The Plant: industrial symbiosis as a business incubation model for sustainable urban agriculture

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Abstract
Around the world, urban communities are confronting issues of how to feed expanding populations without further taxing their energy, water, waste and transportation infrastructures. For temperate cities, where growing cycles are limited to the warmer months, indoor farming offers an option of utilizing buildings as growing spaces to enable year-round, local food production. While indoor farming can reduce the use of water, fertilizers and pesticides, it requires large amounts of energy for lighting and climate control and can generate significant amounts of organic waste. Thus, the material and energy flow must be effectively coordinated in order to realize the potential environmental benefits while maintaining economic viability. Industrial Symbiosis (IS) presents a unique model for business incubation based on 'filling ecosystem niches' as well as offers opportunities to recirculate and conserve materials and energy among diverse businesses. In this study, we analyze how the industrial symbiosis approach is being used as a model for business incubation in an urban agricultural context, using a case study from Chicago, Illinois, USA.

Background
Since the early 1990s, the industrial ecosystem in Kalundborg, Denmark has inspired advocates around the world to plan and implement by-product synergies between pairs of industrial facilities and as well as across larger eco-industrial networks (Ehrenfeld and Chertow 2002). Industrial symbiosis as a strategy for regional economic development suggests that utilizing place-based resources and existing businesses as anchors for attracting new businesses could strengthen the economic diversity and stability of regions, while reducing system-wide environmental burdens (Gibbs *et al* 2005). However, most of the eco-industrial parks proposed in the late 1990s and early 2000s in the United States failed to launch or were realized with significantly different goals than industrial symbiosis (Chertow 2007). While there are numerous reasons why these efforts were not successful, a lack of market tested synergies, critical mass of participants and enabling policies have been highlighted. For industrial symbiosis business models to be effective, they must present a compelling value proposition and enable those engaging in the synergies to create and capture value from their activities (Short *et al* 2014). In addition, as the impetus for many urban agriculture initiatives is socioeconomic improvement, their social impact must be evaluated in addition to the economic viability and environmental performance. Figure 1 demonstrates the logic of business models for social impact.

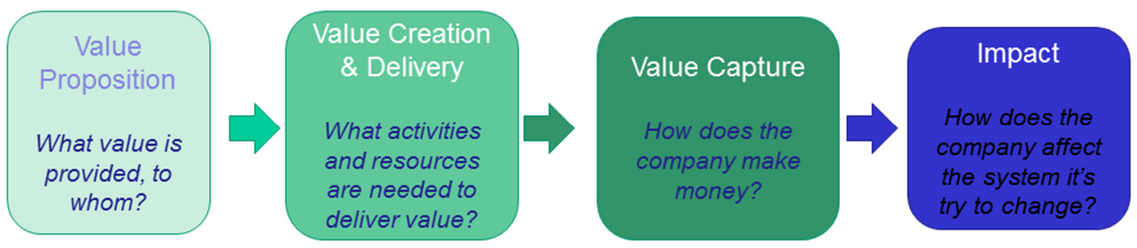

Figure 1: Business Models for Social Impact

Research Objectives
The aim of this study is to **explore how an industrial symbiosis approach could be utilized to incubate food and agriculture businesses and close material and energy loops in an indoor farming environment**. We utilize a case study methodology to examine how these principles are being put into practice at a single study site - 'The Plant' in Chicago, Illinois, USA. There are two key research questions

1. How effective is the system developing closed loops and what savings (energy, materials, costs) do they provide to individual tenants and the building on the whole? Are the savings advantageous over other indoor farms or traditional "big agriculture"?
2. How effective is the Plant's strategy for recruiting and incubating new businesses, what benefits are being provided and are they greater than traditional business incubators?

