Norwegian School of Economics
Bergen, Spring, 2018

# Indoor Farming: Fancy Concept or Environmental Breakthrough?

*Economic Analysis of A Small Scaled Indoor Farm Producing Iceberg Lettuce In Bergen, Norway.*

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Master Thesis, M.Sc. in Economics and Business Administration, with profile: Energy Natural Resources and the Environment

NORWEGIAN SCHOOL OF ECONOMICS

# ABSTRACT

The purpose of this thesis is to evaluate the concept of indoor farming from an economic perspective. In evaluation of the concept, the study aims to clarify whether current trends and applications of the concept do consider, to provide a contribution to tackling of environmental and agricultural challenges. In clarification, the study builds a case of establishing a small-scaled indoor farm in Norway, by following paths as indoor farms and authorities suggest. Once the indoor farm is established and costs are determined, the study pursues an additional task of examining prospects of this indoor farm within Norwegian agricultural market. This part of the study intends to figure how does pricing and sales strategies of a small scaled indoor farm varies, depending on profitability and competition.

In evaluating the position of the indoor farm, the study applies two analysis methods from corporate finance. Initially, the viability of investment to the small-scaled indoor farm is measured by application of net present value calculation. Secondly, production efficiency and pricing strategy of the indoor farm is measured by break-even analysis.

Due to significant findings regarding costs determination of the indoor farm, financial analysis of the study is extended into three different scenarios. While first scenario is kept as is, in following two scenarios project leader is expected to cover role of some labor used in production, in order to decrease costs.

As the study reflects several critical factors in economic viability of an indoor farm, most notable finding is that indoor farmers are currently concerned with gaining economic profit, rather than contributing to tackling of environmental challenges. With suggestion of further efforts to aid development and existence of indoor farms in agricultural production, the study suggests indoor farmers to make further attempts in forming an image to the concept as a practice to provide a better environment to current and future generations.

# ACKNOWLEDGEMENT

This dissertation is written as a final study of a Master of Science in Economics and Business Administration at the Norwegian School of Economics, with profile of Energy, Natural Resources and the Environment.

As the author of the dissertation, I would like to note contribution of distinguished individuals and organisations to this study. Initially, support and guidance of Professor Gunnar Eskeland has been worthwhile. In understanding and representation of the title academically, his advices and encouragement to achieve more accurate results regard a significant part in this study. I also would like to thank Associate Professor Ivar Gaasland, for dedicating his valuable time in leading me to a useful direction in consideration of agricultural economics to the concept.

Furthermore, I would like to mention my appreciation to team members of Byspire A.S., Bright Agrotech and Tåsen Microgreens A.S., for providing valuable insight and feedback that were influential to this study.

I also would like to thank my classmate and my friend Ahmet Yilmaz Vural for introducing me inspiring concept of indoor farming. Finally, my special thanks to Mr. Bartlomiej Grabowski and my mother Mrs. Songül Erten, for providing me a valuable support in completion of this thesis.

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# LIST OF ABBREVIATIONS

**B.C.**: before century

**CAPEX**: capital expenditures

**$CO_2$**: carbon dioxide

**EC**: electrical conductivity

**FAO**: Food and Agriculture Organisation of the United Nations

**GR**: the Green Revolution

**HVAC**: heating, ventilation and air conditioning

**IPCC**: Intergovernmental Panel on Climate Change

**kWh**: kilo-watt hours

**LED**: light emitting diode

**$m^2$**: square meters

**$m^3$**: cubic meters

**NFT**: nutrient film technique

**NOK**: Norwegian krone

**NPV**: net present value

**OPEX**: operational expenses

**pH**: relative acidity

**Ph.D**.: doctor of philosophy

**U.S.A**.: United States of America

**USD**: United States dollars

**SSIF**: small-scaled indoor farm

**WACC**: weighted average cost of capital

# LIST OF TABLES & FIGURES*

* Tables and figures in appendices are excluded in this list.

# 1. INTRODUCTION & SCOPE

## 1.1 Research Description

Access to food has been a steady concern of the humanity ever since. With occurrence of agriculture in history, societies have advanced or weakened, according to this basic need. Therefore, many sub-fields of economics closely follow developments in agriculture, and food production. Following the green revolution of the recent century, further developments arose in agriculture. A notable concept among these developments, indoor farming is the primary focus of this study. Investors and academics who are in favour of indoor farming argue that it can be a solution to many environmental issues of today and future. Notably, it will enable societies to produce any plant in any location, regardless of the environmental conditions in this area. However, it is difficult to pinpoint an indoor farm, producing commonly used plants. Instead, many indoor farms appeal to niche markets, producing exotic products that do not necessarily satisfy daily needs of individuals. The study aims to explore, whether this preference is due to economic concerns and profitability that an enterprise needs in order to survive. Currently it is challenging to cite studies that provide a critical approach to feasibility of an indoor farm from an economic, financial, or entrepreneurial perspective. Kozai (2013) summarises several criticisms which are often argued against indoor farming. These criticisms can be summarised in two sub-arguments:

1- Most of indoor farms do not make profit.

2- Initial cost, production cost, electricity cost and labor cost of indoor farms are too high.

Possibly these criticisms can give a hint to realise the reason indoor farmers tend to produce exotic goods while the concept promises to contribute provision of regular food to societies, and to tackle environmental issues. Theoretically, this dissertation will provide the background and history that highlight various global challenges related to food scarcity, agriculture and the environment. Following, concept of indoor farming will be introduced, hypothetically offering a solution to these problems. Yet the theory aside, a discernible criticism from observations of the author will be elaborated, underlining misconceptions of indoor farming in European countries (particularly Norway). With practical assessment to economic feasibility, the study will aim to disclose a premise, whether indoor farming appreciates environmental concerns or not.

The general practice of this dissertation is to assess the economic feasibility of a small-scaled indoor farm (SSIF) that would be established in Bergen, Norway. With aim of achieving such assessment, there are three sub-research topics considered in this study. These sub-topics can be listed as follows:

1- **Feasibility of production in an indoor farm.** With accordance to its characteristics, what are costs of establishing an indoor farm? What is annual yield for a regular plant in an indoor farm? Consecutively, what are fixed and variable costs of producing the plant throughout the year?

2- **Examination of agricultural market and market prices.** What is the process in provision of a regular product to the market? Who are the actors in this process? How does price of the product develop throughout the process?

3- **Market analysis of an indoor farm product.** Considering findings from previous sub-topics, where can a small-scaled indoor farm position itself in this market? At which scale should be the price of this regular product, in order to become competitive?

Due to vast amount of products in food market, this study narrows down the research to one particular plant: iceberg lettuce. With consent to answers of aforementioned sub-topics, the research question of this study is as follows:

**To what extent a small-scaled indoor farm in Bergen, Norway can become profitable, by production of iceberg lettuce in Norwegian agricultural market?**

Once competition of an indoor farm with current actors of the market is measured, it will be possible to illustrate potential improvements for the concept to become economically feasible. As will be elaborated in following chapters, indoor farming can be a solution to many social and environmental problems. Nevertheless, the concept still requires further economic analyses, in order to become a considerable solution to these problems.

## 1.2 Scope

The study requires learnings from teachings of both agriculture and economics. Since the author has no formal educational affiliation to agricultural studies, most estimations related to production are based on limited knowledge the author acquired in less than a year. Several assumptions made in agrarian (technical) decisions can be examined in sub-section below, followed by limitations to economics.

### 1.2.1 Limitations to Agriculture

- Numerous studies define the concept in different names as vertical farming, plant factory with artificial lighting, zero acreage farming and more. To provide a simplified context, the concept is solely defined as indoor farming in this study.
- In contrast to many studies relevant to indoor farming, production facility is in small-scale. Net use of 50m$^2$ is estimated for the production facility. Among various production techniques for an indoor farm, nutrient film technique (NFT) method is used, as suggested by indoor farmers.
- Regarding yield, 100% efficiency is assumed in this study. Despite better than outdoor farms, most indoor farmers cannot achieve full yield. Results of profitability is likely to decrease, depending on production efficiency of the facility.
- Various technologies to automate and to optimise production in indoor farms develop gradually. Technology used in this study is limited to existing processes described by Kozai (2013) and additional suggestions provided by indoor farmers.

### 1.2.2 Limitations to Economics

- Due to availability in most recent data, 2016 is the base year in the analysis. However, various data as expenditures, electricity and water prices, U.S. Dollar (USD) to Norwegian Krone (NOK) rate and average salaries are acquired from year 2018.
- In market analysis, only imported goods from Spain are regarded, as it accounts for more than 98% of iceberg lettuces imported to Norway.
- Individual residents of Norway are regarded as customers, for simplification of the study. There are several alternative definitions available in the market to the notion of customer, such as hotels and restaurants.
- For realisation of the project, it is assumed that the project leader has sufficient funds to establish her business. Therefore, financial and entrepreneurial applications to provide investment budget or liquidity are ignored in this study.
- Material expenditures relevant to marketing *(e.g. advertisements),* public relations (*e.g.* leaflets) and digital media (*e.g.* web page hosting) are ignored in this study, as making an accurate cost estimation to these expenses require notable further research.

# 2. LITERATURE REVIEW

## 2.1 Background

In the world we live in, consumption is a common activity for every breathing creature. Notably, nutrition is one of the most primary form of consumption for living things (Miller, 2005). Defined by respected biologists, human is one type of a creature, among millions of other types of livings, as member of tiny mammals class (Haeckel, 2012). Surprisingly, human has a different instinct with respect to motive of consumption. Human wastes, and human is constantly yearning for more. Anthropologists, sociologists and other scientists pursue countless amount of research to figure out the reasons behind. Hence, as members of this modern time mammals, we are all aware that humanity consumes increasingly. Food consumption, among all, is one critical activity that needs to be fulfilled, in order to maintain a promising future to current livings of humans, as well as to their future generations.

Since 10.000 B.C., agricultural development has been a critical factor for societies, in maintenance of food consumption (Diamond, 1997). Yet when the food is scarce, impact is greater than thought. History teaches us that for these societies, lack of food is not an individual but a collective threat (Gráda, 2010). Taking its roots from politics, economics, the environment - and the policies established within their frames - famine leads to a major degree of casualties for nations, including mass mortality, increased crime, migration and more (Gráda, 2010). Providing food accounts for more than just a physical need. It is a vital activity to maintain a certain safety and quality among modern societies.

Leaders of today learn from past, and make efforts to prevent hunger for both developed and developing nations. To refer, Food and Agriculture Organisation of the United Nations (FAO) is an intergovernmental agency, aiming prevention of hunger and malnutrition for societies, receiving support from the United Nations member states (Fao.org, 2018).

Along with FAO, there are thousands of organisations in the world working for the same cause. It is possible to realise within scope of all these institutions, productivity in agriculture and food production is essential to prevent collective hunger and undernutrition. As the history proves, tackling hunger has always been challenging for the humanity. Current issues and collective efforts aside, following decades are also adept to generate further challenges regarding agriculture and maintenance of food consumption.

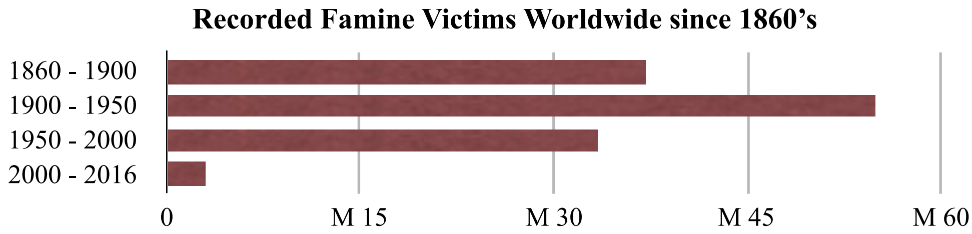


Figure1. *Despite the promising development, famine is an existing problem of the new millennium, with potential of taking millions of lives in future. (Hasell & Roser, 2013)*

The Population Division of the United Nations estimates approximately 10 billion people to live in year 2050 (The United Nations, 2017). With reference to current amount, this means a 31% increase in global population. Together with increasing number of mouths to feed, FAO expects a rise in daily energy supply. In other words, each individual will require higher amount of daily calorie intake in 2050, compared to an average individual of today (FAO, 2012). Starting with 2005, in 45 years of period, food production in globe has to increase at least 60%, to satisfy global food demand (FAO, 2012). Whether by increasing the yield and cropping intensity, or by expanding arable land; solutions to satisfy such demand will require sufficient labor in rural areas, to produce, harvest and deliver the food to the rest of the society. Controversially, rural population is also decreasing in globe. Only one out of three persons is expected to live in rural areas by 2050 (ESA, 2014). It is possible to argue various types of solutions to aforementioned issues stated. However, even these solutions were to take place in reality, it would not be possible to implement such solutions by omitting significant changes in practices of traditional farming.

Until mid-20th century, farmers followed natural methods to preserve quality in soil and crops, by replacement of crops or by seasonal resting of fields (Tilman, 1998). These methods made farmers, and the people they feed, reluctant to weather conditions. For farmers in developed countries, this uncertainty can be slightly tackled with use of science, or by trade of goods. However, for developing countries alternatives are rare. Goods are limited to trade, and science to diminish the uncertainty is not feasible for most. Thus, developing nations eventually experience famine due to such uncertainty, as nature brings drought, disasters, or diseases with it (Gráda, 2010). Nearly a decade after World War Two, agricultural development had its focus to outdo the same uncertainty, by offering an alternative to farmers with regards to provision of goods. Instead of using traditional methods to expect a certain quality in soil, farmers received crops that provide higher yield, as well as synthetic fertilisers that are suitable to these highly efficient crops (Mazoyer & Roudart, 2006). This term of agricultural research, and the development followed with it is known as “the Green Revolution” (Tilman, 1998; Mazoyer & Roudart, 2006; IFPRI, 2002). Considering from social perspective, the Green Revolution (GR) had notable positive impacts in developing countries. Income per capita increased significantly, poverty declined, nutrition intake improved, farming opportunities expanded (IFPRI, 2002). Albeit the positive impacts are indisputable, several research took place in recent decade evaluating impact of GR invalidates ultimate revolutionary notion of GR.

