Investing in Opportunities
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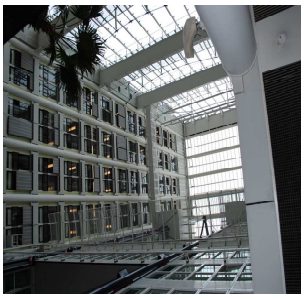
INTERREG IVB

ResilieNtWEB
Innovate for a sustainable business

INTEGRATED INDOOR FARMING PLANNING TOOLBOX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INTRODUCTION

Integrated Indoor Farms, referred to here as *Building-Integrated Greenhouses* (abbr. BIG.), include a diverse variety of structures, from industrial farming facilities to multifunctional living & working places. BIG are gaining in popularity due to their flexibility and due to new demands for interior urban green space and reliable organic sources of locally produced food. As well, new BIG technologies provide value-added services like cleaning air, purifying water emissions, and re-using waste heat.

However BIG are not new. For centuries they were integrated as winter gardens and atria in buildings to extend growing seasons by capturing light in winter and providing shade in summers. BIG are an improvement on a time-honoured approach.

PURPOSE AND AUDIENCE

The EU ResilieNtWEB programme as well as the *Région Bruxelles-Capitale* (RBC) expressed a strong interest in supporting integrated indoor farming. The Toolbox can be used by them and their experts to support stakeholders in early planning of value-propositions for integrated indoor farms. The main audience for the Toolbox is experts advising stakeholders, but well-informed individuals who want to do it themselves can also use it.

Because urban indoor farms have many options and value propositions it is important to know financial parameters & stakeholder preferences before selecting technologies.

The Toolbox is for inventorying & planning those parameters because planning is where most important decisions are made and most mistakes can be avoided. For more technically-oriented information on indoor farms see Annex B *Further Reading*.

CONTEXT OF BIG FOR BUILDINGS

BIG can be applied to diverse building types including schools, factories, office buildings, hospitals and large area developments.

BIG are also part of the new trend towards healthy buildings. There is no broadly accepted definition for a healthy building, but in other publications it is described as;

> *A structure that generates added value by using materials safe for human contact and the environment, actively improving air, water and soil quality, generating and using renewable energy, and providing comfortable, safe, enjoyable and inspirational space for living and working.*[1]

Neither is there a broadly accepted definition for BIG but here is one example;

> *A defined enclosed space that adds quality and value to buildings by using renewable energy to recycle water and nutrients, purify air, improve lighting, produce agricultural products, enhance and protect occupants' experience, and provide educational, promotional and economic opportunities for stakeholders.*

WHERE TO USE INNOVATION TOOLS

Table 1 shows where the Tools described in this booklet fit into the building development process. The main purpose of the Table is to show where innovative approaches can be adapted to the traditional planning and building process.

[1] For the broader perspective on healthy buildings refer to Mulhall, D., Braungart, M. & Hansen, K. 2013. *Guide to Planning Cradle to Cradle-Inspired Value in Building Developments,* Rotterdam School of Management.

TABLE 1

WHERE TO USE *BIG* PLANNING TOOLS IN THE BUILDING DEVELOPMENT PROCESS

BIG TOOL / BUILDING STAGE	IDENTIFY STAKEHOLDERS, THEIR GOALS & ORGANISATIONAL CULTURE See p. 4	QUICKSCAN FINANCIAL RESOURCES See Table 2	IDENTIFY POTENTIAL VALUE-ADDED SERVICES See Table 3	COMPARE POTENTIAL VALUE-ADDED SERVICES TO STAKEHOLDER GOALS	IDENTIFY GROWING METHODS, PARTNERS, STRUCTURE See Table 3	IDENTIFY POTENTIAL QUICK WINS See p. 19	ALIGN EXPECTATIONS WITH REALITY See p. 19	FINALISE BIG FEATURES Highlight preferred features in Table 3	ROADMAP TIMETABLE Use priorities from Table 3
CONCEPTUAL & FINANCIAL PLANNING	✓	✓	✓	✓	✓	✓	✓		
SITE DEFINITION & CONCEPTUAL DESIGN	✓	✓			✓	✓	✓		✓
MUNICIPAL & REGULATORY APPROVALS	Municipalities are often stakeholders to be consulted				Municipal conditions influence technical choices		✓	✓	
TECHNICAL DESIGN								✓	✓
PROCUREMENT					Use for specifications	Re-evaluate after tenders received		Re-evaluate after tenders received	
CONSTRUCTION									
OPERATIONS								Evaluate during operations	✓

LEARN WHAT STAKEHOLDERS WANT !

The best results are produced when Stakeholders determine what they want instead of being told what they want. Advisors can support Stakeholders in setting their goals but in the end the Stakeholders decide.

Sometimes Stakeholders don't know exactly their goals but have a general concept of what they want. Other times they focus on a narrow technical goal.

