Integration of HVAC Value Chains across Eight Competitive Arenas for Better Wellbeing Indoors

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SUMMARY

The aim is to advance HVAC businesses, procurement, and marketing. The Porterian concept is applied to integrating HVAC value chains. The logic of HVAC focused, 8-arena competition is as follows. Arena 1 (of wellbeing indoors): occupants exploit HVAC systems. Arena 2: owners compete with buildings. Arena 3: providers offer services for managing high HVAC system life-cycle performance. Arena 4: investors compete by realizing (renewing) new (old) buildings. Arena 5: wholes contractors and CM consultants compete in realizing buildings as wholes. Arena 6: HVAC engineers compete with solutions and HVAC contractors with systems. Arenas 7/8: HVAC products/materials suppliers and traders compete with (in)direct deliveries. The integration of HVAC value chains is in its infancy in most countries. HVAC inputs procurers (and outputs marketers) are encouraged to set challenging procurement (marketing) objectives and to attain them by adopting the three logics. Cross-national research is called for to conceptualize and to test the espoused logics further.

INTRODUCTION

Two interrelated questions are herein addressed as follows: “How to replace the current ineffective rules of separated or multi-phased competition in building markets? and “How to pioneer some new more effective ways of integrating all HVAC knowledge and value chains for producing better innovative solutions for the wellbeing of occupants indoors?” It is posited that these questions and the related replies are highly relevant as part of advancing HVAC solutions and practices as well as the life-cycle management of new buildings and building stocks as a whole in various (inter)national contexts at least at three levels as follows.

At the broadest level of (inter)national practices, building markets are facing with constant challenges, that being the separation of designs and construction works culturally, contractually, and technically. Emerging integration efforts are influenced by political, economic, social, and cultural concerns. These efforts become highly significant when supported by governmental stakeholders [1].

At the level of buildings, many new concepts of sustainable and green buildings, spaces, or workplaces are being co-planned and adopted. In the exemplary context of Canada, there is a growing momentum in both the public and private sectors for more sustainable approaches to buildings. This momentum arises from the need to reduce raw materials, water, and energy use as well as waste and greenhouse gas output. However, even more important than mitigating these negative impacts is the potential of amplifying the positive impacts of occupant satisfaction and performance. The life-cycle benefits of sustainable construction appear to considerably outweigh their 2-7 % higher first costs. However, there are several
impediments to implementation that are slowing the adoption rates. These impediments include (i) changing the ways of implementing buildings, (ii) adopting sustainability and still meeting each owner’s needs and cost requirements, (iii) removing the resistance of stakeholders to change, (iv) eliciting action, support, and involvement by all participants in supply chains, and (v) reducing the lack of relevant skills and knowledge. In order to meet these impediments, one of the essential principles is the use of fully integrated teams who consider all aspects of buildings from cradle to grave [2]. In the context of the USA, more and more workplaces that are distributed, connected, adaptable, flexible, serviced, enabled, and move seamlessly between space and cyberspace are not only the source of future competitive advantage; such workplaces may now be a matter of company, business, and organizational survival [3].

At the level of HVAC solutions and systems, the first integrated HVAC value chains are readily playing decisive roles in meeting energy efficiency and first cost objectives on high performance green building projects across national building markets. The well thought-out networks of interrelated processes are being designed to satisfy the needs of building owners and users. However, there are still many disabling structural features that must be overcome such as extreme specialization within functionally stove-piped organizations and industry fragmentation, optimized to meet each individual participant’s performance objectives but far from optimal from the perspective of integrated HVAC value chains, not to talk about building value chains as a whole (applying [4]).

Herein, the aim is to advance core strategic thinking in HVAC business management as well as in related competition, procurement, and marketing by re-defining the three existing logics and applying them to integrating HVAC value chains across many competitive arenas. For advancing the wellbeing of occupants indoors, the sub-aims are as follows: (1) To introduce the logic of HVAC related competition as eight arenas, (2) to introduce the two logics of HVAC related procurement and marketing in terms of principal routes connecting the eight arenas, and (3) to suggest a set of principles for integrating HVAC value chains and solutions across arenas, and (4) to discuss some key implications of such integration for both practitioners and scholars.

METHOD

The nature of this paper is that of applying one of the authors’ recent Porterian concepts [5], [6] on competition in construction to defining and explaining some new ways of integrating HVAC value chains as part of building markets. Briefly, the original rationale involved the (self-)critical evaluation of the related literature as follows. Within the strategic management literature, Porter’s [7] five forces framework offers a generic frame of reference for any firm who aims at attaining repeatedly its marketing goals. This framework applies to all high-tech, low-tech, and service businesses, including global and local building and HVAC related businesses. Indeed, Ofori [8] recalls several construction-related applications such as Yates et al.’s [9] analysis of the US construction industry and Betts and Ofori’s [10] framework for strategic planning in construction enterprises. Over time, the structures, advancement, and applicability of Porter’s frameworks have been criticized in both generic (e.g. [11]) and construction-related (e.g. [12]) terms.