To elaborate,. Evenson and Golin (2003) divide GR term into two periods (1960 to 1980 and 1980 to 2000), initially proving that benefits from high yielding crops dominantly took place in second period. Furthermore, the benefits received in early times of GR, were not due to high yielding crops or mineral fertilisers only, but also due to expansion of arable lands, which may have arguably occurred as result of other incidents (deforestation, migration to new lands and more). Questioning ultimate benefits of GR aside, there are also various negative environmental impacts that took place. Tilman (1998) summarises these impacts in his study as eutrophication of water resources, further emission of greenhouse gases, damage to biodiversity and most notably contamination of ground water.

From social perspective, one can highlight the importance of millions of lives saved, and welfare improved in developing nations thanks to efforts made within GR scope. Yet, environmental perspective obligates science to examine and evaluate both positive and negative impacts of policies over resources. Therefore, policy makers have lots to learn from consequences that GR brought to future generations. The Green Revolution is an effort of yesterday, to overcome challenges of earlier past. Agriculture of today, and tomorrow have greater challenges, that to elaborate a few, in aim to have a further understanding:

- **Extensive use of machinery increases global carbon emission levels.** According to IPCC report, machinery used in agricultural operations is considered as part of energy sector in calculation of global carbon emissions (IPCC, 2015). Nevertheless, according to research of Ceschia et al. (2010), emissions caused by machinery use can rise up to 36% on a single farm, depending on the intensity of technology used. As the agriculture becomes more machinery intensive, enhancing its efficiency potential with use of latest technology, it is likely to observe increase in amount of carbon emitted by machinery used in traditional agricultural operations.

- **Commodity prices are heavily reluctant on oil prices.** Machinery is used almost in every phase of food provision cycle. For transportation of input resources, production activities, and for transportation of harvested plants, gasoline or other types of crude oil is necessary. This factor makes food prices heavily reluctant on oil prices. World Bank (2013) submitted a report analysing positive correlation between crude oil prices and food prices in global scale.
- **The arable land for traditional farming is on a diminishing trend.** As mentioned earlier, expansion of arable lands in 20th century was another important factor in tackling agricultural challenges of that period. Unfortunately it is not possible to expect a similar expansion for following decades. According to study of FAO (2011), despite an increasing movement until 2050, there is a significantly decreasing trend in arable land per person (World Bank, 2013a). This can be overcome only by acquiring even further yield efficiency, which is likely to have further impacts on the environment.

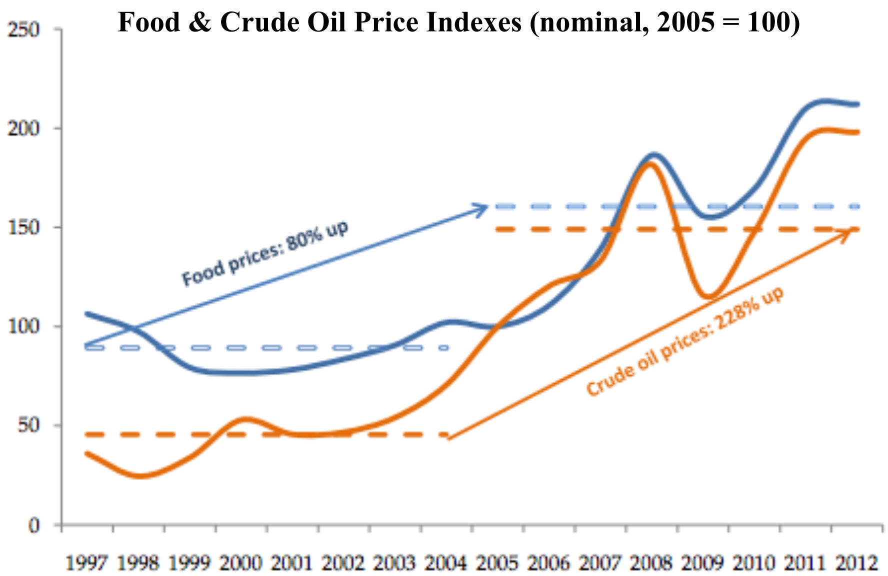


Figure 2. *As machinery becomes critical part of production and supply in agriculture, crude oil prices become more influential, in determination of food prices (World Bank, 2013).*

- **Soil is losing quality due to overuse of chemicals.** If not regulated, it is up to producer to decide the amount of fertilisers and pesticides to use. Overuse of these chemicals lead to soil degradation, salinisation, and erosion. These incidents create serious risk for provision of food to people. Furthermore, a greater risk exists for people and environment in the periphery, once these chemicals are leaked to downstream resources through irrigated or rain water (Töpfer et al., 2000).
- **Water resources are being depleted due to over-irrigation.** Agricultural production has a major influence in global water footprint, as it accounts for more than 90% of it (UNESCO, 2011). Besides, irrigation is an increasing practice in farms. Considering the fact that only 30-60% of irrigated water is returned for further use, it is possible to notice a remarkable risk in depletion of water resources due to over-irrigation (Töpfer et al., 2000). Unless a significant standard is captured among farmers, or an alternative method of production takes place, it highly predictable to experience negative impacts of lacking water resources.
- **Climate change is negatively influencing plant biodiversity**. A popular subject concerning the environment in recent decades is determined as the greatest threat to global biodiversity for the near future in study of Bellard et al. (2012). Apart from extinction of various of types of plants, climate change also leads to a "mismatch" between potential growing plant and its pollinator. Therefore, ordinary production process fails and plants may not grow naturally.

## 2.2 The Concept

It is possible to state additional factors to provide grounds that could frame traditional farming as a risky practice for food production. Agronomists, scientists, institutions and policy makers are considering various solutions to aforementioned factors. Doubtless to tell, assorted types of innovative approaches to agriculture can bear methods to overcome these issues. Among these methods, a modern concept, alternating traditional production method entirely, takes a remarkable attention with privilege of further examination to this dissertation.

Current efforts to improve practices of traditional agriculture should not be underrated or avoided. Yet, with this alternative method, it is possible to establish a contributory practice to traditional agriculture, that will provide significant benefits to both producers and consumers.

The concept is indoor farming. In general, indoor farming indicates production of herbs, greens, fruits and vegetables, in closed and controlled facilities.

Depending on conditions, soil can be replaced with artificial media, and natural sunlight can be replaced with electronic lighting tools. Abandoned buildings can be used for production, instead of arable lands. Light emitting diode (LED) lights can be used as lighting resource, instead of natural sunlight. Instead of constant irrigation without recycling from the soil, water tanks can continuously pump water in production systems, providing minerals and humidity required for plant production controllably. Possibilities are vast, thus will be described in the rest of the study once there is a relevance to the subject.

Historically, the idea is introduced back in 19th century by Dr. William Gericke (1882), with replacement of soil to artificial media (also defined as hydroponics). Several sources claim that similar applications took place in various industries. Thus, the most notable framework to the concept of indoor farming was introduced by two respected academics, each from the United States and from Japan. Former, Dickson Despommier demonstrates the concept to modern farm growers in his book published in 2010, named: the Vertical Farm. Latter, Toyoki Kozai, following Despommier's study, published Plant Factory with Artificial Lighting book in year 2013, introducing same concept from an agrarian perspective. Both books are vital to determine the application of producing plants indoors. With respect to their preferences in naming of the concept, indoor farming is the name that will be used in this study.

| | Traditional Farm | | | Greenhouse Farm | | | Indoor Farm | | |
|---|---|---|---|---|---|---|---|---|---|
| | Resource | Cost | Controllability | Resource | Cost | Controllability | Resource | Cost | Controllability |
| **Light** | Natural | Free | No | Natural \| Artificial | Free \| High | No \| Yes | Artificial | High | Yes |
| **Water** | Natural \| Artificial | Free \| High | No \| Yes | Artificial | Medium | No | Artificial | Low | Yes |
| **$CO_2$** | Natural | Free | No | Natural | Free | Yes | Natural \| Artificial | Free \| Low | Yes |
| **Fertilisers** | Natural \| Artificial | High | No | Natural \| Artificial | High | No | Artificial | Low | Yes |

Table 1. *Assessment of traditional, greenhouse and indoor farms regarding resource, cost and controllability.*

Apart from seed and production media (naturally soil, artificially mixed ingredients), light, water, $CO_2$ and minerals are the most essential elements of production. Table 1 provides comparison of these elements in three aspects. Firstly, regarding resources, while traditional and greenhouse farming provides flexibility in use of natural or artificial resources, indoor farming dominantly relies on artificial resources. As an example, while natural sunlight is used in traditional or greenhouse production, indoor farms use LED or fluorescent lights to replace sunlight. Secondly, cost comparison highlights the intensity of light cost for indoor farm, compared to other elements. Contrariwise, traditional and greenhouse productions have flexibility of using free sunlight, while costs of water and fertilisers take higher account in their costs. Finally, controllability is an important factor to distinguish indoor farming from others. It is possible to determine, measure and recycle some of the resources used: water and fertilisers. Light can be provided anytime during a day. Humidity, temperature and $CO_2$ levels accordingly, can be adjusted with use of dehumidifiers and air conditioners. However, most of these possibilities are not feasible in other production methods. As mentioned earlier, lack of control in recycling of water and fertilisers have significant negative impacts on the environment we live in.

In Table 1, it is conclusively possible to frame indoor farming as a substitute of artificial resources to natural resources, with gain of controllability in production. Yet, cost factor is difficult to measure from this table. Thus cost comparison of indoor farms to regular farms are still unresolved, and not many research took place in this field.

### 2.2.1 Potential Benefits of Indoor Farming

Leading entrepreneurs of today argue, once businesses are examined in history, most of socially beneficial concepts are developed to accomplish one of these three challenges: solve a certain problem, advance availability of a limited activity or resource, or improve features of an existing substance (Kawasaki, 2005). Indoor farming has focus to provide an accomplishment to all of these challenges. Hence it is sensible to underline some solutions indoor farming offers to problems stated in earlier section:

- <u>Electricity use from renewable energy, to replace machinery use with conventional energy:</u> Although production is electricity sensitive, it is possible to maintain production with electricity that is acquired from renewably energy resources. Equipment used in indoor farming production do not require use of conventional energy resources. This eliminates reluctancy of commodity prices to oil prices. Besides, in cities which change electricity prices during the day (also known as time-of-use pricing), indoor farmer has the flexibility to adjust is production in most cost effective time of the day.

- Usage of existing buildings, leaving arable lands to natural production: As traditional farming methods are reluctant to arable land availability, indoor farming tackles this dependency. Any building can be used as a production facility. Moreover, in traditional farming methods, only current surface is used for production. Indoor farming architecture enables production of goods in multiple layers (as seen in photo below), which provides additional yield efficiency to farmer per area.

A*n indoor farm in Molde, Norway.*
*Source: NRK (2018), Remi Sagen.*

Once production of various plants are transferred significantly to indoor farms, there is a possibility to increase availability of arable lands outdoors. These regenerated lands can be used for further production of plants that are not feasible to grow indoors, or can be used in reforestation and carbon capturing, to abbreviate negative impacts of $CO_2$ emissions (Nogrady, 2017).

- No needs for pesticides; fertilisers used controllably, with higher efficiency: Indoor farms are designed as controllable and hygienic environments. Thus, production facilities are also designed to produce insect-free production. Therefore, there is no use of pesticide chemicals in indoor farms (Kozai, 2013). More important, fertilisers used in indoor farms neither contain any ingredients to damage human health nor leaked to outer environment. Most of fertilisers are absorbed by plants before they are collected in the water tank. This means a potential to eliminate more than 90% of agricultural contribution to climate change, as earlier sources prove (UNESCO, 2011).

- Water is recirculated in production, disabling depletion of water resources. In traditional farming applications, irrigated water is absorbed by the soil, leaving almost no possibility for recycling. Comparably, indoor farming production methods are designed as recirculated use of water resources. Flowing water in the production facility is recollected in water tanks, enabling 70-80% economy in water use compared to traditional farming methods (Despommier, 2013). According to Toyoki Kozai's research, water use efficiency rates are 30 to 40 times higher than same rates of both traditional and greenhouse farming (Kozai, 2013a). Furthermore, as plants in indoor farms are produced pesticide-free, there is no need for washing of produced products, as soon as they are accurately packaged.
- Habitat loss is overcome for maintenance of plant biodiversity. For the plants that are in critical condition of extinction, indoor farms can be used as secure facilities to expand their presence thanks to conditions brought by controllable environments. Even more, mismatch between plants and pollinators can be examined in indoor farms for enhanced integration (Snyder et al., 2016).

Considering these benefits, it is possible to exemplify outputs of indoor farming to advancement in availability of limited resources, or to improvement in features of an existing substance. In aim to not narrow potential outcome of indoor farming to only these bullet points elaborated, further benefits can be briefly listed:

- Research and development in technology of indoor farming is in remarkable progress. Cost of producing plants indoors are likely to decrease in near future, possibly to provide lower costs than traditional production.
- Plants imported abroad can be produced domestically. This would carbon emissions due to transportation, and also would add assorted values to the Norwegian economy.
- Easier reach to domestically produced, fresh and organic food can increase awareness of society to nutritional quality for daily food consumption. Overall, better nutritional quality leads to general health improvement. This may have even external economic benefits of cutting from medical costs, especially in developing countries.
- In developed countries, particularly in metropolitan areas, indoor farming can help improvement of mental health, as green areas are usually rare to reach for individuals. However, indoor farms can provide the atmosphere to provide positive impacts of spending time in green environments.

- From elementary level, to universities, students can get insight regarding agricultural production, plant development and permaculture, which will increase their intellectual knowledge and interest in various types of science.

As these bullet points refer to, many other benefits can be examined from book of Toyoki Kozai (2013) and from the article of Kalantari et al. (2017).

### 2.2.2 Misconceptions Of Indoor Farming

In Section 2.1, some major problems that we face today or we will face in future in the world were mentioned. Indoor farming was introduced as a potential solution to these problems with its promising capabilities. Hence, in order to concede indoor farming as a general solution to these problems, one can doubtlessly expect an evident alteration that can take place by expansion of indoor farming. In other words, for indoor farming to become an alternative to traditional farming, it should be possible to grow same plants that can be produced in outdoor farms. An initial concern that arises to this thought can be that indoor farms can produce plants only up to 30 centimetre height. Yet, there is already research aiming to produce plants that have length and yield greater than this volume (Campagnol et al., 2012). There are also architectural design firms, such as Kono Designs in Tokyo, Japan, dedicating projects to accomplishment of such task. In short, it is likely that technology will enable indoor farming to produce plants in larger sizes. However, there is a more notable problem that occurs in indoor farms, once an in-depth evaluation is applied to it from an economic perspective.