The challenge for advisors is to support stakeholders to clarify their goals. The following steps are designed to support advisors in that role;

PRIORITIES FOR ADVISORS TO START

- *Identify the Stakeholders*. For examples see Annex A, reproduced from the earlier referenced publication *How to Build a Big Beneficial Footprint*.
- *Identify potential value-added services*. See Table 3 for examples.
- *Identify Stakeholder expectations and perspective* on e.g. their own customers, environmental and social questions.
- *Identify if Stakeholders have measurable goals* for generating added value, or have just general ideas.
- *Identify added value of BIG which fit Stakeholder goals but which Stakeholders might not know about.*

  For example;

  - The owner wants to maximize returns by maximizing floor space, but has not yet considered other ways to do it e.g. putting BIG on unused roofs generate revenues from the same space.
  - The employees' representative wants good working conditions but has not considered the benefits of greenhouses and vegetation for the working environment.
  - The Corporate Social Responsibility department might want a transparent process for involving Stakeholders but is not aware of Roadmaps as a way of improving transparency.

Learn Stakeholders' Culture and Business

Einstein said; *facts are facts but perception is reality !* In most cases the perception of the owner plays a central role in defining Goals.

By answering these questions the advisor can learn how innovative or conservative to be and which parts of the customer's business can be used with BIG ;

- *Is the customer a frontrunner or conservative?*
- *Is the customer proactive or reacting to outside pressure for changes e.g. new regulations or public pressure?*
- *Does the customer encourage input from outsiders or rely more on its own designers?*
- *Might part of the owner's business be applied to the building construction or operations? E.g. monitoring, materials, management systems?*

QUICKSCAN RESOURCES & VALUE PROPOSITIONS

The Quickscan is a type of rapid assessment of potential strengths, weaknesses, opportunities and threats (SWOT).

The Quickscan relies on experience of the customer and experts to quickly scan available resources and value propositions to arrive at the best available information without the time and expense of a full-blown assessment.

☐ SCAN POTENTIAL VALUE PROPOSITIONS BEYOND TRADITIONAL SUSTAINABILITY

Traditional sustainability assessments call for a Life Cycle Assessment (LCA) to determine environmental impacts. However LCA is expensive and time-consuming and focuses on minimizing negative impacts like water and materials use, emissions to the air, and energy use.

BIG Quickscans take another approach by evaluating how to *maximizing positive impacts* to add value. BIG focus on healthy water and materials, healthy emissions, and accelerating renewable energy use.

Challenges
One potential barrier to a BIG positive assessment is in large organizations the sustainability department might be confused by the positive benefits approach because they focus on reducing things, and on regulatory compliance.

In those cases you can position added value as a "next step" to improve on what is already being done, and describe how BIG can support them to meet regulatory requirements.

☐ INVESTIGATE FINANCING PARAMETERS

To develop effective goals and value propositions, identify financial parameters described in Table 2.

One important question for the advisor to ask from Stakeholders; Do they expect the BIG to pay for itself only in hard financial results, or is it also possible to generate benefits from "soft" values?

Frequently soft values such as for example improving the customer experience in a retail store, are just as important to the stakeholder as hard values such as energy savings from using natural lighting. In this context, the distinction between soft and hard financial values becomes important.

QUICKSCANNING VALUE PROPOSITIONS

Value propositions for BIG include value for Economy, Ecology and Social Equity.

Table 2 & Table 3 describe value propositions to select from.

Table 2 describes financial factors important for supporting BIG.

Table 3 is used to identify and prioritise value propositions, as well as develop a roadmap for implementation.

TABLE 2 INTEGRATED INDOOR FARMING FINANCIAL INVENTORY

FINANCIAL MECHANISM	INFORMATION TO INVENTORY	VALUE-ADDED POTENTIAL
IDENTIFY ECONOMIC GOALS OF STAKEHOLDERS	Economic stake of each Stakeholder. Include greenhouse operator and the municipality who give zoning approvals.	Use to determine how value propositions might support financial Goals of Stakeholders.
IDENTIFY ZONING INCENTIVES & RESTRICTIONS	Incentives or restrictions by local zoning for different types of BIG e.g. rooftops or ground level.	Identify economic incentives or restrictions.
FEASIBILITY OF INTEGRATING CAPITAL COSTS & OPERATING COSTS	Is *Total Cost of Ownership financing* (TCO) possible? Identify if the Design-Build-Finance-Maintain-Operate framework (DBFMO) will be used. Identify which stakeholders benefit from TCO and which might not.	Determine if TCO can be used to optimize operating costs & capital costs together, e.g. investing in BIG features that generate operational savings. Try defining common financial optimization goals.
OWNER OCCUPANCY POTENTIAL	Will owners be users or operators, or just rent the facility to operators ?	Identify if owner as occupant has a self-interest in using BIG to make the building healthier.
IDENTIFY OWNER INTENTIONS FOR KEEPING THE BUILDING	Do the owners plan to keep the building where the BIG is located for a long time or sell it quickly?	(a) Recovering materials from demolishing can be part of the value proposition. (b) Integrating capital and operating costs.
POTENTIAL LIGHTING MODEL	Lighting is a big cost in many greenhouses. Can natural lighting be integrated with artificial lighting ? Can lighting be leased from providers?	Operating savings from light leasing & integrating natural and artificial light. Identify opportunities for computerized modulation of natural & artificial light.