Since the year 1994, Kiiras and Huovinen have applied the same Porter’s framework to the various contexts such as a spearhead strategy for entering a new construction market in Europe [13]. Nevertheless, it was concluded that the six aforementioned references had
produced only the fairly applicable concepts for practitioners by the mid-2000s. Thus, these two authors engaged themselves in designing three recent concepts or logics [5], [6].

RESULTS

The three logics of arena-based competition, procurement, and marketing are re-defined in the context of HVAC markets. This is followed by the new applications for integrating HVAC value chains when such integrators inside the upstream Arenas 1-5 involve users, owners, investors, wholes contractors, and wholes CM consultants, respectively, and when pioneering integrators inside the downstream Arenas 6-7 involve the focal HVAC systems engineers and contractors as well as products and materials suppliers and traders.

Three logics of 8-arena competition, procurement, and marketing in HVAC markets

The logic of HVAC focused competition as part of any building market is herein defined in a form of eight interrelated Porterian arenas. In Arena 1 of wellbeing indoors, users occupy the stocks of buildings and exploit the HVAC systems that enable to perform their purposes in business, public, and private life. In Arena 2, owners compete with their building stocks including HVAC systems on a long-term basis. In Arena 3, providers offer their services for managing the high HVAC system performance over the life-cycles (L-Cs) as part of building stocks. In Arena 4, capital investors compete through investing in the realization of new buildings and the renewal of the existing ones including HVAC systems. In Arena 5, wholes contractors and CM consultants compete through the realizations of new and to-be-renovated buildings as wholes including HVAC systems. In Arena 6, HVAC engineers compete with their solutions and HVAC contractors with their (sub)systems when buildings are realized as parts. In Arena 7, HVAC products suppliers and traders compete with their (in)direct deliveries. In Arena 8, HVAC materials suppliers and traders compete with their deliveries as well.

Table 1. Logic of 8-arena competition in HVAC markets (applying [5], [6], and [7]).

<table>
<thead>
<tr>
<th>No</th>
<th>Competitive arena</th>
<th>Incumbents and entrants</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wellbeing of occupants using HVAC systems</td>
<td>Owner users and tenants</td>
</tr>
<tr>
<td>2</td>
<td>Ownership and trading of buildings incl. HVAC systems</td>
<td>Owners + traders</td>
</tr>
<tr>
<td>3</td>
<td>Life-cycle services for HVAC systems in buildings</td>
<td>L-C services providers</td>
</tr>
<tr>
<td>4</td>
<td>Investing in and trading of buildings incl. HVAC systems</td>
<td>Investors and traders</td>
</tr>
<tr>
<td>5</td>
<td>Realization of buildings as wholes incl. HVAC systems</td>
<td>Contractors + CM consultants</td>
</tr>
<tr>
<td>6</td>
<td>Realization of buildings as parts such as HVAC systems</td>
<td>Engineers + contractors</td>
</tr>
<tr>
<td>7</td>
<td>Supply and trading of HVAC products</td>
<td>Suppliers + traders</td>
</tr>
<tr>
<td>8</td>
<td>Supply and trading of HVAC materials</td>
<td>Suppliers + traders</td>
</tr>
</tbody>
</table>

The logic of the route-based procurement of HVAC inputs from downstream arenas is defined in terms of those procurement routes that couple the eight competitive arenas and the ones that enable sub-procurement inside any given arena. Focal procurers have one or more routes to pull together more or less integrated HVAC value chains across markets, businesses, downstream arenas, and projects. It is axiomatic that each particular procurement route, which any procurer chooses, determines the nature and rules of competition in the next downstream arena(s).
The logic of the route-based marketing of HVAC outputs to upstream arenas is defined in terms of those marketing routes that couple the eight arenas and the ones that enable a marketer to win deals also inside its base arena. Each route is coupled with a particular kind of buying behavior of clients or procurers. It is axiomatic that each marketing route, which any client/procurer in the chain prefers or accepts, determines the rules of competition in the next downstream arena(s). Focal marketers have one or more routes for connecting their base arena to one or more targeted upstream arenas or for enabling their marketing inside the base arena. Each HVAC related firm occupies the two principal roles of a marketer and a procurer in its primary competitive arena (or its base arena). As a marketer it interacts via various routes with targeted clients in upstream arena(s). As a procurer it acquires specified inputs via various routes from inside the same arena and from one or more downstream arenas.

