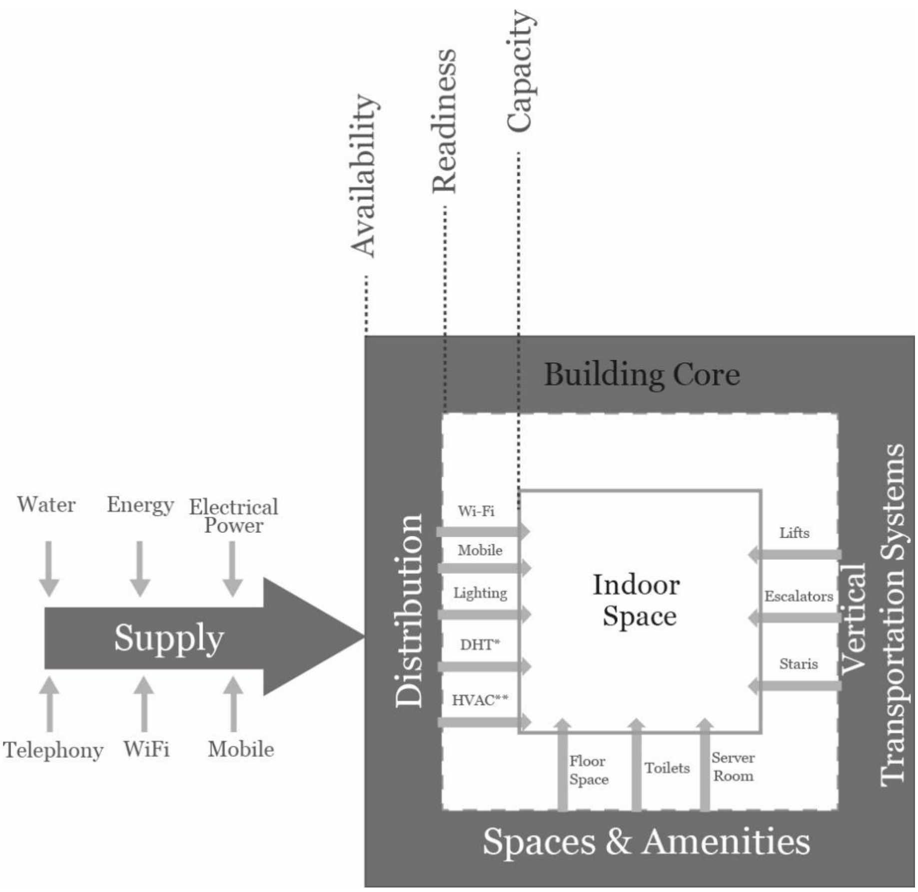

Fig. 1: The relationship between the technology supply and distribution and capacity (*DHT indicates domestic hot water, **HVAC includes heating, ventilation, and Air conditioning)

Figure 1 highlights the issue of technological provision ownership or the level of control different stakeholders has over different technological provisions. A stakeholder can be defined as “any groups or individuals who can affect, or is affected by the achievement of objectives or purpose” (Diamond & Liddle, 2005, p.79). A stakeholder can be categorised as a supply and/or demand actor (Brugha & Varvasovszky, 2000; Carmona, De Magalhães, & Edwards, 2002), and can take a primary and/or a secondary role in any process (Friedman & Miles, 2006; Garvare & Johansson, 2010; Jones, Wicks, & Freeman, 2002). For the purpose of this research, we have defined the main stakeholders influencing technological provision in a building as:

- tenants (building users),
- property owners and
- external stakeholders which include Local Authorities (LA) or municipalities and utility companies including Wi-Fi, mobile and telephony in addition to energy suppliers and water/sewage companies.

The areas of control for different stakeholders against technology provisions, which is not necessarily one-to-one function, is presented in Figure 2. For example, although building users consume electrical energy for lighting and can at least to some extent control lighting levels, the power supply to a building is fully controlled by utility company whilst the positioning and security of power connection is within building’s owner’s control too.