FINANCIAL MECHANISM	INFORMATION TO INVENTORY	VALUE-ADDED POTENTIAL
RENEWABLE ENERGY TECHNOLOGIES FOR HEATING AND/OR COOLING	Are PV, Geothermal, Co-generation considered in the building and can they be integrated with BIG?	Integrating renewable systems with BIG e.g. PV-integrated glass to improve payback times.
CAPITAL & OPERATING COSTS FOR ENERGY PURCHASE AND GENERATION	Are energy Power Purchase Agreements (PPA) used in the region? If not, why not? Are third party PPA's used? Are cladding substitutions or residual value of materials included in payback calculations?	Determine if PPA can be used to save capital costs or generate revenues from BIG, and if third party PPA partners might be available.
BUILDING LEASE STRUCTURE	Who holds the lease on the building and for how long? Is the lease on the building separate from the lease on the greenhouse ?	Determine if the building payback time is integrated with or separated from the BIG. Important for BIG operator.
WHO PAYS UTILITY COSTS	Do the occupants pay for energy and water?	Determine who benefits from water and energy recycling, savings & revenues.
DESCRIBE WATER INFRASTRUCTURE	Which authority is responsible for irrigation, drinking water, and wastewater infrastructure?	Determine who can gain from recycling water, e.g. local water agency, owner, occupants?
INNOVATION FINANCE	Are grant funds or subsidies available for innovation to let you focus on innovations?	Accelerate innovation while cutting development costs.

TABLE 3

SELECTING FEATURES FOR BUILDING-INTEGRATED GREENHOUSES

HOW TO USE THIS TABLE

Because they are integrated with diverse types of buildings and have diverse stakeholders, BIG have many optional features and value propositions so it is important to systematically approach them.

Table 3 provides a systematic overview to let you choose value propositions, stakeholders, types of structures and growing methods. Results of the example used here are shown in Table 3a.

It is important for the **main stakeholder** to complete the Table rather than the advisor. In this way you can be sure the stakeholders are making the decisions instead of the advisor just guessing what they want.

1. *Start by selecting value-added services so you know what you want from the facility.*

2. *For value-added services identify which priority you want for each selected service. See guidance notes at the end of Table 3a for how to prioritise the information.*

3. *After completing the selections use the results to work with stakeholders to start financial calculations and site planning. See Table 3a as an example.*

Identify preferred features by NUMBERING, CHECKING OR SHADING each cell in the right column. It will give you a quick visualisation of the features so they can be extracted and put into your Roadmap.

The shading and scoring in Table 3 & 3a is a fictitious example but based on a combined event facility/greenhouse facility.

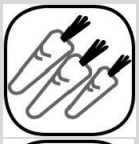
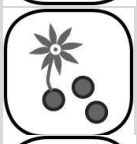
TABLE 3	SELECTING FEATURES FOR BUILDING-INTEGRATED GREENHOUSES	
CATEGORY	**FEATURE OPTIONS**	**PRIORITY**[i] 0, 1, 2, 3 or check
	**CROPS FOR FOOD OR FEED** Are the crops intended to feed building occupants, other customers, or be sold on the market? Is there added value to having the production source close to consumption so consumers of the food see added value from knowing where their food comes from ? First learn your intended markets, then investigate which types of crops to grow. **Timeframe;** Begin planning immediately for start of operations. Focus on finding a greenhouse management company with experience integrating the players.	2
	**CROPS FOR FEEDSTOCK FOR PRODUCTS** If producing feedstock is being considered, identify a potential customer and bring them into the process early. Timeframe; Consider one year after start of operations.	0
	**SEEDLING PRODUCTION** Growing seedlings or preserving certain species of seeds might be a value proposition. Timeframe; Begin investigations immediately for potential start of operations.	1
	**MAXIMISE EARNINGS FROM CROPS, E.G. HIGHEST TURNOVER AT LOWEST COSTS** The challenge is to identify a greenhouse management company with experience to make this type of high productivity production cost-effective.	3
	**SAVINGS ON SPOILAGE & LOGISTICS COSTS BEING CLOSE TO PROCESSING OR MARKETS** If your consumption market is right next to the BIG then your spoilage losses from transport will be minimal and this can improve profits.	3
	**AGRICULTURAL PRODUCTS QUALITY IMPROVEMENT COMPARED TO OPEN FIELD.** Crops are less prone to damage than in open fields, adding to productivity.	1
	**TOPSOIL MANUFACTURING VIA E.G. COMPOSTING, OR TOPSOIL PRESERVATION VIA SOIL-LESS AGRICULTURE.** Investigate if organic residue sources nearby can be used to generate topsoil for the BIG.	0
	**NUTRIENT RECYCLING VIA PHOSPHATE & FERTILISER RECOVERY** Recycling of nutrients from food residues will be done via composting ? On site vs. offsite composting has to be decided. Recycling of nutrients from effluent from irrigation is desirable. Timeframe; research into optimal composting & irrigation effluent options to begin immediately. Probably does not affect structural design although piping retrofit might be more expensive later.	0