First, according to extensive search took place for this dissertation, most research regarding indoor farming have their focus solely on large scaled indoor farms. In comparison to expansion of indoor farms in small scales in multiple numbers, academia tend to expect expansion of indoor farms in larger scales yet possibly in smaller numbers. This converts indoor farming into a very costly project, that can be established only by investors with large budgets, as governments or multinational enterprises. However, there are many indoor farms in North America, Europe and Asia today, established by individuals with minor budgets, producing plants in small scale, and offering services and products to local markets.

Similar to many innovations that are dominant in existing industries, change is expected to come in lean steps, by gradually growing and becoming larger. The tendency of introducing indoor farming as a large, skyscraper size concept is prone to equip an “utopian” thought to it.

Once existing small scaled indoor farms are examined, it is also possible to realise another problem that may hinder benefits the concept can provide. Several large scaled indoor farms exist in North America and Asia. Yet, most of indoor farms in Europe are in small scale. Besides, another common fact of these indoor farms is that many of them actually produce plants that attract specific markets as restaurants, hotels or community groups. Hence, the type of plants produced in these farms are also mostly exotic plants, or greens that are not considerably part of everyday consumption. Most notably, micro-greens, baby type of plants that are smaller than 10 centimetre height and used as a garnish to salads and other meals are grown in these facilities. Albeit some may claim growing such micro-plants as a hobby, according to learnings from Upstart University (n.d.) and Kozai (2013), indoor farmers prefer growing micro-greens as they are highly profitable. When it is already possible to grow more frequently consumed products as tomatoes, strawberries, cucumber, lettuces, paprika and others, why indoor farmers grow exotic plants? According to observations and research of the author, this is simply due to economic concerns of indoor farmers, with respect to fact that their facilities are not profitable enough. Keeping this speculation in mind, small-scaled indoor farmers deserve a critique whether economic and industrial outputs of the concept are adequate to how it is introduced, as it is to become solution to various environmental and societal concerns. In order to shed a light to this criticism, it might be useful to evaluate an indoor farm in small scale, once it produces a commonly consumed, domestically produced and seasonally imported food. According to findings of the study, an assessment to relation between economic and environmental enhancements of the concept can be measured. Even though the research concludes that the facility simulated for the study is not profitable, it will be crucial in development of the indoor farming concept to understand; what factors prevent evolution of indoor farming with an environmentally beneficial motivation.

## 2.3 Research Process

With regard to the research question, currently there is no small-scaled indoor farm producing iceberg lettuce in Bergen, Norway. In this case, it is crucial to aim a built-up event, that can reflect inputs, attributes and outputs of an indoor farm, as realistic as possible. With realisation of such aim, a case study is simulated by the author, in order to understand some critical factors regarding feasibility of indoor farming.

This case study will imitate establishment, management and enterprise of a small-scaled indoor farm to become involved in the lettuce market. To maintain a sensible study, the author has gained knowledge and information from various areas and studies relevant to indoor farming. Initially the objective of the research is to illustrate attributes of an indoor farm. Besides, evaluation of results, combined with further analyses aim providing answers to questions listed in sub-topics. Thus, tasks that are followed and achieved can be examined in three categories as well. With aim of providing integrity in the study, same sub-topics will be used in definition of these categories.

### 2.3.1 Examination of Agricultural Market and Market Prices

#### 2.3.1.1 Description

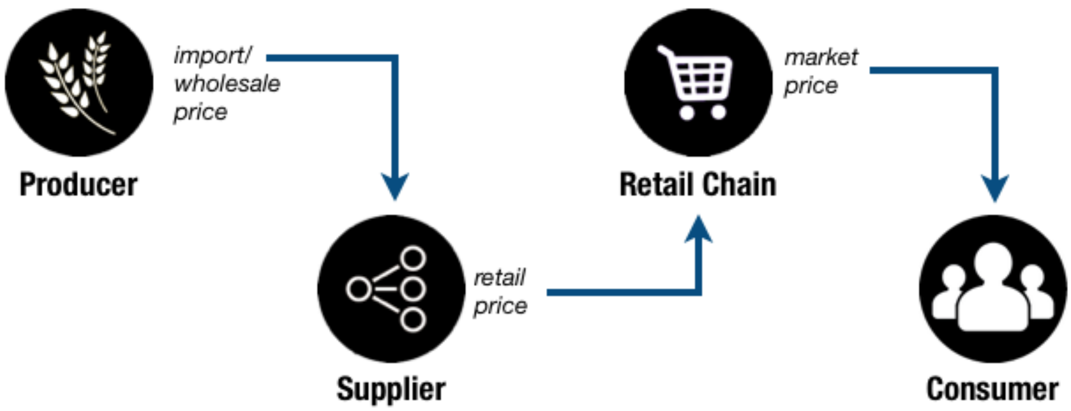


Figure 3. *There are four main actors in production and consumption process of iceberg lettuce, with having three main sales transactions in between.*

At first hand, it is important to understand, how Norwegian market supplies iceberg lettuce to consumers. Albeit several alternatives for different plants and locations, iceberg lettuce is mostly supplied to Norway via two channels. It is either imported from other countries, or it is produced domestically in traditional farms. Collecting information received from these sources, market can be determined as follows:

- There are four main actors in provision of iceberg lettuce to the market: producer, supplier, retail chain and consumer.
- Producer is either a farmer in Spain, or a farmer in Norway. Supplier is the middlemen, distributing lettuces to retail chains. Retail chain is a chain of stores providing groceries to most of inhabitants living in Norway. Consumers are limited to individuals who visit these retail stores and buy iceberg lettuce with their own will.
- An iceberg lettuce produced is acquired with a certain cost, and supplied with a corresponding profit to the next actor. This process is defined as “sales transaction” in this study. As illustrated in Figure 3, there are three possible sales transactions that can take place between four actors.

Among these sales transactions, there are different costs which determine competition and profitability for actors. Firstly, producer has a production cost which determine costs of all inputs used in production. Adding profit to its production cost, the producer determines a certain price for its goods. In analysis of market, it is possible to acquire an overview of such prices from wholesale price or import price data.

Wholesale price pertains to average amount paid to domestic iceberg lettuce producers, while import price pertains to suppliers who provide iceberg lettuces from Spain throughout the year. In Norwegian market, mostly lettuces are obtained in bulk amounts by middlemen whom defined as “supplier” in this study. Suppliers add their own profit, and determine a retail price for the product. These lettuces are sold to retail chains in bulk amounts as well, and distributed to stores all around the country. Finally, each retail chain determines a price due to its own pricing strategy. Consumer as final actor of the process decides whether to buy the product or not. The product is also sold in a price that covers retail price and profit of retail chain. Final price of the product is defined as market price in this study.

#### 2.3.1.2 Data Resources

There are three major tasks followed in acquisition of relevant data and information. Firstly, structure of iceberg lettuce provision was examined by gathering necessary information from Norsk Gartnerforbund (Norwegian Gardeners Association) and Bama, dominant supplier of vegetables in Norway. Secondly, both import and domestic markets discovered in details, with aim of examining costs and prices of iceberg lettuce. Grøntprodusentenes Samarbeidsråd (Vegetable Producers Union of Norway) provides data regarding domestic production cost and wholesale prices of iceberg lettuce (GPS, 2016). Import costs are also acquired from same source, yet from two different data sheets (GPS, 2017;GPS, 2018). While one data sheet provides detailed costs of import throughout the year, other data sheet is used to determine import volume, as well as the fact that Spain is dominant country in import.

Landbruksdirektoratet (Norwegian Agriculture Agency) provides retail prices in details for iceberg salad, as well as trends in the market which will be beneficial in latest phase of the study (Landbruksdirektoratet, 2016). Finally Norsk Gartnerfobund also provides detailed numbers, providing sales volume and market value of iceberg lettuce for the relevant year (OFG, 2016). In need of additional information, the author reached to these organisations for further validation. It has been significantly challenging to acquire retail prices from suppliers or retail chains. Despite continuous attempts of the author, none of the respected institutions in Norway have agreed to provide any price data. As a solution, a considerable price estimated between market, wholesale and import costs.

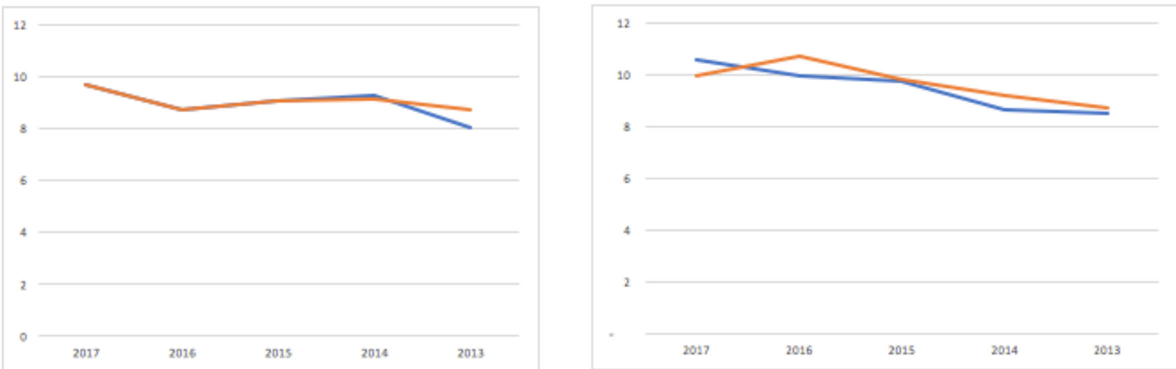


Figure 4. *Annual average price comparisons due to regular and agricultural calendars. Wholesale price comparison on the left, import price comparison on the right.*
*Orange color: agricultural calendar. Blue color: regular calendar.*

In calculation, it was suggested that retail prices are between maximum of wholesale prices and market price of the corresponding month, with a 40% less margin to the market price. For accuracy of the study, it is suggested in future to acquire retail prices from authorities, yet with their support to research and the academia.

According to feedback received by these institutions, agricultural calendar begins on 20th week of the year and is followed until 19th week of the consecutive year. In acquisition process, data were organised according to regular calendar. Some authorities suggested to organise remaining data accordingly to agricultural calendar as well. This suggestion was due to fact that interpretation of average pricing might be confusing, in case it is done according to regular calendar.

Therefore, comparison made for both possibilities, in order to understand whether any preference would make such difference. Taking inputs as weekly average prices, first prices are averaged to monthly prices. Then in one hand, monthly prices are averaged to annual prices according to agricultural calendar, while on the other hand they are averaged to annual prices according to regular calendar. Results of average prices can be examined in Figure 4.

Despite some fluctuations especially in wholesale price comparisons, it is possible to argue that use of regular calendar does not make a notable difference compared to use of agricultural calendar. Possibly in agrarian studies, which acquire multiple sources from agronomy relevant fields, it is sensible to remain loyal to agricultural calendar. However, in this study, data is evaluated due to regular calendar.

### 2.3.2 Feasibility of Production in an Indoor Farm

#### 2.3.2.1 Description

In parallel to examination of Norwegian agricultural market, information gathered for establishment of an indoor farm in Bergen. Initially, planning and designing of the indoor farm completed. In planning phase, technical details has been used as reference information. Technical design and structure of the indoor farm are portrayed in Appendices. It is possible to gain further efficiency from designing of the indoor farm. However, this improvement of efficiency would require extensive knowledge in architecture and industrial design. Therefore, efficiency in this study is limited to author's knowledge, supplemented with studies shared at technical learnings part. By completion of design and planning of the indoor farm, a list of required tools created for the production facility. These are basically devices (lighting systems, production racks, sensor units *et cetera*.), as well as various resources to satisfy land and management needs of the farm (rent, insurance, or plumbering services *et cetera*). In accordance with the plant to produce (iceberg lettuce), price information have been collected for all requirements.

An entrepreneur or project manager can collect and organise these costs in various types of tables. Yet, in this study, tables are organised in accordance with financial accounting concepts. In following phases, various financial analyses will be made to the costs. In order to maintain these analyses accurately, most of tools that will be purchased for use are listed in table of capital expenditure (CAPEX) as an initial outlay. Further, fixed costs are estimated with collection of annual depreciation from capital expenses, rent expenses and operational expenses. Finally, variable costs are measured to define costs changing with production volume. Regardless of tools used in production, there are also costs to maintain required infrastructure. These costs are collected as utility costs, covering two major needs: electricity and water use costs. After collecting all data necessary, a year-round production has simulated. The amount of use for various tools have influenced cost calculations. Reflecting the numbers to the entire year, annual cost of electricity and water are estimated. Similarly, cost calculations are completed for all resource use throughout the year

Doubtless to tell, it has been crucial to determine production cycle of iceberg lettuce. According to time, energy, air conditions and minerals needed for iceberg lettuce production, an estimate amount of annual yield was calculated. In case of unexpected incidents, buffer time was also considered in production cycle. Calculation of the production cycle has been also useful to determine labor required for production. By listing various tasks needed for use of labor; weekly, periodic and annual workloads were calculated.

Depending on further calculations for the study, all information were collected in a data sheet. Initially cost measurements were completed for a fully functioning, completely efficient indoor farm. In this phase of the process, it was assumed that there will be no deficiency in production. However, neither outdoor, nor indoor farms are capable to provide full yield. Many of harvested goods are wasted due to inefficiency in production. It is remarkably important to ensure that the scenario built is realistic and sensible to a production that would take place in an indoor farm. To validate a sensible follow up to the study, author has shared findings and acquired data with representatives of Byspire A.S., a small-scaled indoor farm in Oslo, Norway. Several visits are made to production facility of Byspire. Research process is shared with business leaders and agronomists. According to their feedback, updates are made to the analysis, until their confirmation were received to validate the study as a realistic research.

### 2.3.2.2 Data Resources

Obtaining relevant data in this phase has been the most time consuming part of the research process. Alternatives for collection of tools and establishment of the facility are multifarious. Market is evolving so dynamically, within seven to nine weeks spent in collection of data, there have been noteworthy improvements in provision of various tools. Therefore, it is necessary to underline that data acquisition process of this phase took place between second week of January 2018 to third week of March 2018. Equipments used in production facility are divided into six categories. Light, media, NFT system, sensor units, heating-ventilation-air conditioning (HVAC), various equipments are six categories that are used in the list. Costs and calculations of each equipment is collected in the CAPEX table. In order to collect costs, author has reached to various suppliers for each equipment, requesting price inquiries in relevant amounts or volumes. Thus, inquiry information collected can be defined as spot prices for the study.