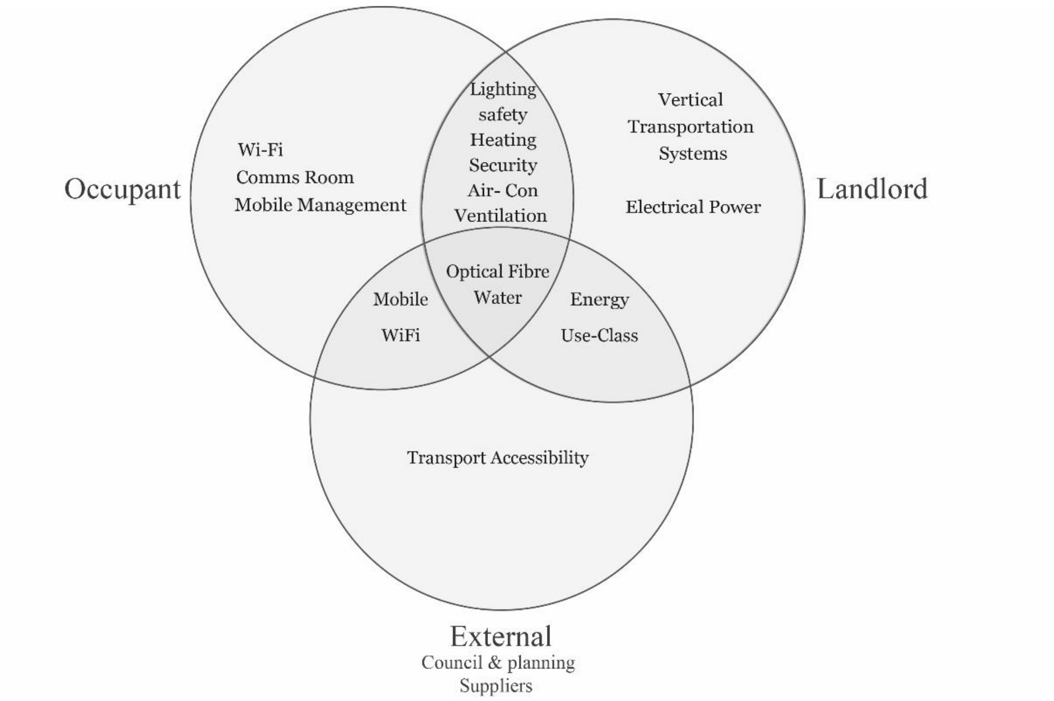

Fig. 2: Stakeholders boundaries over technology KPIs

The provision of vertical transportation system is on the other hand is controlled by the building owner (the building will be both designed and built with that provision or not). The use class of the building is in the control of relevant planning authority or local authority/municipality and whilst the owner can apply for the change of use class, the ultimate decision is with the planning department. On a separate spectrum, how the internal space will be used is under the control of tenant(s) based on the lease agreement. For example, based in their business needs, the tenant's might decide to use higher speed optical fibre or a wireless service (if a wireless network service is available as defined in availability assessment). Furthermore, the use of telephony, mobile and local Wi-Fi provision is also under the tenant's control. Even if these technologies are distributed at the building level, the tenant might decide not to use them for their business purposes. In addition, user demands are changing across all of these systems. Building users have higher standards for baseline aspects of utilities operation, management and control; such as safety and security, lighting, heating, ventilation, air conditioning, water, vertical transportation systems (Mansfield & Pinder, 2008; Pinder & Price, 2005; Pinder, Price, Wilkinson, & Demack, 2003).

The resulting framework is the basis for an Availability Assessment Report for the ICT systems infrastructure in a commercial building. This report is the basis for a standardised set of metrics that allow providers and users to have a better understanding of the availability of ICT systems infrastructure within a commercial building. This small step will then enable a second report on the readiness and capacity of these systems to support organisation's activities.

3. Action based research design

The project is best described as an action based research design. This approach enabled the commercial nature of the project to be fully realised. In addition, the project is underpinned by incorporating appropriate theoretical constructs, relevant statutory requirements, and guidance from relevant professional organisation such as Chartered Institute of Building Service Engineers (CIBSE) and Royal Institute of Chartered Surveyors (RICS) and established building assessment approaches (sustainable buildings assessment methodologies, ICT adaptation strategies, and building quality assessments). As a business-driven performance framework the project has to combine different research approaches: market research techniques (Mager, 2008; Nunan & Di Domenico, 2013; Sarstedt & Mooi, 2014); building assessment tools methodologies (Fraunhofer, 2012; Gann, Salter, & Whyte, 2003; Ness, Urbel-Piirsalu, Anderberg, & Olsson, 2007); and stakeholder analysis techniques (Friedman & Miles, 2006; Jensen, 2010; Lorne & Dilling, 2012; T. Lützkendorf et al., 2011; Verbeke & Tung, 2013). To achieve this, overall methodology was broken into three stages as presented in Figure 3 below.