Integration of HVAC value chains as part of buildings in base Arenas 1-2 and 4-5

The integration of HVAC value chains as part of value adding building related processes in the base Arenas 1-2 and 4-5 is illustrated in Figure 1. In Arena 1 of building uses and wellbeing occupation, many advanced owner users and most attractive tenants aim readily at being extremely well indoors inside pioneering high-performing green buildings, workplaces, and spaces across the globe. On the one hand, they desire to manage well the environmental impacts in terms of reducing energy consumption, emissions, electricity use, water use, solid waste, wood and materials use, and land exploitation (e.g. [14]). On the other hand, future workplaces are ecosystems comprising a careful balance of people, processes, and places. The focus is shifting from places to people: supporting their performance, satisfaction, and wellbeing in indoor climates. By analyzing work people do and then creating the right combinations of spaces, processes, and tools to support it, workplace management enables to increase both effectiveness and efficiency as well as to accelerate cultural/organizational change (applying [15]).

In Arena 2 of building stock ownership and trading, many advanced long-term owners and traders aim readily at cultivating their building stocks toward high-performing green buildings. In the OECD countries, people spend the bulk of their time indoors. Indoor climate has a direct impact on their health and productivity at work. Typically, personnel’s salaries form the dominant shares of the life-cycle costs of office buildings (e.g. [16]). By improving indoor climate conditions, the wellbeing and productivity of personnel can be enhanced markedly. Therein, the energy efficiency of HVAC systems and the limited need for maintenance add to the profitability of indoor climate investments. In addition, the Internet convergence requires a new approach to designing the spaces in which principal processes are conducted, from stores to offices to factories to classrooms. This requires a new kind of convergent architecture including HVAC systems (e.g. [17]).

In Arena 4 of capital investing, many advanced short-term investors (along long-term owner investors) aim readily at enabling their pioneering clients to stay on the cutting edge in their core businesses or public services by maximizing the total productivity of their buildings, workplaces, spaces, and special rooms. Handing-risk-out investors rely on wholes contractors with their integrated value chains or nets. Instead, carrying-risk-themselves investors rely on wholes CM consultants with their core competences in integrating even unique, complex building systems and system-specific value chains. For example, integrating energy efficiency throughout building design processes will yield significant first cost savings. Capital and operating cost impacts are considered in tandem in order to realize maximum value from
HVAC based facility improvements. Efficiency is also associated with healthier and higher quality work environments, especially regarding the use of outside make-up air. In addition, the pre-diagnosis of HVAC solutions as part of the life-cycle engineering of buildings enables the early identification of maintenance problems, safety issues, and premature equipment failures (aligning with [18]).

**In Arena 5 of realizing buildings as wholes**, many contractors and CM consultants aim at enhancing their core competences to higher levels where they can assume those integrative roles of pulling together value chains or nets. At the same time, many of them may become the providers of life-cycle services vis-a-vis targeted owners and their building stocks. In Finland, special system contracting is being developed to advance the adoption of extended building contracts with the detailed design and engineering, manufacturing, delivery, and installation of various building systems (e.g. HVAC systems), modules (e.g. clean rooms), and functional elements (e.g. wellbeing in a high-level indoor climate) [19].

![Figure 1. Eight basic routes for (a) procuring HVAC inputs from downstream arenas and (b) marketing HVAC outputs to upstream arenas within any given building market.](image-url)

**Integration of HVAC value chains by systems engineers across Arenas 3 and 6-8**

**In Arena 6 of HVAC systems realized as parts in buildings**, pioneering independent HVAC systems engineers can aim at (i) integrating their engineering-based HVAC value chains in terms of the most advanced and evolving HVAC solutions, expertise, and core E&D competences, (ii) developing such chains internally and acquiring them externally in a form of (inter)national mergers, acquisitions, licensing, and collaboration, (iii) enlarging the scopes of their services to include also an array of HVAC systems life-cycle services, and/or (iv) becoming the HVAC knowledge-based members of the most competitive building-level value chains led by some of globally, internationally, regionally, or nationally leading wholes contractors. Engineering-based HVAC value chains can market their integrated solutions and competences via **four connecting marketing routes** to (a) wholes contractors and CM consultants in the upstream Arena 5 and/or (b) capital investors in the Arena 4. In addition,
such integrated engineers can market their HVAC systems life-cycle services to building owners in Arena 2 and/or responsible users in Arena 1. These four marketing routes are shaded in Figure 2.