TABLE 3	SELECTING FEATURES FOR BUILDING-INTEGRATED GREENHOUSES	
CATEGORY	**FEATURE OPTIONS**	**PRIORITY**[i] 0, 1, 2, 3 or check
	**RE-USE EMISSIONS AS NUTRIENTS (E.G. CO_2 FOR PLANTS)** ***Added Value*** BIG can profitably use building emissions like CO_2 & water to supply safe fresh food and flowers for cafeterias, restaurants and shops, and save transport costs and emissions. They can provide valuable biodiverse habitat e.g. for pollinating insects. ***Challenge;*** Check local regulations for reusing emissions from buildings ***Timeframe;*** Investigations can start immediately.	**3**
	**WATER QUALITY IMPROVEMENT OR REUSE** ***Added Value*** BIG can capture and reuse rainwater and greywater to save water costs and reduce stress on storm water systems. In some cases this can generate financial savings for stakeholders such as building owners by reducing water fees and for sewage system operators by reducing inputs. ***Challenges*** Operations personnel might see bionutrient systems as a wildcard. It is important to show working examples of systems. If a facility generates a constant flow of greywater, the potential for reuse is good. If only occasional events are held at the facility it will require a buffering capacity. **Timeframe;** immediate investigation	3
	**DESIGNING FOR RECOVERY OF COMPONENTS & MATERIALS** It is a priority to do a financial assessment of the potential added value to the owner of designing for recovery of materials. Greenhouses traditionally are designed for deconstruction. Components to be considered for disassembly and recovery are the frame, the glass, and the mechanical/electrical systems including e.g. lighting. Light leasing might be an important component of the approach to save capital costs. Timeframe. It is recommended a full analysis be done as soon as possible on potential DfD advantages and risks.	2
	**PROTECTION FROM PESTS** Greenhouses provide a protected environment which is less vulnerable to invasive species as well as from harmful insects, animals and biological damage. Check your local area to see which pests are problematic and how BIG can protect against them.	**2**
	**BIODIVERSITY ENHANCEMENT, BIOTIC BALANCING** Organic urban farming will enhance local diversity and is a priority advantage of BIG. **Timeframe**; Start investigations now and implement in first phase of operations.	2
	IMPROVED AIR QUALITY INCLUDING CONDITIONING, PARTICULATE REMOVAL, HUMIDIFICATION CONTROL	2

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CATEGORY	**FEATURE OPTIONS**	**PRIORITY**[i] 0, 1, 2, 3 or check
	Certain species of plants such as moss are custom-designed for air cleaning and the question is if e.g. Xeroflor C2C certified moss products which metabolise pollutants can be used for purifying the air during events. Air-cleaning plants might be grown in a separate section of the BIG from other plants. E.g. at the inlet and outlets. **Timeframe;** Early priority to determine the impacts on air-handling system designs	
	**POLLUTION BUFFER (INCL. FROM ACID RAIN, PARTICULATES AND AIR POLLUTANTS)** The greenhouse structure protects crops and occupants from particulate pollution which is moderate to serious in many urban regions. It is a major benefit for occupants suffering from allergies or asthma. Protection from pests is also a standard benefit of most greenhouses. **Timeframe;** Start early to determine importance of noise buffering to the main stakeholder before designing for noise buffering.	2
	**NOISE BUFFER (INSIDE-OUT AND OUTSIDE-IN)** BIG provide an effective noise buffer inwards and outwards. The main question to answer is the importance of noise buffering on each site? Timeframe; Start early to determine importance of noise buffering to the main stakeholder before designing for noise buffering.	2
	**IMPROVE PRODUCTIVITY OR WELL-BEING OF OCCUPANTS** ***Added value*** CO_2 and other interior emissions as well as exterior pollutants have negative effects on performance of occupants. BIG can counteract these effects by using emissions as nutrients for plants. BIG can also improve performance by establishing a buffer zone that reduces chronic noise and pollution from the exterior. ***Challenges*** (a) Stakeholders are often not aware their own CO_2 and other emissions are poisoning them and instead attribute tiredness in meetings to other factors. Solution. Educate the customer with data and examples like the Desso clean air school in Waalwijk, The Netherlands. (b) CO_2 reuse might be a regulatory problem in some regions. Check ! (c) Capture might be impractical because concentrations are not high enough to capture effectively or the building systems cannot feed it into the BIG. ***Solution.*** Careful technical assessment **SUPPORTING WELL-BEING** ***Added Value*** BIG are inspirational, enjoyable and comfortable places to learn and work! Healthy buildings prevent, capture and metabolize polluting particulates that cause lung and	**1**