In collection of spot prices, author followed a market research primarily in two areas of the world. First, Scandinavian and European market due to location advantage as well as customs incentives that can be beneficial for the investment. Second, Chinese market as market prices are usually considered lower in China. Eventually, most of suppliers in China provided cost-effective offers for equipments needed. Nevertheless, several equipments in use (production media, seedling, flood tray cover *et cetera*) are expected to be acquired from Scandinavian or European market. Another important factor in the study was calculation of freight, customs and other relevant costs. Avoiding extensive details, each price calculation is made accordingly, considering these costs in expenses. Finally, most of spot prices were offered in USD. In rest of the study, USD has transformed to NOK, as most of price data in the rest of study are gathered in NOK. Regarding rent prices, two resources were used in the study. Various estate agencies in Bergen announce facilities for rent in public advertising websites as FINN.no (n.d.). Author conducted a search in finding a few of production facilities suitable to the case, and reached to agents who validate price information for renting of these facilities. Secondly, similar search took place by reaching to DNB Eiendom, which is a major estate firm providing various facilities in Bergen. Collecting information from both sources, an estimate price 84.000 NOK for the rent, and 10.000 NOK for insulation (applying necessary changes in facility to provide a controllable environment in production) calculated.

Remaining expenses for the phase are as follows: selling and administrative expenses: to cover employee needed for marketing, accounting and product delivery; indirect labor: to cover technical services needed for legal expenses, plumber and electricity services. Finally other operating expenses as office equipment, insurance and administrative supplies. In collection of these data, author contacted to providers of relevant products or services, collecting offers in a data sheet. Collection of such data took place between first week of February 2018 to last week of March 2018. As mentioned earlier, utility costs cover electricity and water costs that took place in production. Regarding electricity, first step is to determine use cost per kWh for agricultural production in Bergen. Data for electricity prices provided by Statistisk Sentralbyrå - Central Statistic Bureau of Bergen (SSB) are used in determination (SSB, 2017). There are two price tables relevant to calculation in the corresponding reference data. First is Table 7, providing average price of electricity for agricultural use: 0,54 NOK per kWh. Second is Table 8, providing electricity price index per county. According to the table, electricity price accounts lower for Hordaland region compared to country average. After calculation, electricity price for the indoor farm is estimated as 0,5272 NOK per kWh. This price is multiplied with daily electricity consumption, calculated by use of the formula as follows:

$$E_{kWh/day} = P_{W} \, . \, t_{h/day} \, / \, 1000_{W/kW}$$

E: Daily amount of electricity consumed.

P: Unit power consumed by product.

t: time electricity used.

Once calculated, amount of E is multiplied with electricity price for each tool. To illustrate an example; air conditioner has unit power of 760W, which pertains to $P_W$ in the formula. Turned on for 18 hours every day ($t_{h/day}$), daily consumption ($E_{kWh/day}$) for air conditioner is calculated 13,68 kWh/day. Once this value is multiplied with number of days in a month, monthly electricity consumption for air conditioner is 534 kWh/period. Finally, rounding up to year-round consumption, 4.802 kWh/year electricity is consumed for air conditioner. This input multiplied with cost of electricity per kWh, 2.532NOK is estimated for electricity expense of air conditioner use during production. Similar calculation took place for remaining products that require electricity: lighting equipments, dehumidifier, pumps and storage.

Regarding water use costs, two separate sources of Bergen Commune used in calculation. At first source, information elaborating that water use is charged by water consumption as well as annual abonnement is acquired (Bergen Kommune, 2018). Secondly, prices for water per cubic meter ($m^3$) and for abonnement per square meter ($m^2$) are shared (Bergen Vann, 2018). With consideration of aforementioned data, relevant costs are calculated for water use. Both uses are also detailed by considering remaining uses, such as cleaning or lighting used in the office. To cover up these costs, annual costs are rounded up. As mentioned earlier, calculations for utility costs are shared with Byspire A.S., and necessary feedback gathered to ensure that these costs are sensible. For remaining expenses, such as insurance cost, plumber services, electricity services, accounting and legal services, author reached to various service providers and concluded their price offers in the calculation. However, further improvements are possible in acquisition of more cost-effective offers.

### 2.3.3 Market Analysis of an Indoor Farm Product

#### 2.3.3.1 Description

Final part of the research process is highly relevant to outputs of earlier phases. Findings of first phase; import and wholesale price, retail price and market price of Norwegian market for iceberg lettuce will be used to determine base prices for analysing markets. Followed by second phase, calculation of production cost through the analysis will provide the basis to determine production cost of iceberg lettuce in a SSIF. In order to compare pricing strategies to sell lettuces to various actors, the analysis is divided into three parts: sales to supplier, sales to retail chain and finally sales to consumer. In analysis of pricing strategies, there are two financial analysis methods used.

- Net Present Value (NPV) is calculated to figure, if the investment is profitable in long term.
- Break-even Analysis is measured to determine the minimum amount of sales or estimated price to acquire a break-even point, which means neither loss, nor profit in long term.

Functional details and findings of both analyses will be explained in details in following chapters. Conclusively, it is crucial to introduce estimate numbers used in calculation for these analyses. Particularly in NPV analysis, there are several variable inputs that needs to be determined critically, in order to measure realistic results.

#### 2.3.3.2 Data Resources

In calculation of NPV, there are several market assumptions that needs to be considered. To provide a referent portrait to future researchers, each of these assumptions are to be introduced as follows:

- Explicit growth rate: This ratio represents the proportional growth of the company in following years. Annual net income is calculated for the first year. Then, this net income is reflected to following years. Presumably, explicit growth rate is 1%. This means in year two, annual net income is 101% of first year annual net income. As size of the indoor farm remains the same, one can claim that explicit growth rate is constant. Yet, this amount of growth may take place due to increase in production efficiency, decrease in costs or improvement in use of space by applying improved technologies to facilitation of the farm.

- Terminal growth rate: represents growth of the company with correspondence to its cash flows. In financial analysis, different estimates take place depending on loans, investors and debts. However, for simplification it is assumed that the investor covers the budget from own funds. Therefore, terminal growth rate is also preferred to be equivalent to the explicit growth rate as 1%.
- Depreciation rate: Apart from depreciation value is calculated annually, it is expected that the investments will lose value each year due to their use in production, as well as due to expiration. In this study, depreciation rate is estimated 25%. This means, year two depreciation rate will be 75% of year one depreciation value.
- CAPEX / Net Income: Initial investment made by purchases of goods are defined as initial outlay. According to financial tables, this value is counted as expenditure of year zero. Gradually, some of these equipments will be defective and will need to be replaced with newer purchases. To cover up such expenses, financial analysts use a ratio of CAPEX to net income. According to this study, CAPEX/Net Income is defined as 2,75%. Current inflation rates of Norway, China and European average are considered in determination of such rate (Inflation.eu, n.d.). To give a practical example, Net Income in year 2018 4.688 NOK, if products are sold to consumers directly. 2,75% of this net income value is expected to cover costs of newer capital expenses. Therefore, it is assumed that approximately 129NOK will be spent in year 2018 for newer equipment.
- Weighted Average Cost of Capital (WACC): Relevant to inflation rates of invested country, as well as industry that the investment is made, WACC is calculated to determine the "current value of money" that will be earned in future. Considering inflation rate of Norway, as well as WACC determined for the market (NKOM, 2017), a conservative WACC rate is used in this study as 10%. Later in NPV calculation, this rate is used in determination of the discount factor. Further details to be introduced in following chapter, discount factor is used in measuring current value of future earnings.

- Tax Rate: In calculation of net income, certain tax has to be paid to the government as part of business transactions. Various tax schemes available for agricultural markets, a conservative rate of 28% is assumed for indoor farm production. This rate depends highly on how indoor farming is considered by the government. If the concept is anticipated as a supplement to current agricultural practices, it is very likely to expect lower tax rates in market. If otherwise, it is likely to expect maximum 28% tax rate.

## 2.4 Theoretical Literature

To an individual without a practical experience of growing a plant indoors, it is challenging to understand the perception of establishing an indoor farm. Learnings within economics and business administration aside, it is necessary to comprehend the needs of a plant to grow efficiently. Furthermore, technologic development of indoor farms necessitates researcher to examine latest developments in the area, in order to maintain a realistic result to the study. In light of this fact, initial part of literature pertains to technical learnings that took place, to cover the knowledge needed in order to demonstrate a sensible indoor farm simulation. Following the simulation, evaluation of analysis realistically within the market is also critical. In this matter, the author followed learnings relevant to the discipline of economics and business administration. Elaborated in details, this second part of literature is introduced as market and investment learnings, in order to draw the frame of the literature more precisely.

### 2.4.1 Technical Learnings

For an individual without an agricultural science background, making right decisions and managing adequate calculations in production have been challenging tasks to achieve. Nevertheless, discoveries of two notable sources have been useful to overcome this task. Firstly, Upstart University (USU), founded by Bright Agrotech in U.S.A., is an online educational platform, providing assorted information and network to acquire the knowledge and resources needed to establish a functioning indoor farm (Upstart University, n.d.). Although USU does not provide an accreditation to an academic learning, its teachings are collective output of multiple experiments, conducted by respective Ph.D. agronomists, business owners and farmers.

Among various learnings gathered from USU, some of the information that the study is based upon are critical. Temperature of the production facility, relative acidity (pH) and electrical conductivity (EC) of water , amount of energy required from lighting sources, amount of water needed for production, as well as harvesting timeline and details are critical knowledge gained. Initially, technical details shared in USU are used as reference to develop the scenario. However, to guarantee respectable resources that can prove teachings of USU in these critical matters, author pursued further research in order to confirm credibility of learnings. Teagasc (2017), as the Agriculture and Food Development Authority of Ireland, covers several technical requirements in its study particularly relevant to growing of an iceberg lettuce. EC and pH ranges, suggested temperature, water levels and cropping distance of the production is elaborated. As another useful resource, The German Aerospace Center published an extensive research regarding production of multiple types of plants in a large-scaled vertical farm (2013). Many other useful learnings aside, in this study it is possible to examine suggested harvesting timelines and energy requirements for production of a lettuce. In assessment of details shared in the research, it is possible to observe an accuracy of technical details that are estimated in this study. Production details of growing lettuce aside, maintaining an ideal condition for growing any plant is also an extensive task of an indoor farm. In completion of this task, various other details are also acquired from the research. As introduced in earlier chapter, heating, ventilation and air conditioning measurements are collected in a general form called HVAC. Depending on the plant produced, it is crucial to form a HVAC system that can provide optimal air conditions. In feasibility and planning of requirements for an optimal HVAC, same resource has been used as a reference, with support to detailed learnings from USU. Finally, a significant detail of production method, nutrient delivery has been also examined in details to ensure accuracy in feasibility of NFT production method. Another technical resource used in the study is published by Minnesota Department of Commerce (2015). This report is used initially for understanding whether use of LED lights are feasible in production of lettuces, secondly for figuring the amount of energy needed in production of lettuces. Graamans et. al. (2018) compare resource use efficiency of an indoor farm to greenhouses that are built in several locations, in which all of them produce lettuces. Important findings regarding electricity and water use are compared to findings of the data analysis.

### 2.4.1.1. Teachings of Dr. Toyoki Kozai

Even though methods involved in indoor farming were implemented in assorted times for centuries, a collective definition of plant production in a controllable environment has become popular thanks to two authors in their respected fields. First to mention, Despommier (2011) introduces and analyses the concept extensively in his book, notably highlighting potential benefits of indoor farming to future societies, as well as suggesting agronomists, researchers and policy makers what areas to focus on improvement of indoor (vertical) farms. Albeit motivating factors endorsed from the book, most of the information provide grounds for possible benefits that can be acquired from the concept, yet without a handful evidence.

Alternative to the book of Despommier (2011) is written by Kozai (2013), which is a significant source for learnings relevant to indoor farming. As a foundation to all research, reports and articles published, Kozai's book has been the most useful source to gather necessary background, as well as to organise the structure needed in maintenance of the dissertation. As mentioned earlier, findings of Kozai have been directly influential in determination of the research question, as well as sub-topics. Furthermore, many of the findings in the book are critically reviewed, and compared with findings of the analysis, which will be noted in following chapters.

Providing critical hypotheses aside, various other benefits are gained by reading of Kozai's book:

- discovering of research & development taking place in various countries of the world,
- understanding efficiency measurements used in production facilities (greenhouse and indoor farms),
- alternative production methods to indoor farms, such as rooftop production systems,
- physics and physiology background needed to understand functionality of an indoor farm,
- designing, planning and management of indoor farms, including future possibilities for improvement,
- production systems, biology background needed to understand functionality of an indoor farm,
- major indoor farmers and indoor farming associations in the world, including their contact details.

Reader should notably take into account that most of technical knowledge in this study is based upon Kozai's book. In following parts of the study, Kozai's book will be referred only when there is an argument worth noting regarding the case.

### 2.4.2 Market and Investment Learnings

In parallel to sub-topics and the research question introduced in previous chapter, it is crucial to acknowledge relevant context within theory of economics, finance and business. To provide an overview, the main theory of this study is built on framework of microeconomics, facilitated with related areas of corporate finance and agricultural economics. Pindyck and Rubinfeld (2013) illustrate notions defining actors of the market as producers and consumers, to determine how competitive markets function. As part of the section, the cost of production and relevant definitions are elaborated. In creation of the analysis, one of the main goals is to determine fixed costs, variable costs and marginal costs, as defined in the theory. In general context of microeconomics, fixed costs are expenditures regardless of the volume of production, while variable costs are expenditures that vary depending on the volume of production. Marginal cost on the other hand, is the measurement of expenditure that will occur with decision of producing one additional unit of product. Even though very relevant, these notions differ in the study, depending on production efficiency, as well as different strategies followed by the producer.

Once costs of production is determined due to such context, competitive strategy and market structure is evaluated within frame of microeconomics. Pindyck and Rubinfeld (2013) initially evaluate certain dynamics in markets, introducing monopoly and monopsony. Following, pricing strategies of firms are assessed due to their revenues and costs. Pindyck and Rubinfeld (2013) denote that once marginal revenue is equal to marginal cost, profit reaches to maximum for the firm. In light of this "rule of thumb" further analyses are followed for profit maximisation.