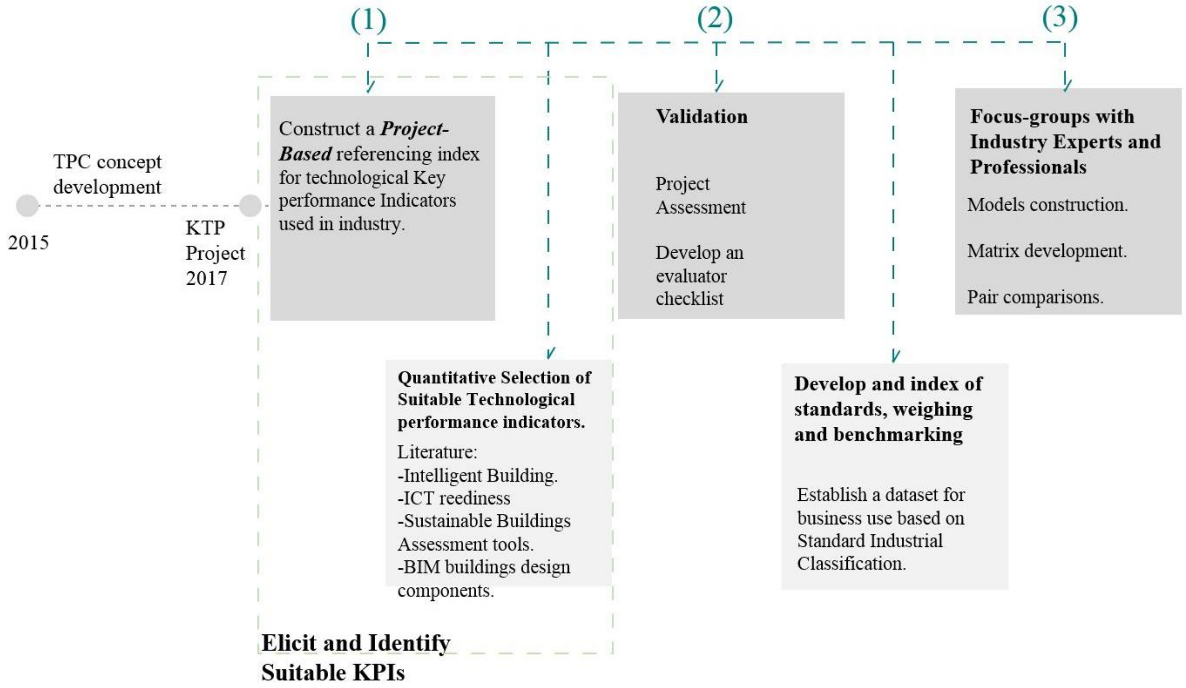

Fig. 3: Project framework development process

The first stage is discussed in the section on taxonomy development. This forms the basis for the framework for the availability report. This report framework is the basis for eight case studies used in the second stage. The second stage established a validation process using a case study approach that includes site assessments, client communication and in-house desktop studies. This stage provided market feedback that enabled the project team to test and refine the general conceptual model. Eight case studies were used to validate and refine the assessment framework (assessed between March and June 2017). The context of these case studies is illustrated in Table 3.

Tab. 3: Case-studies context

Number of floors	Floor(s) assessed	Total floor area (m2)	Net lettable Area assessed (m2)
9	Part of the fifth floor	5400	400
2	Ground and first floor	230	230
2	Ground floor	1000	500
3	Ground floor	1245	1166

2	Ground and first floor	100	100
2	First Floor	150	75
2	Ground and first floor	500	500
2	Ground and first floor	600	300

The third stage is a focus-group discussion with market professionals and clients. The aims of focus-group was to:

- confirm the building technology framework and measures
- validate the assessment approach, and
- comment on the reporting information

The participants were asked to compare the pre-project reports with the revised report based on 8 of the 11 measures developed for the project. This report was produced in an availability assessment format. The participants were asked to rank the usefulness of the elements. Each element was scored in a scale from 0 to 9. With 0 represents if the information provided is ‘not at all useful’ and 9 ‘Extremely Useful’.

4. Focus Group results

The availability assessment approach was tested during the first Knowledge Transfer partnership (KTP) project focus group organised at 30/06/2017. In total, 8 representatives from RICS, CIBSE FM, building wayleave lawyer and clients contributed the discussion and review of the availability report. The assessment results were presented as a report with information that are used to identify risks and how to transform these risks, i.e. (1) if evidence of supply is not recorded (2) if an office space infrastructure has limited capacity to facilitate technology distribution. Thus, three classifications were presented to show the identified level of technology as an indicator of confidence in the follow up technology readiness and capacity assessments – high (Management only), medium (Install and management) and low (Design, install and management). An example assessment result visualization is presented in Figure 4.