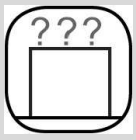
TABLE 3	SELECTING FEATURES FOR BUILDING-INTEGRATED GREENHOUSES	
CATEGORY	**FEATURE OPTIONS**	**PRIORITY**[i] 0, 1, 2, 3 or check
	heart disease, as well as providing skin-safe and lung-safe materials for occupants. BIG can also protect occupants from chronic external noise. ***Challenges*** Stakeholders are often not aware of particulates risks. (See also further reading "Years of life lost in EEA countries due to PM2.5 pollution, 2005"). Solution. Educate the customer with convincing examples like the Desso clean air school in Waalwijk, The Netherlands.	
	**ENHANCE AESTHETICS & IMPROVE CUSTOMER EXPERIENCE** ***Added Value*** In customer-intensive operations like stores, a competitive edge is often gained by improving customer experience in the store. BIG can achieve this e.g. improve natural light & aesthetics, provide a place to relax or leave the kids, and improve air quality. ***Challenges*** Operations personnel are used to narrowly defined operating conditions and might view BIG as a wildcard and risk. These concerns can be overcome by pointing out examples like Ferrari who use plants to fine tune the air in their factories which are seen as some of the cleanest and most closely controlled anywhere. Important to resolve two potentially conflicting goals; One is to enhance the aesthetics and experience of occupants. The other is to separate the greenhouse from occupants to avoid contaminating some types of plants. It is important to determine if contamination is an issue with the plants used, and if yes how to achieve those things together. Occupants can be separated from the plants but still see and enjoy them. As well, not all plants have to be separated from the event-goers. Timeframe; As soon as possible it is important to develop an approach to accommodate those potentially conflicting goals.	**1**
	**USE UNDER-UTILIZED SPACE (E.G. ROOFSPACE, WALL SPACE)** ***Added Value*** BIG can use under-utilized space in and around buildings e.g. rooftops, façades and common spaces. BIG can join multiple buildings to create valuable new space. This can provide added recreational and meeting space for occupants. They can be constructed on parking lots where the support structure is already financed. ***Challenges*** ✓ *Zoning might restrict use of rooftop or building-added space. Solution; find another part of the building where BIG can be used in the zoning limit.* ✓ *Operations personnel might perceive risk from BIG as presenting undefined conditions. Solution. Pointing out examples like Ferrari who use plants to fine tune the air in their factories* ✓ *Sometimes owners don't want their buildings to be visible targets ! Solution. BIG can be virtually invisible to the outside if they are positioned properly.* ✓ *Perception greenhouses compete for PV space. Solution. PV-integrated glass.*	**2**

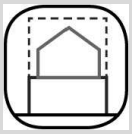
TABLE 3	SELECTING FEATURES FOR BUILDING-INTEGRATED GREENHOUSES	
CATEGORY	**FEATURE OPTIONS**	**PRIORITY**[i] 0, 1, 2, 3 or check
	**TEMPORARY USE OF LAND PLANNED FOR DEVELOPMENT** Because some types of greenhouses are easy to assemble and disassemble they make good temporary structures for site promotion, food production for worker canteens, and noise buffers for construction.	**0**
	**NATURAL LIGHTING/SAVINGS ON ARTIFICIAL LIGHTING COSTS** It is accepted practice in many buildings to use software to save energy and keep constant light levels by balancing sky lighting with indoor lighting.	2
	**HEATING, COOLING, ENERGY GENERATION OR STORAGE (SPECIFY)** ✓ *Capture and reuse heat generated by heating or manufacturing systems.* ✓ *Use solar energy to generate heat and grow plants profitably. Every greenhouse uses solar energy, but* **Solar Greenhouses** *are a specific technical type consisting of one side of the greenhouse as a heat-gathering and storage wall to extend growing seasons and comfort levels as well as insulating from over-heating. Solar greenhouses are used extensively in northern China for example.* ✓ *Store energy. The important feature for using renewable energy when it is required.* ✓ *Save air conditioning costs by deflecting heat-creating energy to the outside.* ✓ *Integrate with other renewable energy systems e.g. photovoltaics, geothermal sources, solar thermal & storage.*	2
	**URBAN HEAT ISLAND MITIGATION** There is a misconception that greenhouses create urban heat islands when actually new studies show they improve the heat island effect by absorbing thermal energy or deflecting solar energy away before it creates heat or by evaporative cooling with aquacultures.	3
	**RESEARCH & DEVELOPMENT** ***Added Value*** BIG support a range of R&D activities by companies including testing employee and customer satisfaction levels, expanding the use of monitoring systems which might be manufactured by the business. Other R&D applications; ✓ Seedling development ✓ Preserving endangered crop species ✓ Improving plant productivity ✓ Improving air quality ✓ Improving occupant experience ***Challenge*** Fitting BIG into existing R&D, either physically or business wise like using a BIG as an interesting demo/exhibition center.	1