Case Study
'The Plant' is an industrial building on Chicago's economically distressed South Side that is owned and operated by a social enterprise that aims to host a net-zero energy food business incubator in the facility. The facility began development in 2010 in a vacant, former meat packing plant when the owner, John Edel of Bubbly Dynamics, made a conscious decision to repurpose the existing infrastructure through deconstruction, recycling of materials and renovation in line with its historic use as a food production facility. While Bubbly Dynamics is a for-profit enterprise, its sister organization, Plant Chicago, is a not-for-profit organization aimed at promoting "closed loop models" of urban agriculture through demonstration farms and educational programming (The Plant, 2015). Fundamental to its design is the use of organic waste from on-site and off-site businesses to generate all of its own energy using anaerobic digestion, as well as by-product synergies among tenants. At the core of the agricultural production are several aquaponics enterprises that symbiotically grow fish and leafy green crops. Agricultural and food enterprises are recruited in order to fit together like an industrial ecosystem, including a mushroom grower, a kombucha tea producer and a bakery. To achieve its social mission, the Plant hosts facility tours for educational groups and the public, as well as a farmers' market that features products grown or made on site. Another significant social impact is that the staff has worked with lawmakers to change local ordinances that govern agriculture within city limits, such as to allow livestock production through aquaponics.

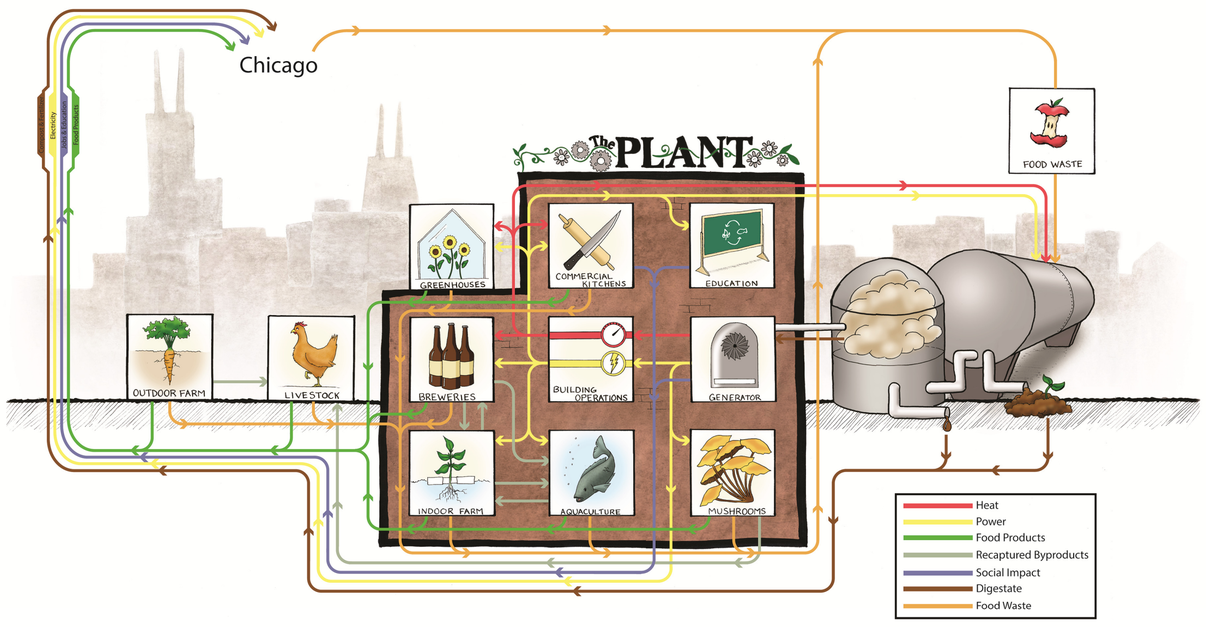

Figure 2: Industrial Symbiosis at The Plant

Results
Material and Energy Flows and Closed Loops: The monthly material and energy input and output flows are detailed in Figure 3. Very little material ends up in landfills, with the majority of materials not reused on site going to recycling or composting. When the anaerobic digesters and onsite generators become operational in 2017, they will provide 360,600 KWh of electricity per month; 97,500kWh will be consumed on site and the rest will be sold to the power grid.