In particular, it seems that integrated HVAC engineers can attack many pervasive problems such as the systematic over-sizing of utility systems and the resulting oversized cooling equipment caused by overestimating first electrical demands thereby creating the fictitious sources of heat within a facility. This is compounded by the aggregate impact of multiple disciplines (owners, process engineers, electrical engineers, HVAC engineers, etc.) each adding “safety factors” to their calculations. The result is also higher operating cost due to excessive and inefficient on-off cycling and/or part-load operation. For example, a combination of high-performance glazing, low-pressure-drop HVAC design, and efficient right-sized lighting systems results in major reductions of the mechanical and cooling system sizes. Smaller duct sizes even allow to lower overall building heights for significant construction cost savings. This reduces the sizing of generators, resulting in additional first-cost savings. Ideally, above-standards performing buildings enable substantial savings in annual operating HVAC cost (applying [18]).

In part, engineering-based HVAC value chains can be virtualized, i.e. they may establish collaborative one-stop virtual engineering services such as the COVES project in Singapore. With the help of collaborative platforms and virtual communities, collaborative HVAC engineers might target to offer and to integrate services for heat ventilation and air-conditioning, fire and smoke, pollutant dispersion, and indoor air quality. Virtuality is being enhanced via e-modeling, e-analyses, e-simulations, and e-visualizations [20].

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**Figure 2.** Systems engineers and contractors integrating HVAC value chains across Arena 3 and Arenas 6-8.
Integration of HVAC value chains by systems contractors across Arenas 3 and 6-8

In Arena 6 of HVAC systems realized as parts in buildings, pioneering HVAC systems contractors can aim at (i) integrating their contracting-based HVAC value chains in terms of the most advanced HVAC technologies, systems, products, and materials as well as core system management competences, (ii) developing such chains internally as well as acquiring and procuring them externally in a form of (inter)national mergers, acquisitions, licensing, partnering, networking, and/or competitive bidding (vis-à-vis key contractors, suppliers, and traders), (iii) enlarging the scopes of their services to include also an array of HVAC systems life-cycle services, and/or (iv) becoming the HVAC system-based members of the most competitive building-level value chain led by some of globally, internationally, regionally, or nationally leading wholes contractors. Contracting-based HVAC value chains can market their integrated solutions and competences via four connecting marketing routes to (a) wholes contractors and CM consultants in the upstream Arena 5 and/or (b) capital investors in the Arena 4. In addition, such integrated contractors can market their HVAC systems life-cycle services to building owners in Arena 2 and/or responsible users in Arena 1 (Figure 2).

The integration of HVAC systems targets opportunities in terms of integrating better the pieces of equipment, systems, or facilities. High variations in the equipment efficiency (e.g. cleanroom fan-filter units) can be minimized. Challenges and opportunities extend beyond swapping in and out HVAC products/components. It is not enough for pumps to be efficient. Indeed, even small improvements that enable and enhance high system integration can yield large benefits. In turn, building automation and control systems enable system-level energy savings opportunities. For example, variable-speed fans need to run at full speed less than 10 hours per month. Buildings with more advanced ventilation control systems are more resistant to chemical and biological attacks. The use of outside air improves the overall air quality [18].

DISCUSSION

This is a theoretical paper where the application of three logics of 8-arena competition, procurement, and marketing to the context of HVAC markets is initially supported with the selected exemplary references on the empirical status in some national contexts. Nevertheless, it is herein posited that the integration management of HVAC value chains is still in its infancy. Across most national practices, stakeholders are still focused on achieving partial, in-house process performance improvements. Overall, many pioneering owners, investors, wholes contractors and CM consultants as well as HVAC systems engineers and contractors have shifted to a view outside in their value chains including both first-tier and higher-tier stakeholders along upstream and downstream arenas. However, only a few efforts are spanning the entire length of any one value chain, not to talk about the life-cycles of HVAC systems embedded in building stocks and those of inherent HVAC systems (aligning with [4]). Readily, many existing barriers have been identified and the first progressive paths toward best practices are being outlined (e.g. [18]).

In turn, pioneering HVAC inputs procurers (outputs marketers) are hereby encouraged to set more advanced procurement (marketing) objectives and also attain them by (i) adopting the three logics, (ii) identifying the incumbents and their procurement (marketing) routes connecting the base arena with the targeted downstream (upstream) ones, (iii) anticipating changes in the focal arenas, entrants, and routes, (iv) deducing non-existing procurement (marketing) routes and/or inventing the new ones, and (v) (re)designing their procurement (marketing) strategies accordingly. Admittedly, the real usefulness of the espoused
applications of three logics to integrating HVAC value chains needs to be tested, for example, in the context of building and HVAC markets in Finland and some other EU countries in the near future. Thus, collaborative cross-national research is called for in order to reveal the most advanced benchmarks for advancing best integrative practices internationally. In addition, the three HVAC focused logics may be conceptualized in more detail, arena by arena, by rolling the focus over upon each of stakeholders forming the targeted HVAC value chains.

REFERENCES