TABLE 3	SELECTING FEATURES FOR BUILDING-INTEGRATED GREENHOUSES	
CATEGORY	**FEATURE OPTIONS**	**PRIORITY**[i] 0, 1, 2, 3 or check
	**EDUCATION & TRAINING** ***Added Value*** BIG are effective tools to educate students, teachers and office occupants how to improve their health and performance as well as how biodiverse systems work. It is also instrumental in the education of children about vegetable and fruit production. ***Challenge*** Getting them accepted by the operations department in educational institutions.	2
	**CORPORATE SOCIAL RESPONSIBILITY (CSR) / GLOBAL REPORTING INITIATIVE (GRI)CLAIM** How important is a CSR claim to the owner? Does the owner use GRI?	3
OWNER TYPE	**BUILDING OWNER OWNS THE FACILITY**	✓
	COMMERCIAL URBAN FARMER	
	AMATEUR GARDENERS	
	COMMUNITY ASSOCIATION	
	3RD PARTY (SPECIFY)	
OPERATOR TYPE	**COMMERCIAL URBAN FARMER**	✓
	BUILDING OWNER Do the owners want to operate the greenhouse themselves or do they want to partner with a third party operator ? One of the most important questions to answer early so the operator is involved from the start.	
	AMATEUR GARDENERS	
	GREENHOUSE SYSTEMS COMPANY	✓
	BUILDING OPERATIONS COMPANY	
	STUDENTS	
	PROFESSIONAL RESEARCHERS	✓

TABLE 3	SELECTING FEATURES FOR BUILDING-INTEGRATED GREENHOUSES	
CATEGORY	**FEATURE OPTIONS**	**PRIORITY**[i] 0, 1, 2, 3 or check
GREENHOUSE INTEGRATION TYPE	**GREENHOUSE AS OUTER ENVELOPE CONTAINING MULTIPLE FACILITIES OR STRUCTURES**	
	STAND-ALONE GREENHOUSE WITHOUT OTHER STRUCTURES INSIDE	
	GREENHOUSE AS SKIN FOR BUILDING	✓
	EVENT FACILITY INTEGRATED	✓
	RESTAURANT/CAFETERIA -INTEGRATED A good marketing tool is to be able to show customers where their food is coming from so it can be trusted and they can share the experience. Determine if there will be café or restaurant services or will this only occur during special events ?	
	SUPERMARKET-INTEGRATED Integrated indoor farms provide fresh on-site products and enhance customer experience.	
	PENAL INSTITUTION-INTEGRATED Greenhouses have been identified as productive rehabilitation mechanisms in prisons.	
	AGRO-INDUSTRY PROCESSING FACILITY INTEGRATED Locating production next to processing facilities saves spoilage and transport costs.	
	FACTORY, LOGISTICS OR TRANSPORT FACILITY INTEGRATED Ferrari in Italy uses indoor trees and other plants to fine-tune air in its clean-room facilities.	
	HEALTHCARE INSTITUTIONS, SENIORS HOMES, PALLIATIVE CARE Greenhouse gardens have been used for many years to improve recovery rates of patients and improve quality of life in chronic care facilities.	
	SCHOOLS & TRAINING CENTERS INTEGRATED Building integrated greenhouses are already used in schools in e.g. Manhattan as curriculum-integrated teaching tools.	
	OFFICES INTEGRATED Atria are common in office buildings but usually under-utilised and can be optimised.	

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CATEGORY	**FEATURE OPTIONS**	**PRIORITY**[i] 0, 1, 2, 3 or check
	RECREATION FACILITY INTEGRATED Spas and sport facilities often have atrium areas which can be optimised for integrated indoor farming especially to grow speciality herbs and other healthy foods for cafeterias.	
	SITED AT ONE BUILDING BUT WITH PRODUCT SALES AGREEMENT TO ADJACENT BUILDINGS Integrated indoor farms in the U.S. have production agreements with supermarkets.	
	APARTMENT CLUSTER INTEGRATED Community gardening is a well-established practice and especially well-suited to multi-unit apartment complexes where rooftop or landscape space often goes under-used.	
	SINGLE-FAMILY DWELLINGS INTEGRATED Referred to as 'winter gardens', integrated indoor farming is a welcome addition to homes and can be optimised using planning steps described in this toolbox.	
	FLOATING ON WATER One of the first indoor farms in New York city was built in a river barge to save space.	
	BUILDING INSIDE THE GREENHOUSE	
GREENHOUSE PLACEMENT RELATIVE TO BUILDING	**STAND-ALONE, NOT INTEGRATED WITH BUILDING**	
	ROOFTOP INTEGRATED	✓
	GROUND FLOOR ATTACHED TO EXTERIOR	
	MULTI-STORY ATRIUM INTEGRATED WITH BUILDING	
	SINGLE STORY INTEGRATED WITH INTERIOR USING DAYLIGHT	
	INTERIOR OF BUILDING ABOVE GROUND NOT USING DAYLIGHT	
	VERTICAL WALL/ENCLOSED BALCONIES	
	BELOW GROUND LEVEL WITH OR WITHOUT DAYLIGHT	