In this study, the status of lettuce market is analysed, whether current actors fit to definition of monopoly or monopsony as sellers or buyers. Regarding competitive strategy, as there is no existing indoor farm in Bergen, author made effort to follow aforementioned theory in evaluation, and targeted a forecast to figure critical factors that can affect strategies of an indoor farm in Norwegian agricultural market.

In assessment of determining costs of an indoor farm, the author aims to refer to context that can be obtained from agricultural economics. Barkley and Barkley (2016) define resources of an agricultural products in four labels: capital, labor, land and management. This definition in general is known as factors of production, and evolved in the book as the economies of production. Whether labor intensive, or machinery intensive, factors of production of a regular (outdoor, greenhouse) agricultural properties tend to show different dynamics compared to an indoor farm. In evaluation of cost analysis, author evaluates the indoor farm from perspective of economies of production. Findings are shared with reader, suggesting further research in this context. As supporting the theory used from microeconomics, it is possible to witness various common theories used in this study, which pertain to both microeconomics and agricultural economics.

Once the case of establishing an indoor farm in Bergen is simulated in the study, it is necessary to evaluate the idea from an entrepreneurial perspective. The author is an entrepreneur self. According to personal experience, it is a common method of investors to evaluate a business proposal from financial perspective, to consider its profitability. Personal opinion aside, Myers and Majluf (1984) exhibit a remarkable argument stating that investors decide investing in a project, as soon as the investment idea gives positive results in calculation of NPV for the project. In another study, Graham and Harvey (2001) proves notable popularity of NPV calculations among financial managers. In most of business proposals, it is a common suggestion to measure financial feasibility of the proposal by implementing an NPV calculation. In light of these presumptions, an NPV calculation, together with a further break-even analysis is implemented in the data analysis.

In examination of NPV and break-even analysis, Brealey et. al. (2008) elaborate NPV as part of investment decisions for corporate finance. To introduce initially, the general formula followed for NPV calculation is as follows:

$$NPV = \sum_{t=1}^{T} \frac{C_t}{(1+r)^t} - C_0$$

in which *T* is total length of years estimated for measurement of the investment, *C* is annual cash flow and *r* is the discount rate. Exceptionally, $C_0$ pertains to cash flow of initial year. This value naturally represents the investment cost, as there is no profit made before the beginning of the business. Once the business starts functioning, cash flow calculations are made for each year and collected. In a certain period of years, collective cash flow is subtracted from the investment cost ($C_0$). If the result is positive, this means from the context of corporate finance, the business proposal bears a potential to make profit once implemented. Furthermore, break-even analysis is determined as part of project analysis, supporting decisions made in order to guarantee profitable decisions made from a financial perspective. In break-even analysis, financial accounting aims to detect the level of sales that will equalise profits to zero. In other words, question of "How many products need to be sold at minimum, so financial loss is prevented?" is answered in break-even analysis. Brealey et. al. (2008) determines formula of break-even level as follows:

$$\text{Break-even level of revenues} = \frac{\text{Fixed Costs (incl. depreciation)}}{\text{additional profit from each sale}}$$

With calculation of break-even analysis, financial analysts manage to compare revenues to costs, defining a critical point to compensate costs through number of sales. Similarly, in evaluation of a SSIF, author aims to measure break-even point of sales from various measurements.

To explain briefly, depending on the market competed, different scenarios occur for a functioning indoor farm to become profitable. Therefore, as followed in NPV calculations, break-even analyses are also implemented for each market scenario, separately. Secondly, volume of sales, correspondingly revenues, vary depending on amount of production, as well as price. Therefore, break-even analysis is followed with considering variations in unit output, as well as prices. In finalisation of the break-even analysis, minimum amount of production, as well as minimum price that can be given in market are determined for the business idea to survive.

With calculation of such critical numbers, this study aims to provide a possible picture to the market, clarifying to what extent a small-scaled indoor farm stand financially for Norwegian agricultural market.

# 3. METHODOLOGY

Aligned with the theory, methods and resources explained in the research process section; the methodology used in this dissertation addresses an objective, yet also an instinctive aspect. Together with multiple findings, the aim of the research is to provide an exploratory framework to the reader regarding indoor farming, elaborating its needs, risks, opportunities and potential outcomes collectively.

As the research concentrates on almost every phase of an operating indoor farm, it is possible to argue that the case study also covers a holistic structure in its application.

Since research process is divided into two different areas (technical learnings, market & investment learnings), it was also a necessity to divide acquisition of knowledge and data into two different areas. Regarding technical learnings, most of the knowledge required was due to agrarian studies. Covered in what is learned from aforementioned sources, it has been also possible to obtain some data, most notably some technical facts useful for agricultural production. To give an example, from cropping its seeds until the harvesting period, an iceberg lettuce requires between 35 to 43 days. This is a singular, yet very valuable data that is used in the study. Collection of most of these data have been through teachings that took place relevant to the study. Conjointly, these information created a set of quantitative data that are used in the dissertation. Yet, in planning and simulation of the case study, research still required a subjective and estimate settlements in order to operate an indoor farm. To give an example, one can claim to fit four, or even six iceberg lettuce into a mini tray with 25cm to 50cm dimensions. However, the author agreed to fit three iceberg lettuces into each mini tray. In decision process of such mechanisms, a qualitative approach took place, notably by two applications: initially by observing relevant indoor farms, what standards do they use; secondly by meeting indoor farmers, having interviews and using their feedback conforming to their experience. Similar in market & investment learnings, quantitative data are acquired from resources mentioned in the research process section. With following principles mentioned earlier for technical learnings, the author reached to these authorities, in order to ensure that data acquired use accurately in this study.

Commercialisation of indoor farms in private sector is a fresh trend. Therefore the research and implications related to it are somehow narrow and insufficient. Hence, it is not possible to argue some universal, scientifically proven facts about indoor farming. In light of this thought, the study aims to accommodate an exploratory research, that recognises currently stated scientific findings regarding the concept, evaluated together with common known facts about indoor farming. By this study, the author aims to encourage academia and professionals to reconsider whether dynamics of an indoor farm in a developed country as Norway are similar to correlatives of other countries that earlier studies took place. Furthermore, it is also crucial to inspect whether indoor farming is feasible to contribute environmental benefits to societies, as argued. Albeit a general, long term implication to the concept is vital in realisation of indoor farming, this study denotes to a cross-sectional time frame. As mentioned earlier, base year to this study is 2016, and the economic analysis pertains to following five years of due to serviceable life of equipment. However, findings of the study is believed to be an appropriate reference to current dynamics of indoor farming, as existing indoor farms confirm the reliability of output. In accomplishment of data acquisition, application and evaluation, the author has reached to more than 200 suppliers, contacted to all indoor farms in Scandinavia (Norway, Sweden and Denmark) together with roughly 20 other indoor farms in Europe and Japan. The author also visited five indoor farms personally, also had short phone interviews with agricultural authorities in Norway for many hours. Albeit the thorough time and effort spent in order to acquire accurate data, it is possible to state that some information used in this study have changed already. To sum up, although this short time horizon study is suggested to reflect a realistic view to indoor farming for the current year, it is important to underline that the concept and technology, applications related to it are notably dynamic and rapidly evolving. In light of this, even though a purely objectivist philosophy is aimed to achieve in this study, the author eventually was contrived to follow a critically realistic approach in this study. According to epistemological philosophy, critical realism takes its fundamentals from direct, observable perceptions an individual has towards “things”. Yet, in interpretation of these things, senses and experience of these people influence notions. Even though scientific and measurable realities of the nature are respected in this study, various conclusions are made due to common thoughts and assumptions of people in the area of study, due to their preferences, culture and impressions.

# 4. Data Analysis

## 4.1 Introduction

With facilitation of earlier chapters, this chapter aims to elaborate remaining details of the data analysis. Additionally, the main goal of this chapter is to exhibit findings of the study, as well as analysis of earlier theory with corresponding conclusions.

Since there are various findings relevant to aforementioned sub-topics, results will be classified in several sections. Firstly technical findings will be shared, together with details estimated regarding annual yield, lighting cost, production efficiency and investment costs. These findings will be also useful to determine presumptions for the rest of the study. Following, factors of production will be assessed for the case. Secondly, costs of lettuce for the reference year - 2016 will be examined in monthly basis. Estimate prices will be categorised in wholesale, import, retail and market prices. Average prices for each market type will be evaluated, in order to provide necessary data for the following section. Finally, critical factors in marginal costs, as well as production costs will be examined. Pricing strategies, profitability and production efficiency factors will be measured. In implication of the final section, analysis will be divided into three different scenarios, in order to examine findings for three different markets.

## 4.2 Production

### 4.2.1 Annual Yield Estimates

If the goal is to produce plants for any facility, harvested goods (in other words yield) are the sole output of the production. Therefore, result of harvested goods are critical in evaluation of performance or other characteristics from perspective of economics. Distinctive to assumptions mentioned earlier in the study, amount of harvested goods is not a hypothetical number. Rather, based on earlier assumptions, further calculations and analyses provide certain numbers to the amount of harvest for the year. In case further technical details needed to examine the production, harvest details in the Appendices A can be followed.

Regarding the product, an iceberg lettuce that weighs between 350 to 400 grams, with diameter of 15 to 19 centimetres estimated. In the study, $50m^2$ net area is reserved for production, together with equipment necessary. With reference to these attributes, maximum annual yield for an indoor farm can be no more than 48.000 lettuces.

Depending on the production efficiency, annual yield level is expected to vary between 23.000 to 48.000 lettuces. Alternative yield volumes can be examined in Table 2.

| PRODUCTION EFFICIENCY SCENARIOS | | | |
|---|---|---|---|
| *Scenario Name* | *Efficiency Score* | Monthly Yield | Annual Yield |
| Full Yield | 100 % | 3 996 | 47 952 |
| Efficient | 90 % | 3 596 | 32 368 |
| Tolerable | 70 % | 2 797 | 25 175 |
| Inefficient | 50 % | 1 998 | 17 982 |

Table 2. *Depending on hygiene, environmental controllability, productivity and several other factors, production volume can vary to lower levels. Possibility of diminished efficiencies should be considered in business processes of indoor farms.*

Compared to findings of the German Aerospace Center (2013a), SSIF is expected to be less productive regarding year-round production, in particular amount of production periods per year. Referred study suggests 13,04 periods of production in a year for iceberg lettuce. However, this study estimates only 9 periods of production in a year. This difference is mostly due to lack of most recent technology. In order to acquire better technology, further investments in equipment is necessary, which would increase costs of production and would hamper possibility of a SSIF to compete with current markets. In plant density, large-scaled indoor farm provides 20 lettuces per area, while small-scaled indoor farm provides 24 lettuces per area. Despite an advantage in rounds of production throughout the year, SSIFs can be still advantageous in use of area. This factor is due to optimal use of space, as well as limiting production to only iceberg lettuce in SSIF.

### 4.2.2 Factors of Production

Taking its roots from fundamental norms of economics, factors of production are used as a major aspect in various areas of economics. Similarly, Barkley and Barkley (2016) introduce resources for agricultural production in four different names: land, labor, capital and management. According to their findings, agricultural economics define factors of production as follows:

- Land: Natural and biological resources, including climate.
- Labor: Human resources used in production cycle.
- Capital: Machinery, tools, equipment and manufacturing resources used in production.

• Management: Entrepreneurs who assist circulation of inputs and outputs.

Considering a traditional outdoor or greenhouse farm, it is possible to reflect various material to these definitions. The land property, which is used for cultivation or processing of crops is represented as land. Production labor; ploughmen, crofters, collectors, agronomists and other individuals working in process of production are represented as labor. Tractors, plows, sprayers, irrigation systems, and other agricultural machinery are represented as capital. Farm owners, middlemen working for the farm, as well as employers finding necessary labor are represented as management.

According to the theory, these four factors of production are initially assessed whether it is possible to acquire an optimal amount of input for production. To illustrate one example used at Figure 5a, a farmer can measure the most efficient amount of fertiliser that can be used in production, and adjust its production input accordingly.

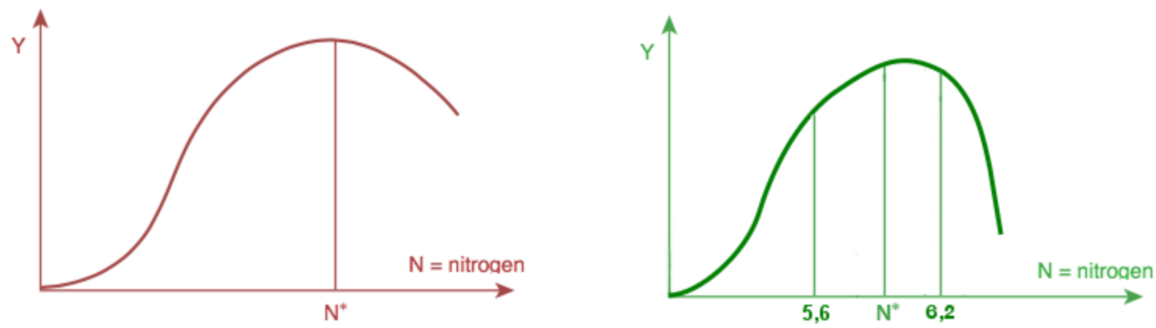


Figure 5a (*left - brown color). Yield difference as a function of nitrogen to an outdoor farm.*
Figure 5b *(right - green color). Yield difference as a function of nitrogen to an indoor farm.*

Optimal amount of fertiliser is volatile for traditional farms. This amount changes depending on the climate in the production location, soil attributes, as well as type of plant. Yet, there are less variables in analysing resource use for indoor farms. Comparably, optimal amount of fertiliser use does not depend on location, or the climate in the production location in an indoor farm. The only important factor is the type of plant produced. Through this research, an optimal efficiency in production to this particular farm can be achieved. Relevant to amount of nitrogen used, pH range of water for lettuce shall be kept between 5.6 to 6.2 (Storey, 2016). This possibility of determining certain numbers for indoor farms provide a significant advantage to development of agriculture under such concept. While it is difficult to state a universal, widely applicable numbers in production for outdoor farming, it is possible to highlight specific numbers for use of various resources in global level for an indoor farm.