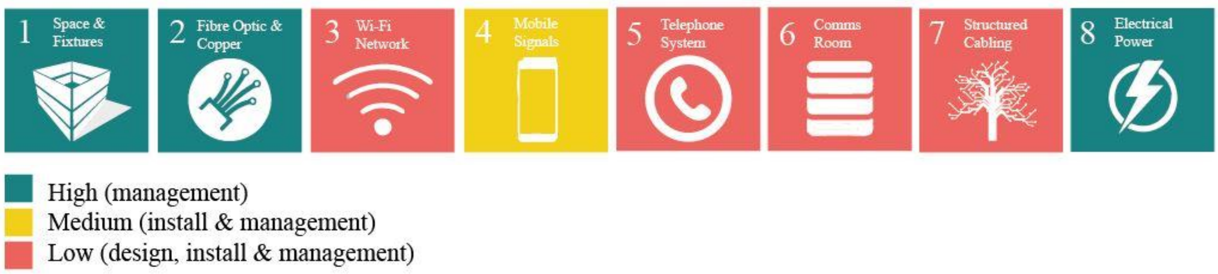

Fig. 4: An example of an availability survey results visualizing

At this stage, eight technology elements assessment protocols and benchmarks were presented. These are space; fibre optic and copper connectivity; Wi-Fi networks; mobile signal; telephony system; telecommunication room; structural cabling; and electrical power.
The results are presented in Figure 5.

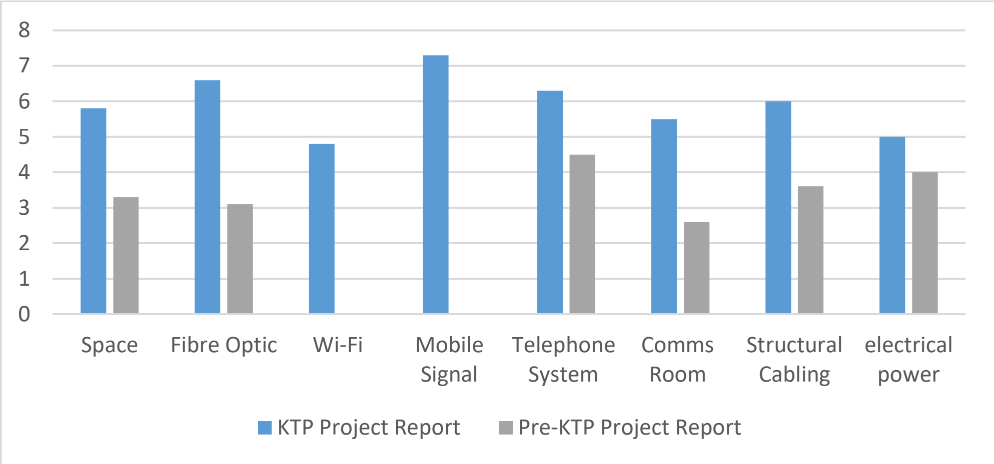

Fig. 5: The focus-group comparative feedback of the usefulness of the pre-KTP and KTP Availability Assessment Reports.

The discussion highlighted how building technology is defined differently between clients and experts. Further, how associated assessment information can be presented as an instrument to support provisioning decision-making. Thus, clear distinction must be drawn between how each technology element assessment method is integrated within the assessment tool quantifiable results, i.e. how mobile signal availability benchmarks are related to the elements with more physical presence in the building infrastructure. Examination of the relationships between these measures is necessary in order to avoid misunderstanding.

5. Conclusion

This paper presents the results of the development of a taxonomy for measuring ICT systems infrastructure within existing commercial buildings in the UK. The initial measures are presented in an availability report as a commercial offering. This report and associated measures seeks to standardise the approach to the market and users' understanding of ICT systems infrastructure provision. The results of the focus group suggests that Availability Assessment Report is a viable format for integrating landlord, occupant and wider stakeholders' views on

ICT systems infrastructure measures. One of the anticipated benefits of this framework is to assist all stakeholders in minimising the risk of investing in technology provisioning and addressing building infrastructure obsolescence. The formwork also creates opportunities for novel representation of information on technology performance that can be integrated in database management system. Further papers will present the comparative quality and merits of a buildings' technical infrastructure to inform investment and/or occupation.

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