TABLE 3	SELECTING FEATURES FOR BUILDING-INTEGRATED GREENHOUSES	
CATEGORY	**FEATURE OPTIONS**	**PRIORITY**[i] 0, 1, 2, 3 or check
GREENHOUSE CONSTRUCTION	**OPEN-TYPE**	
	CLOSED-TYPE (EG WATER OR ENERGY RE-USE)	✓
	GLASS (GH, WHITE, AR, SINGLE, DOUBLE)	✓
	PLASTIC (PMMA,PE, PC, ETFE, TFE, SINGLE, DOUBLE)	✓
	NORMAL WEIGHT CONSTRUCTION	
	LIGHT WEIGHT CONSTRUCTION	✓
	ULTRA-LIGHT WEIGHT (EG BAMBOO+FOIL)	
	HIGH TECH (HVAC, LIGHT, COMPUTER CONTROLLED)	
	MEDIUM TECH (CONTROLLED ENVIRONMENT)	✓
	LOW TECH (PASSIVE CATCH OF SOLAR HEAT)	
	NEWLY BUILT / RENOVATION	

RESULTS OF FEATURE SELECTION USING EVENT FACILITY EXAMPLE

The results of the process from Table 3 identify priority characteristics and questions to solve.

For example the question marks next to priorities in Table 3a indicate;

- *How will operations be divided between the commercial operator, the greenhouse systems company and the researchers who are growing seedlings ?*
- *Which materials to use for the building skin?*

After those questions are resolved the resulting table can be shown to the prospective greenhouse operator, contract, municipal permitting authorities and other stakeholders to give them clarity on priorities for the facility. It will be a guide throughout planning, construction and operations.

Table 3a Priority features resulting from Table 3 category selections using the example of an event facility integrated with a greenhouse.

VALUE-ADDED SERVICES SEEDLING PRODUCTION RESEARCH & DEVELOPMENT AGRICULTURAL PRODUCTS QUALITY IMPROVEMENT COMPARED TO OPEN FIELD. IMPROVED AIR QUALITY IMPROVE PRODUCTIVITY OR WELL-BEING OF OCCUPANTS ENHANCE AESTHETICS & IMPROVE CUSTOMER EXPERIENCE
OWNER TYPE BUILDING OWNER
OPERATOR TYPE ?? COMMERCIAL URBAN FARMER ?? PROFESSIONAL RESEARCHERS ?? GREENHOUSE SYSTEMS COMPANY
GREENHOUSE INTEGRATION TYPE GREENHOUSE AS SKIN FOR BUILDING EVENT FACILITY INTEGRATED
GREENHOUSE PLACEMENT RELATIVE TO BUILDING ROOFTOP INTEGRATED GREENHOUSE AS SKIN FOR BUILDING
GREENHOUSE CONSTRUCTION NEWLY BUILT CLOSED-TYPE (EG WATER OR ENERGY RE-USE) ?? GLASS (GH, WHITE, AR, SINGLE, DOUBLE) ?? PLASTIC (PMMA,PE, PC, ETFE, PTFE, SINGLE, DOUBLE) LIGHT WEIGHT CONSTRUCTION

TABLE GUIDANCE NOTES

[i] PRIORITIES

The priority level for each value-added service is a central feature for your financing and your implementation roadmap.

Level 0 =
Not a Priority

Level 1 =
Start planning now and implement for start of operations.

Level 2 =
Start investigating now but leave implementation decision until after operations start.

Level 3 =
Consider for later use but leave investigation and implementation until after operations are established.

Check mark or colour code can be used also to describe preferred choices.

ALIGN EXPECTATIONS WITH REALITY

☐ IDENTIFY QUICK WINS

Quick wins are important to support stakeholders to find effective value propositions. While investigating customer goals, perceptions and added value, develop a list of potential quick wins.

Example; Park 20/20 near Schiphol Airport acquired a complete greenhouse at low cost by purchasing one from a distressed greenhouse grower. The greenhouse was used to immediately start growing vegetables and as an add-on to a restaurant, as well as providing restaurant seating and promotional space while construction was happening around the site.

☐ REALITY CHECK

For this segment it is important to refer back to the priorities selected for each BIG value-added feature from Table 3. Focusing on priority 1 features, start to establish the level of complexity your stakeholders want compared to what is realistic in the local situation.

Accurately establishing the complexity level requires a careful assessment of;

- ✓ *Financial factors from Table 2,*
- ✓ *The top value-added priorities selected from Table 3. See Table 3a.*
- ✓ *Municipal and other regulations identified during the Quickscan*

Using those findings, consider with the Stakeholders which level of configuration they want, using the following levels as a guide.

For example if the customer wants quick results but high complexity it is important to advise them of the capabilities required. Are the technical capacities available to do the work? The reality of finance and local regulations also have to be considered.

Be sure you fully understand the expectations of your stakeholders and they understand what is realistic to achieve !

☐ SET CONFIGURATION LEVEL

You can mix and match elements from these levels depending on the value propositions selected by the customer.

Level A
Ground-floor unheated greenhouse for plants and leisure but not high level production or active reuse of emissions. Connected to the building by a wall or door, or adjacent to the building.

Level B
Restaurant or cafeteria-integrated for aesthetics and growing basic vegetables but basic as with level A.