Thanks to this advantage of indoor farming, the spectra for determining optimal rates in factors of production can become narrow, which is another opportunity that can be reflected for indoor farming compared to traditional farming, in perspective of economics.

With that it is possible to state a certainty in production efficiency for various resources, factors of production covers use of many other resources that are influential in production efficiency. Keeping this fact in mind, the aforementioned opportunity may not be influential in every resource used in agricultural production. Notably, use of labor in production is also likely to become volatile in an indoor farm, depending on the type of plant produced, as well as location and other characteristics. In light of this possibility, the study will aim to resolve, whether it is possible to determine optimal amount of resource use for other assets as labor, electricity, water or production machinery. For some of these resources, it may be possible to state an optimal amount of resource to be used for a certain product. However, the optimal amount of use may vary depending on time, production facility size, as well as location. Therefore, from factors of production perspective, efficiency of indoor farm should be continuously measured to figure changes in use of resources.

### 4.2.3 Feasibility in Production

As described in earlier chapters, costs for establishing and producing plants in an indoor farm are to be evaluated in practices relevant to corporate finance. In light of this information, cost analyses are also measured in terms of accounting standards. Calculating costs of investment and production, feasibility in production can be evaluated by analysing costs per product, or annual costs in further steps.

Regarding cost analysis, it is possible to categorise the study and its finding in four different fields. Firstly, examination of fixed costs, which cover capital expenses (CAPEX), operating expenses (OPEX), depreciation acquired from CAPEX and land costs. Secondly, examination of utility costs, which pertain to cost of electricity and water use throughout the year. Thirdly, examination of variable costs, which cover use of media, utility, delivery and labor resources that are dependent on unit of production. Lastly, examination of component costs, which provide an overview to distribution of costs evaluated in process of production as a whole. Utility costs, examined separately before variable costs, are also part of variable cost calculations, as the amount of electricity is dependent to amount of production. However, use of electricity and water deserves an extensive analysis, as there are various arguments from respected researchers.

#### 4.2.3.1 Analysis of Fixed Costs

In financial accounting context, the investment made to provide machinery and tools required for production is listed under table of CAPEX, together with other expenses. In this particular case, CAPEX is also used to determine all tools and equipment that are used solely in production of plants. Further details can be assessed in the Appendix B.1., CAPEX is divided into five parts:

- Light: lighting equipment that are used to provide necessary energy to plants in germination and growth periods.
- Media: ground materials that are used in replacement of soil, to provide necessary conditions for both germination and growth.
- NFT system: production racks, water tanks, pumps and fans that are required in build of the system.
- HVAC + Sensor: Devices needed for providing necessary climate conditions within the facility, as well as measurement units to make sure that these conditions are met with needs of the plant.
- Equipment: Devices needed in delivery, packaging and storage of plants, as well as tools needed for management labor.

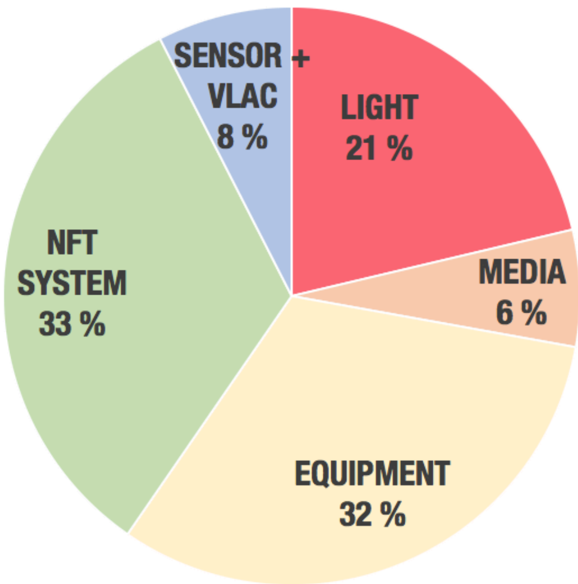


Figure 6. *Distribution of capital expenditures for a small-scaled indoor farm, proportionally.*

In calculation of CAPEX, lighting equipment is expected to be the most dominant expense. Each plant produced indoors, require different amount of light and light quality. According to feedback received from indoor farmers, lighting equipment selected and the amount of light provided to lettuces is adequate for production of plants in efficient levels. The supplier of these lighting equipments is a mass producer located in China, promising a satisfactory quality, yet not one of the distinguished producers for indoor farm lighting equipment. Once spot prices acquired from this particular supplier, cost of lighting equipment accounts only for 21% of the costs. Surprisingly, this is a small proportion in CAPEX for provision of lighting equipment. Alternatively, a price inquiry is also requested from a reputable lighting equipment producer, located in Finland. With reference to the price offered by this supplier, lighting costs increase up to 52% of CAPEX, yet with guaranteeing higher efficiency in production.

Keeping these learnings in mind, it is possible to underline the risk that can be taken by the producer, depending on the type of production that will be followed. If, indoor farmer is interested in producing plants that do not necessarily require high lighting efficiency, then it is possible to acquire lighting equipment from more cost-effective resources. If, produced plant is sensitive to quality of light obtained, additional costs may occur in supply of lighting equipment, and indoor farmer is suggested to direct to more reputable suppliers.

| OPERATING EXPENSES | | | |
|---|---|---|---|
| Name | Amount (NOK) | % in Annual OPEX | % in Annual Fixed Costs |
| S&A Expenses | 338 790 | 76 % | 54 % |
| Indirect Labor | 60 725 | 14 % | 10 % |
| Other Operating Expenses | 47 000 | 11 % | 8 % |
| **OPEX SUM (NOK):** | **446 515** | 100 % | 72 % |

Table 3. *Annual operating expenses for an indoor farm.*

Identical to CAPEX, another unit of fixed costs, OPEX are also analysed before the production takes place. There are three sub-areas of expenditures covered in OPEX. Selling & administrative expenses, covers the salary of employee working in marketing, accounting and delivery tasks.

Indirect labor, that are outsourced for completion of various issues as plumbing, electricity and legal requirements. Finally other operating expenses that cannot be categorised in a specific field, yet covers needs as office supply or annual insurance.

As provided in Table 3, selling & administrative expenses account for dominant part of OPEX with 76%. Within fixed costs, covering direct labor by selling & administrative expenses account for more than half of the costs. This significant amount of dominance within cost analysis reflects one remarkable reality regarding small-scaled indoor farms in Norway.

Individuals who are founders of indoor farms tend to cover S&A administrative expenses of indoor farms. In an ordinary production facility, founders are expected to take responsibilities in executive management, such as becoming chief executive officer, or chief financial officer of the company. However, in small-scaled indoor farms, their executive, leading roles aside, founders tend to cover up the needs of providing selling and administration, such as applying marketing, sales, as well as delivery of the goods.

The author of this study has made several visits to various indoor farms in Europe. During these visits, similar activities are observed in founders of small-scaled indoor farms, from covering up accounting management, to delivery of plants to consumers. As these indoor farms scale up in near future, further employment possibilities may occur for labor. However, it is crucial to realise that sourcing of these tasks by hiring new employee has a substantial influence over the cost of the product. Further analyses to these possibilities will be implemented in following chapters.

Regarding depreciation calculations, there are various types of depreciation methods available. Among these few, straight-line depreciation method is applied, as it is described by Brealey et. al. (2008a). After calculations, yearly depreciation is calculated as 81.635NOK, which accounts to roughly 13% of annual fixed costs.

Finally land costs cover annual rent paid for production facility, as well as insulation made, in order to establish a controllable environment within the production facility. Annual land costs are calculated as 94.000NOK, which covers close to 15% of annual fixed costs. As farming is considered as a traditional, and long lasting business, either in case studies, or in real-time analyses, farmer is expected to own the land. This factor increases land costs remarkably. For most of the cases, land cost account for highest expenditure in use of farms. However, this assumption may not be alike for indoor farms. Alternatively, proportion of land costs may change significantly, if indoor farmer prefers to own the land instead of renting annually. After collecting all expenses covered within fixed costs, 622.150NOK is estimated for annual fixed costs in the case. In case considered necessary, further examinations can be done, as all details of fixed cost analyses are shared in the Appendices A.

#### 4.2.3.2 Analysis of Utility Costs

As introduced in earlier chapters, utility costs account for annual use of electricity and water in production and management. In larger facilities, water use costs can be crucial in acquiring further economy in production. However, for a SSIF, water use accounts even less than 1% in costs of production. According to the analysis, annual cost of water use is 6.406NOK, including cleaning and other costs.

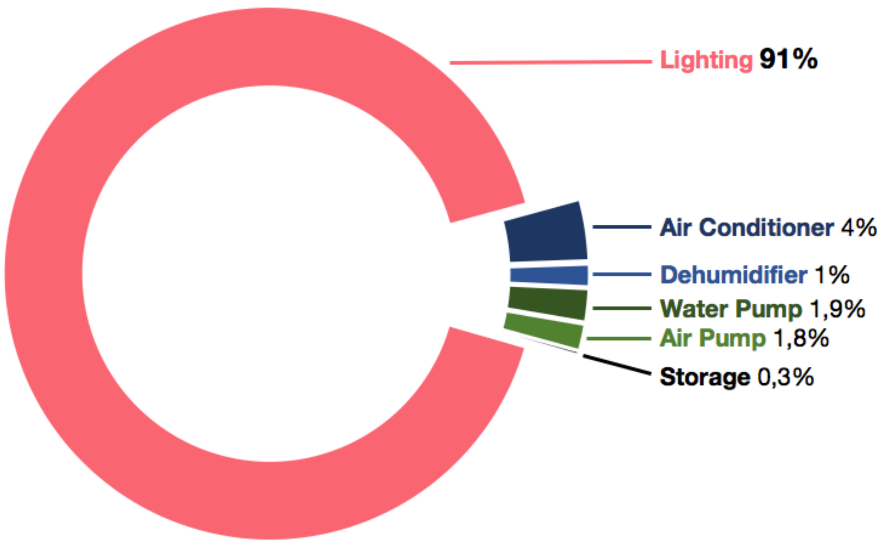


Figure 7. *Proportional distribution of annual electricity costs for an indoor farm.*

Regarding electricity costs, annual cost of electricity use is estimated 71.597NOK. This accounts for 8% of costs of production, which can be influential in following analyses. As mentioned earlier, various theories claim that cost of a plant produced is highly dependent on the price of electricity, as well as amount of electricity consumed by lighting equipment. Kozai (2013) expects between a dominant 70 to 80% share to lighting costs in electricity. According to the analysis, in SSIFs this share can increase even to 91%, which makes lighting electricity use as further prominent expense in determination of costs. As can be examined in Figure 7, HVAC expenses for electricity (dehumidifier and air conditioner) account for 5% of the electricity, while remaining expenses are due to use of pumps and storage units.

Depending on the lighting equipment used, as well as type of plant produced, agronomists are encouraged to make further technical experiments in order to find optimal amount of lighting energy used in production. With this analysis, production costs can be diminished, by ensuring required amount of energy is provided to plants produced.

### 4.2.3.3 Analysis of Variable Costs

Compared to fixed costs, variable costs refer to expenses that very depending on the amount of product produced.Variable costs are divided into four categories. First, media, which contains artificial media that replaces soil (coco coir plugs), seedlings to crop, fertiliser to use in production. Despite bought in large amounts, a total cost is calculated for media costs and estimated 0,28NOK per product. Second, utility costs are calculated, as earlier described in details. 1,63NOK estimated for utility costs. Third, packaging material and transportation expenses (gasoline, toll, parking) are calculated as delivery costs, with expense of roughly 0,27NOK per product. Finally, production labor calculated in details, with costing 2,84NOK per product. In total, variable cost is 5,01NOK per product.

According to findings, production labor accounts for a remarkable part of variable costs in Norway. As Figure 8 represents, 57% of variable costs is due to labor used in production. According to this finding, it can be argued that a significant amount of savings can be acquired in variable costs by cutting costs in production labor.

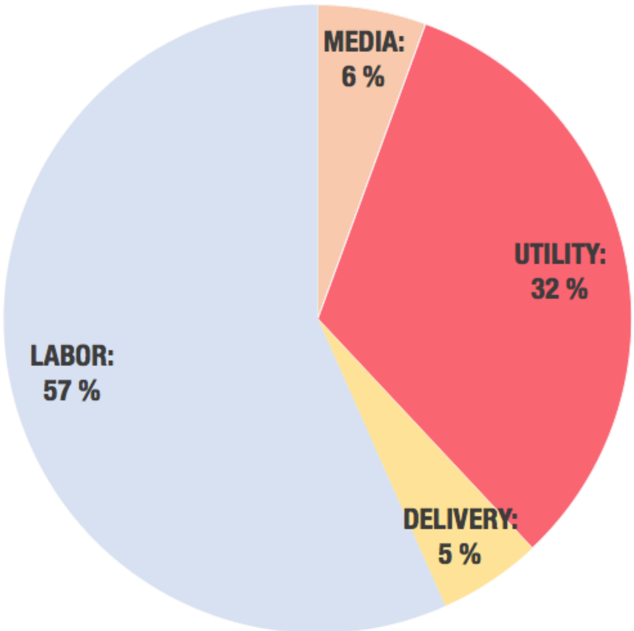


Figure 8. *Distribution of variable costs for a small-scaled indoor farm, proportionally.*

#### 4.2.3.4 Analysis of Component Costs

According to the study of Ohyama (2015), as well as reports shared by Spread Co. Ltd. at Kozai (2013), it is possible to estimate average cost intervals for component costs of a large scaled indoor farm. Both sources producing more than 5.000 lettuces a day, denoting approximate distribution in their costs as 24% for depreciation costs, 23% for labor costs, 27% for electricity costs and 16% for delivery costs. Arguably, component costs of a SSIF in Norway are remarkably different. Due to high labor costs, labor accounts for 42% within costs, while delivery accounts only for 4%.

The interpretation of component costs are useful once it is a necessity for project leaders to consider further savings in budget. Relying on reference research, both academics suggest further development in order to decrease costs in labor and electricity. In parallel, for a developed country as Norway, one can clearly suggest to pursue further research, in order to decrease costs relevant to labor. Currently, existence of indoor farming concept is in minor level for Norway. However, if indoor farming becomes a common method of producing plants in Norway, it is also possible to expect a significant focus on development of automated production.