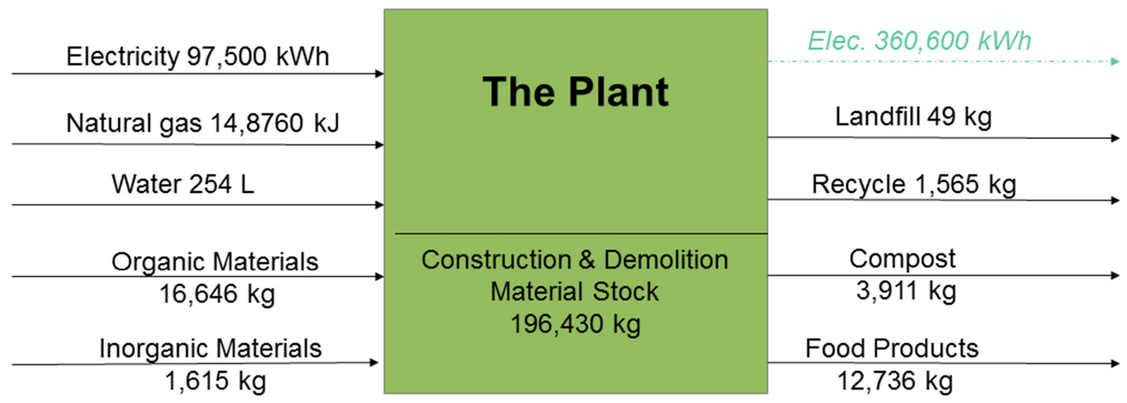

Figure 3: Monthly Material and Energy Input and Output Flows

Business Incubation: The Plant's current tenants include ten for-profit businesses and one not-for-profit organization. Two more for-profit enterprises are expected to begin operations later in 2015, and another two in 2016. Of these businesses, only two, Bubbly Dynamics, which owns the building, and the Great American Cheese Collection, existed prior to the Plant, meaning that the majority of tenants are start-up enterprises. Six of these have persisted for more than three years. A few businesses that were started in the facility have either left or are no longer operating. The current entities employ 44.5 full time equivalent persons. Tenants are offered a value proposition that includes low cost rent and electricity, symbiotic resources and a community that shares their experiences and works together to solve shared problems (see Figure 4). The Plant has been successful in attracting many volunteers and like-minded business people to its facilities, who have created a vibrant community for local food sustainability.

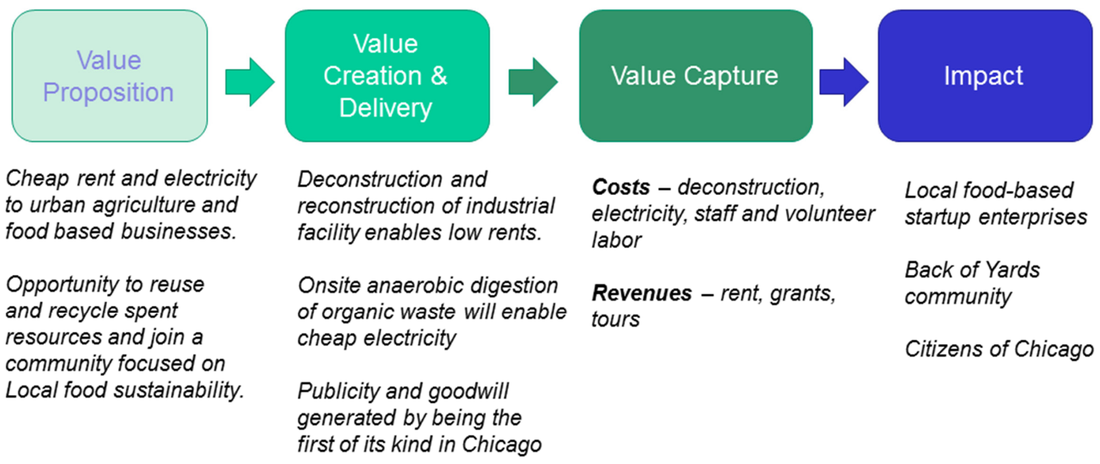

Figure 4: The Plant's Value Proposition for Social Impact

Discussion & Conclusions
The Plant presents a case of a business incubation model using industrial symbiosis that appears to be building slowly and gaining the momentum that was lacking in many of the earlier US EIPs. It is far from a proven, successful case of industrial symbiosis and business incubation, however, as it has a short track record and adequate data for analysis. The facility has received a lot of public and media attention during its first five years of existence, and it utilized several grants to initiate ground breaking projects. It is now at a point where it is able to systematically collect and analyze data in order to benchmark its activities and measure its economic, social and environmental impacts. We hope to continue monitoring this very interesting case and develop and test indicators for its performance and sustainability, with broader applicability to industrial symbiosis as a model for incubating sustainable businesses.

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