Level C
Rooftop greenhouse or full height atrium integrated with the building heating and cooling systems, without high level agricultural production.

Level D
Integrated with the building heating and cooling systems and mechanized to produce high levels of crops.

Level E
Integrated system with features from Level D but including aquaculture and nutrient recycling that reuse emissions from the building. High level of materials design for recycling & value recovery. Recycling water, nutrients, air, CO_2.

WIN RECOGNITION FOR YOUR BIG !

THE REGISTRY

After your BIG is built, The Registry of Cradle to Cradle®-Inspired Elements for Building Developments provides recognition with a peer-reviewed quality assurance registration and award so designers and builders can celebrate, evaluate and replicate excellence.

The Registry' of Cradle to Cradle-Inspired Elements for Building Developments is a new international award-based mechanism to celebrate Cradle to Cradle-inspired innovation in buildings and area developments. The Registry welcomes everybody with a qualified building development to celebrate outstanding Elements.

For more information
http://www.rsm.nl/research/decision-information-sciences/research/cradle-to-cradle-for-innovation-and-quality/registry

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Photo credits cover; Upper center; Douglas Mulhall, Upper right; Lufa Farms, Lower left; Polysolar.

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ANNEX A: EXAMPLES OF STAKEHOLDERS

GUIDANCE

The purpose is to identify and prioritise Stakeholders according to their roles, so it is possible to describe their Goals, or describe if they do not yet have Goals.

One stakeholder might play diverse roles and have diverse Goals, e.g. owner might also be occupier.

ECONOMIC STAKEHOLDERS

1. Investors
    - 1.1. Urban greenhouse owner & operator
    - 1.2. Developer
    - 1.3. Landowners

2. Builders, Users, Operators
    - 2.1.
    - 2.2. Builder incl. Project Manager & Subcontractors
    - 2.3. Suppliers for Builders & Operations
    - 2.4. Service Providers, e.g. water agencies, energy providers, telecom
    - 2.5. Occupants, Users & Tenant association
    - 2.6. Customers who use the development but do not occupy it, e.g. store and restaurant customers, parents of students.
    - 2.7. Lease holder. If a third party, might be different from occupant.
    - 2.8. Property manager
    - 2.9. Technical maintenance manager

☑ Identify priority Stakeholders

3. Government Planning & Regulatory Agencies
    3.1. National, Provincial/State, Regional Authorities who give approvals
        3.1.1. National & Provincial development authorities
        3.1.2. County development & zoning authorities
        3.1.3. National & Regional Environment & Safety
    3.2. Municipal Authorities
        3.2.1. City Council
        3.2.2. School Boards
        3.2.3. Municipal Architect & Planning Dept.

4. Taxpayers. Also ratepayers associations, property owners associations.

5. Non-Governmental & R&D Organizations with an economic stake
    5.1. Chamber of Commerce / Entrepreneur Association
    5.2. Research funding organizations

OTHER STAKEHOLDERS

1. Neighbours & Neighbourhood associations. Might also be economic Stakeholders if property value is affected.

2. Environmental & Public Interest organizations

3. Media & Marketing
    3.1. Local business media
    3.2. PR departments of participating builders & suppliers
    3.3. Municipal marketing team

ANNEX B: FURTHER READING FOR INDOOR FARMERS

Because this publication focuses on value propositions for integrating indoor farms with buildings rather than techniques for indoor farming, it is important for prospective indoor farmers to refer to other publications & websites for information on agriculture and other aspects.

Lim Yinghui Astee, Dr. Nirmal T. Kishnani (*2010*) Building Integrated Agriculture: Utilising Rooftops for Sustainable Food Crop Cultivation in Singapore. Journal of Green Building: Spring 2010, Vol. 5, No. 2, pp. 105-113.

Agricultural Urbanism Lab http://lua-paris.com/index.php

Blue Ridge Indoor Aquaculture http://www.blueridgeaquaculture.com/

Brightfarms U.S.A. http://www.brightfarms.com

Lufa indoor farms in Montreal http://lufa.com/en/

ELIOOO http://www.indiegogo.com/projects/eliooo-grow-your-food

Handbook of Indoor worm composting http://www.thewormfarm.net/products/134-Laverme%27s-Handbook-of-Indoor-Composting/

Happy Healthy School http://www.happyhealthyschool.com/

The Rooftop Greenhouse http://www.rooftopgreenhouse.co.uk/index.html

The vertical farm project http://www.verticalfarm.com/

Urban Farms Switzerland http://urbanfarmers.com/projects/basel/

Urban Organics Minnesota http://urbanorganicsmn.org/

Wikipedia vertical farming http://en.wikipedia.org/wiki/Vertical_farming

Years of life lost (YOLL) in EEA countries due to PM2.5 pollution, 2005 http://www.eea.europa.eu/data-and-maps/figures/years-of-life-lost-yoll

Zfarm Germany http://www.zalf.de/htmlsites/zfarm/Seiten/zfarmenglish/idee.html

Zonneterp Netherlands http://www.zonneterp.nl/english/index_uk.html