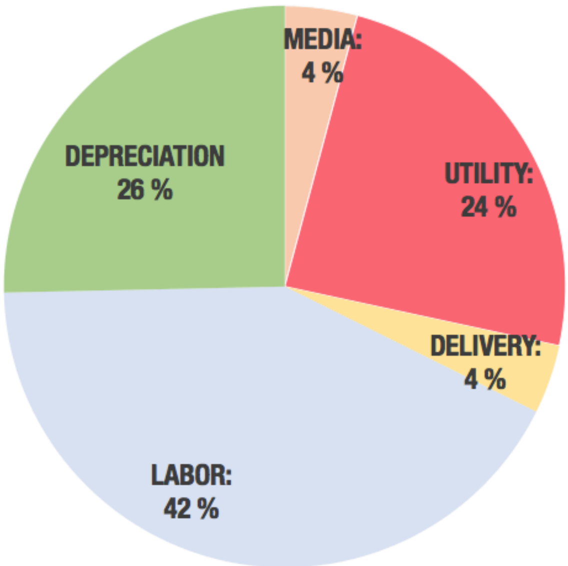


Figure 9. *Distribution of component costs for a small-scaled indoor farm, proportionally.*

### 4.2.3.5 Analysis of the Project Cost

Beyond NPV and break-even analyses that are covered in this study, investors also evaluate viability of projects in terms of "give and take" mentality. How much money is dedicated to the project? How much money is possible to receive in return?

To comply such calculations, various financial analyses as internal rate of return, or return on investment are applied initially, followed by more comprehensive analyses. Even though such calculations are not covered in this study, it is crucial to provide an answer to the question "What is the amount required, in order to establish and operate an indoor farm for the first year?". Several studies include or exclude various parts of expenses in calculation of the project cost. In this study, project cost covers the expenditure for equipments (CAPEX), as well as variable costs and OPEX for the first year. Project cost table is shared in Table 4.

| Project Cost | | |
|---|---|---|
| **Name** | **Value** | **Share in Total** |
| Fixed Cost - Administrative Expenses | 338 790 | 32 % |
| Fixed Cost - Other Expenses | 201 725 | 19 % |
| CAPEX - Equipment Expenses | 89 398 | 8 % |
| CAPEX - Other Expenses | 191 724 | 18 % |
| Variable Costs - Production Labor | 136 264 | 13 % |
| Variable Costs - Other Expenses | 104 224 | 10 % |
| TOTAL (NOK): | **1 062 125** | |

Table 4. *Project cost of an indoor farm (regarding scenario 1).*

According to the calculation, to establish a SSIF, and to provide a year-round production of lettuces for the first year, an amount of 1.062.125NOK is required. Keeping such amount in mind, if the project is likely to pay an amount that is equal to or greater than the project cost, investors are more eager to support realisation of such project. Contrarily, if the project is paying remarkably less compared to its cost, a major risk taken for a minor earning in their assessment, therefore it is less likely to receive support.

| Monthly Estimates - 2016 (NOK/Piece) | | | | |
|---|---|---|---|---|
| Month | Import Price | Wholesale Price | Retail Price | Market Price |
| Jan | 5,97 | - | 13,92 | 19,48 |
| Feb | 5,81 | - | 14,25 | 20,37 |
| Mar | 9,54 | - | 17,30 | 21,25 |
| Apr | 9,58 | - | 18,00 | 22,58 |
| May | 13,52 | 12,07 | 22,52 | 26,11 |
| Jun | 11,74 | 7,77 | 20,39 | 24,34 |
| Jul | 11,39 | 7,10 | 19,70 | 23,45 |
| Aug | 11,59 | 7,52 | 19,51 | 22,80 |
| Sep | 12,72 | 8,14 | 19,53 | 21,25 |
| Oct | 13,21 | 10,49 | 19,97 | 21,45 |
| Nov | 10,21 | 10,14 | 18,22 | 22,14 |
| Dec | 6,74 | - | 14,61 | 19,78 |

Table 5. *Estimate average prices of iceberg lettuce in Norwegian market. Per piece.*

## 4.3 Market and Prices

As introduced earlier, acquisition of prices for lettuce has been a challenging yet an unavoidable task to understand, whether a SSIF can become viable to offer both value and profit to the society. Taking its roots from detailed description at Sub-section 2.3.1.1, price data necessary for each phase of the process are collected and derived. Although some of data are collected in monthly basis, remaining data was collected in weekly, or even daily basis. In arrangement of data for a sensible study, prices of lettuce in monthly basis are constructed in Table 5. As the study considers 2016 as the base year, monthly prices account for months of year 2016 too. In this table, it is critical to understand that the first two, import prices and wholesale prices are effective to one part of the process: when producers sell to suppliers. As competition provides the advantage, suppliers receive bulk amounts of lettuces either from domestic producers or they import same goods from Spain. Concurrently, increases in prices from producer to supplier influence prices in later levels of the phase. Therefore, it is possible to examine an average increase in prices for relevant months, once import price or wholesale price is higher than the market average.

Furthermore, according to feedback received from various authorities, there are many factors influencing the prices of vegetables in the Norwegian agricultural market. Negotiations of producers with their union, representation of producers by the union to the ministry of agriculture, targeted prices for goods, as well as tariffs, quotas or subsidies regarding import of agricultural goods are beyond the scope of this study, albeit they can be critical to prediction of lettuce market and its prices for future research. In analysis of the market and prices, for this study a "market average", or an approximate price area is indicated for determination of a desired price to lettuce produced in SSIF. According to the analysis, wholesale price has an average of 9,03NOK annually, while import price has an average of 10,17NOK annually. Regarding the following market which covers from suppliers to retail chains, an average price of 18,16NOK is estimated for retail price, as second phase of the sales process. Finally, when retail chains sell lettuces to consumers, an average price of 22,09NOK estimated for each lettuce. So simply, these prices are initially calculated by calculating annual average prices of products, once they are divided into monthly basis due to regular calendar. In following parts of the study, these findings are used to decide "What should be the price of a lettuce that is produced in an indoor farm?". In calculation of product price, these numbers are multiplied in certain amounts and defined the profit suggested for each market. To illustrate an example, for each scenario there is an estimated 17% to 47% profit added to product cost. This calculated amount is sales price of the product. In analysis for "producer to supplier scenario", it is possible to realise that sales price is roughly 23% above wholesale price annual average, which can bring various risks or opportunities, as they will be explained in following findings. One final, yet very important point is the price gap that occur between actors of the market. Although a theoretical basis is not granted, it is possible to argue that the closer prices are within the market, the more competitive actors become. Thus, import prices are comparable to wholesale prices. Accordingly, domestic wholesale market competes with import market to provide goods to suppliers. While competition occurs between domestic and foreign producers exceptionally, it is not possible to mention another type of competition between other actors of the market. As observations of the author also suggests, a noteworthy sales transaction by bypassing one of the actors does not take place in lettuce market. Considering these in mind, it is significantly crucial to suggest a SSIF to ensure its positioning in the market. Before deciding how to produce or where to produce, it may be more vital to ask: "Who are potential customers?" and "Who are potential competitors?" which will be analysed in following topic.

# 4.4 Competition and Profitability

## 4.4.1 Introduction

Until this part of the study, the concept has been evaluated from numerous aspects. Each chapter and its sections were elaborated in order to find objective answers to various questions that arise regarding the indoor farming. Findings to these questions (in other words; implications that were highlighted in earlier sections) will be collectively used in this section, to present an ultimate finding regarding the study.

Earlier in Section 4.2., economic factors of production was analysed extensively, underlining most influential instruments in cost, notably labor for production, as well as labor for marketing. In a developed country as Norway, a case in which labor costs dominate the remaining is not unexpected. Nevertheless, economics necessitates to resolve a common factor, then build further scenarios regarding the case. Therefore, the analysis will be divided into three different scenarios, in order to consider the possibility of initiating a viable indoor farm at every case. Three scenarios will be formed as follows:

1. <u>Business As Usual:</u> As planned, the founder will have managerial responsibilities in the project. Both production labor and marketing labor will be employed.
2. <u>Founder As Production Labor:</u> Managerial roles aside, founder will be responsible to provide workload needed to produce goods. One additional employee will be hired only to cover marketing and sales tasks.
3. <u>Founder As Marketing & Sales Responsible:</u> Managerial roles aside, founder will be responsible to provide workload needed for marketing and sales tasks. One additional employee will be hired only to lead production of goods.

In each scenario, initially proportion of electricity cost within variable cost and product cost will be shortly discussed, in order to compare with findings of other studies. Following, proportion of corresponding labor costs will be evaluated within product cost.

As the most significant analysis of the section, viability of the project will be evaluated in the market. First, sales price per lettuce will be determined. Second, with regards to earlier theory, an NPV analysis will be implemented in the scenario, in order to figure whether the project is worth investing or not.

Project length is limited to five years in NPV, as most of equipment and investment have life expectancy of five years or less for use. Third, distributed average price of lettuce will be compared with average prices in the market for the year 2016. Depending on findings, it will be possible to state whether a SSIF in Bergen producing iceberg lettuce can become competitive, as well as profitable.

As final part, a break-even analysis will be implemented, in order to measure risks. In this study, there are two assumptions made to consider best case out of production:

- There will be no wastage in production and lettuce will provide full yield.
- Every lettuce produced will be sold in the market before expired.

  These both assumptions are made, in order to limit the analysis of the study to provide relevant findings. However, doubtlessly wastage and expiration after production should be expected in a SSIF. Both possibilities combined, the possibility of selling less amount of goods will be analysed by decreasing "annual production volume" without making necessary cuts in fixed and variable costs. Due to this fact, cost per product will increase, hence price for product will also need to increase. Break-even analysis suggests to figure, how much should be the price of lettuce, in case annual production volume decreases, in order to survive? In this analysis, break-even points will be highlighted with specific numbers, providing a "neither profit nor loss" status to the reader.

### 4.4.2 Business As Usual Scenario

Most of details that can also refer to this scenario are highlighted in Section 4.2.3. already. To compare with other scenarios, lighting and labor proportions are demonstrated as follows:

- Lighting cost covers 26% of variable costs, as well as 7% of product cost.
- Production labor and marketing & sales labor together cover 53% of product cost.

To remind, Kozai (2013) and Ohyama (2015) estimate an approximate 27% share for electricity, as well as 23% share for labor in cost of production. Arguably, a SSIF, operated as usual in Norway provide remarkably different results, as mentioned above. This might be due to higher electricity costs in Japan, or similarly due to higher labor costs in Norway. Yet, absolute explanation of this particular difference is subject of another study.

Before implementation of NPV calculation, it is crucial to provide a particular answer to the question: "What is the production cost of each lettuce?". According to the study, it costs 17,99NOK to produce each lettuce. Within these costs, variable costs account for 28%, while fixed costs account for 72%. Remaining details of product cost calculation can be examined in details of Appendices B.

As product cost is already greater than average of most of prices in the market, a small positive profit margin is predicted for the scenario, in order to allow the facility to remain competitive. Initially, retail chains are regarded as competitors, while consumers are regarded as customers. 22,12NOK of average market price as reference, 95% of it is calculated for average price of product: 21,01NOK. The price is distributed directly proportional to market prices in monthly level. With determining these inputs, NPV calculation is implemented.

Income statement for the year 2016 is the initial step of NPV. With price of 21,01NOK per product, as well as 47.952 annual sales, 108.760NOK net income is received for year 2016.

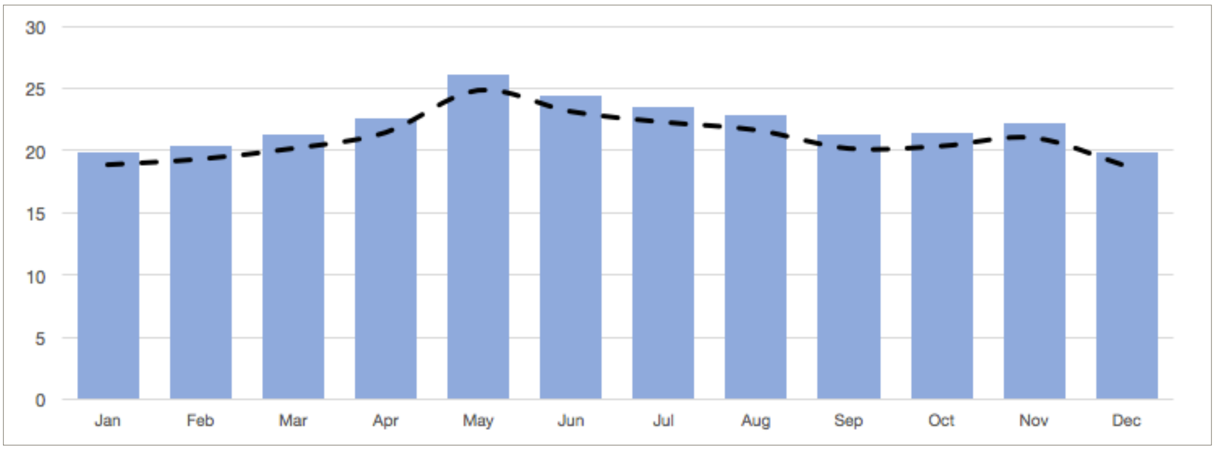


Figure 10. *Monthly average market price and product price for scenario 1.*
*Blue bars: market price of retail chains. Black line: product price of a SSIF. Currency: NOK*

Regarding NPV, after operating for five years, project will return 599.894NOK profit to the investor. Once considered financially, these numbers may indicate an optimistic view to invest for the project. However, there are various concerns that would arise, which can be analysed as follows:

- Yearly income in these rates provide around 9.000NOK each month to the investor. These earnings are notably less than an average amount needed for an individual to afford living costs in Norway. Therefore, additional earnings may be necessary for the founder, which will hamper the dedication needed in order to administer the facility.

- Despite the competitive price in the market, it might be still challenging to convince customers to order products from the facility instead of a retail chain that they find reliable. Therefore, an either additional investment for public relations have to be considered for the goods, or the founder may focus to a niche market instead (*e.g.* organic market, exotic food buyers, vegan communities).
- With compared to project cost of 1,062Million NOK for year 2016, earning less than 600.000NOK in return will be considered too risky from a corporate financial perspective. There are abundant project ideas that provide greater earnings even for lower budgets.

Monthly average market price and product price comparison for this scenario is shared in Figure 10. This figure also illustrates the potential competition possibility between the facility and retail chains. However, convincing customers to buy from the indoor farm, instead of retail chain requires further analyses in areas of marketing and public relations.

Finally break-even analysis will be examined in details, in order to analyse several factors regarding risks of production for a SSIF at Figure 11. There are several findings that can be stated from the analysis. These statements are as follows:

- If the facility could provide a 100% productivity in annual production volume (47.952 lettuces), only a price above 18,09NOK would make the project profitable in five years of period.
- In current pricing of 21,01NOK, there should be no less than 41.282 lettuces produced. To provide such amount, the facility needs to reach at least 86% productivity in production.

**BREAK-EVEN ANALYSIS**

| NPV CURRENT | MARKET PRICE PER PRODUCT | | | | |
|---|---|---|---|---|---|
| 599 894 | 18,09 | 21,01 | 24,72 | 30,90 | 41,20 |
| **ANNUAL PRODUCTION VOLUME** | | | | | |
| 47 952 | 0 | 599 894 | 1 360 934 | 2 629 334 | 4 743 335 |
| 41 282 | - 516 446 | 0 | 655 177 | 1 747 138 | 3 567 073 |
| 40 759 | - 995 879 | - 556 900 | 0 | 928 167 | 2 475 112 |
| 38 362 | - 1 539 237 | - 1 188 054 | - 742 533 | 0 | 1 237 556 |
| 35 964 | - 2 082 595 | - 1 819 207 | - 1 485 067 | - 928 167 | 0 |

Figure 11. *Break-even analysis results of scenario 1.*

- Once productivity decreases by 15%, 20% and 25%; product price has to be increased by 36%, 71% and 128% respectively in order to acquire a break-even point. In light of these analyses, it can be stated that the price of lettuce is notably sensitive to changes in annual production. Therefore, it is crucial for the facility to ensure a productivity ratio as close as possible to 100%.

### 4.4.3 Founder as Production Labor Scenario

As the project cost analysis and various other observations suggest, a possibility of the founder working in the farm also as a production labor, in order to cut production labor costs will be assessed. In comparison to the first scenario, initially, several changes to details described in Sub-section 4.2.3 will be analysed. First evaluation at this sub-section relates to changes in fixed costs. Since production labor is listed in variable costs, there is no change happening in fixed costs to this scenario, and therefore findings in 4.2.3.1 can be also referred to scenario two. Same with utility costs, although their shares within variable costs change, there is no difference in proportion of utility costs within. Therefore, comparison of this topic is also avoided. Changes in following scenarios, as well as analyses will be evaluated in separate topics.

#### 4.4.3.1 Changes in Variable Costs

According to earlier analysis, production labor accounts for 57% of variable costs. However, in this scenario, this cost is covered by the founder and therefore not included in the calculation. In original scenario, variable costs were 5,01NOK per product. With exclusion of production cost, variable costs decrease to 2,17NOK per product.

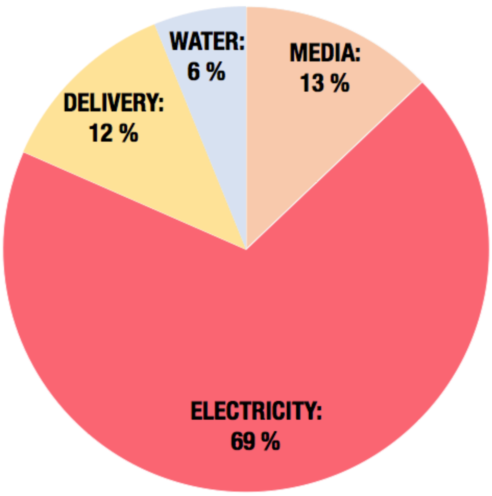


Figure 12. *Variable costs of an indoor farm for scenario 2, proportionally.*

By lowering cost to 2,84NOK, it is possible to save up to 136.000NOK annually. Evaluating it without production labor, variable costs are illustrated at Figure 12 to the scenario.

Once production labor cost is cut, electricity cost is dominant part of variable costs. In this scenario, project manager should consider further research and innovation possibilities to diminish electricity costs in production. Even though electricity cost accounts for low as 1,49NOK in each product produced (10% of product cost), there are extensive research taking place in development of lighting systems for indoor farms, which also provide solutions in production that decrease costs. Furthermore, once the production facility scales up, it is likely that variable costs will become more influential in product costs. Considering this possibility, it is suggested to maintain production with cost-efficient products in this phase as well.

#### 4.4.3.2 Changes in Component Costs

As the production labor is excluded in variable costs, newer overview of component costs are illustrated in Figure 13.

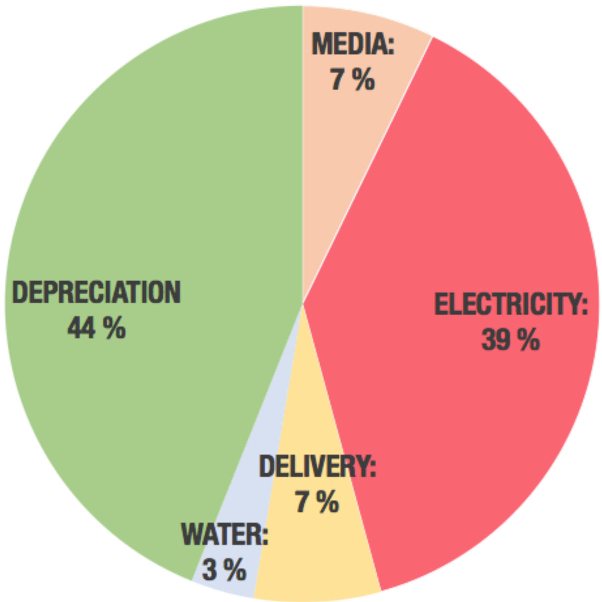


Figure 13. *Component costs of an indoor farm for scenario 2, proportionally.*

Compared to shares in scenario 1, depreciation and utility take higher account in component costs of an indoor farm. However, these results still indicate findings remarkably different than findings of Kozai (2013) and Ohyama (2015). As described earlier, component costs are useful in analysis of further savings. Thus, as previous findings in variable costs suggest it is sensible to pursue further savings in electricity. Savings in depreciation can be done by acquiring equipment that are less costly. However, for ensuring a minimum quality in production, this idea is not suggested for consideration.

### 4.4.3.3 Changes in the Project Cost

In comparison to the project cost shared earlier, with exclusion of production labor in variable costs, updated version of the project cost table is as follows:

| Project Cost Evaluation | | |
|---|---|---|
| **Name** | **Value** | **Percentage** |
| CAPEX - Equipment Expenses | 89 398 | 10 % |
| CAPEX - Other Expenses | 191 724 | 21 % |
| Fixed Cost - Administrative Expenses | 338 790 | 37 % |
| Fixed Cost - Other Expenses | 201 725 | 22 % |
| Variable Costs | 104 224 | 11 % |
| TOTAL (NOK): | **925 861** | |

Table 6. *Project cost of an indoor farm for scenario 2.*

Compared to the project cost of Scenario 1, project cost diminished roughly 136.000NOK as expected. Even though this can be a notable saving in variable costs, as well as cost of product in the market, from perspective of an investor the budget required for the project is still close to one million NOK, which is still an important amount considering whether to invest.

In evaluation of project costs by share, one can realise that administrative expenses account for major part of costs. According to Scenario 1, share of production labor was 13%, compared to 32% of administrative expenses. Once production labor is excluded, administrative expenses rose its share to 37%. This analysis suggests that further savings are possible in project cost, by covering of marketing & sales expenses (as part of administrative expenses) instead of covering production labor by the founder. Effects of this decision will be analysed in details in following scenario.

### 4.4.3.4 General Findings

In Scenario 1, lighting costs accounted for 26% of variable costs, while they covered 7% of product cost. In this scenario, when share in variable costs rise to 61%, product cost share rises to 9%.

This means, the influence of lighting is considerably higher in variable costs, while it still has a minor effect in cost of product. Secondly, with exclusion of production labor in costs, share of money spent to labor decreases from 53% to 44% in total expenditures.

In comparison to scenario 1, it is also necessary to repeat the same question in this sense: "What is the production cost of each lettuce?", in order to examine its potential position in the market. According to the study, with exclusion of production labor, product cost decreases to 15,15NOK per lettuce. As expected, share of variable costs decrease from 28% to 14% in this cost, while share of fixed costs increase to 86%.

In Scenario 1, due to high production cost, indoor farm was suggested to compete only with retail chains, and solely consider consumers as customers. In this scenario, comparing product cost to estimate prices in the market shared in Table 5, it is possible to argue that indoor farm can also compete with suppliers, and may consider retail chains as customers. In this regard, it is possible to implement a price strategy relevant to "retail price" shared in Table 5, which represents the price of lettuce per piece, when it is sold from supplier to retail chains. Another concern of the project leader should be also to gain a valuable income throughout the year, in order to make the project worthwhile. Even though most of employment opportunities provide greater earnings in Norway, a humble earning of 200.000NOK is targeted for the project. In order to earn this amount in a year, the price of each lettuce should be 14% more than average price of 18,18NOK in the market. Thus, in average lettuce is priced as 20,72NOK in this scenario. With evaluation of monthly prices for base year 2016, price comparison to retail price is exhibited in Figure 14.

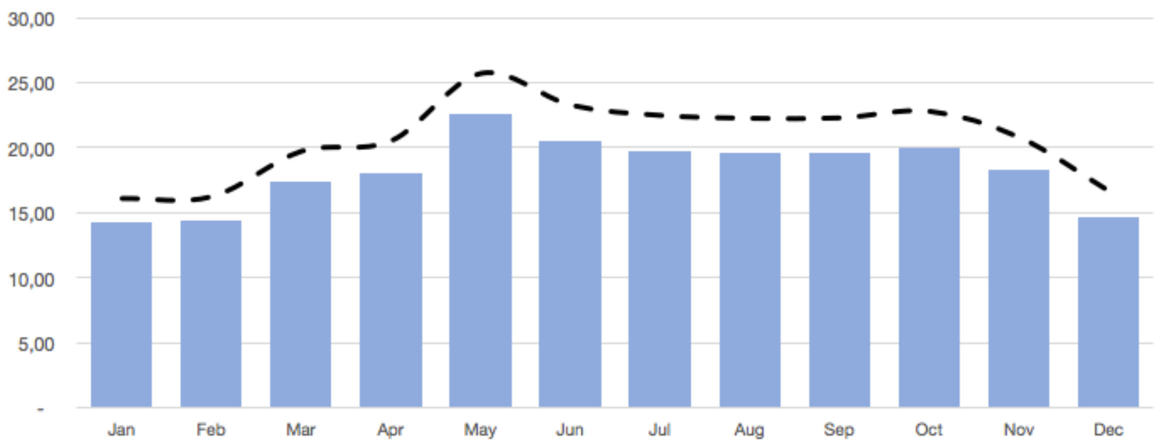


Figure 14. *Monthly average retail price and product price for Scenario 2.*
*Blue bars: market price of retail chains. Black line: product price of a SSIF. Currency: NOK*

As expected, average price of lettuce that are offered by an indoor farm is above retail prices in the market. Here, the risk of decreasing revenues becomes more apparent, as the customer (retail chains) are able to acquire goods in lower costs in the market. Furthermore, it is crucial to understand that these retail chains already have suppliers which prove a certain quality and trust in advance. Therefore, it is suggested for the indoor farm to consider further advantages either in product, or in delivery process, in order to become competitive with existing suppliers. With considered price for lettuce offered to retail chains, NPV calculation for the current scenario is implemented.

With amount of 47.952 annual sales, 200.459NOK net income is received for year 2016. Regarding NPV, after operating for five years, project will return 1.111.733NOK profit to the investor. Despite the promising output in NPV, there are various points that need to be highlighted, in order to assess the project objectively.

- In order to convince retail chains to acquire goods from a SSIF instead of major suppliers, further attempts to introduce the concept, as well as to explain potential benefits of indoor farming will be necessary. In order to do so, marketing and sales expenses may increase even further, although not considered in this case.
- One possible "selling point" to lettuces in this case would be the ability to label products as ecologic, as well as environment friendly. However, in order to label products as such, further regulations and standardisation attempts are expected to take place. Therefore, increase in legal expenses, as well as in CAPEX are also likely to take place, if this strategy is considered.
- By giving the responsibility of production labor to the project leader, managerial responsibilities are also hampered, which are crucial to guarantee a sustainable development for the facility. Especially in case of an unexpected issue in production (disease spread in products, lack of controllable environments or other), project leader will need to spend additional time in production in order to normalise the production. Thus, this may lead to further deficiency in management of the facility.

| BREAK-EVEN ANALYSIS | | | | | | |
|---|---|---|---|---|---|---|
| | NPV CURRENT | WHOLESALE PRICE PER PRODUCT | | | | |
| | 1 111 733 | 15,26 | 20,72 | 21,80 | 25,43 | 30,52 |
| ANNUAL PRODUCTION VOLUME | 47 952 | 0 | 1 111 679 | 1 330 714 | 2 069 999 | 3 104 999 |
| | 35 310 | - 818 597 | 0 | 161 289 | 705 670 | 1 467 803 |
| | 33 566 | - 931 499 | - 153 324 | 0 | 517 500 | 1 241 999 |
| | 28 771 | - 1 241 999 | - 574 992 | - 443 571 | 0 | 621 000 |
| | 23 976 | - 1 552 499 | - 996 660 | - 887 142 | - 517 500 | 0 |

Figure 15. *Break-even analysis results of scenario 2.*

As illustrated in Figure 15, break-even analysis findings can be stated as follows:

- If the facility is able to provide full yield (100% efficiency), any price given above 15,26NOK will return positive NPV. This amount is slightly (0,11NOK) higher than production cost. If the producer decides to follow a strategy to attract customers in the market, low amounts of income should be expected.
- With current price of 20,72NOK per lettuce, at least 35.310 lettuces should be produced annually, in order to maintain a positive NPV. This requires 74% efficiency in production minimum.
- If the production efficiency is low as 70%, 60% or 50%; price of lettuce should be increased to 21,80NOK, 25,43NOK and 30,52NOK respectively.

Under normal circumstances, production labor hired to provide necessary production efficiency is expected to have expertise required for such task. However, if the project leader is not able to fulfil this expertise comparably, production efficiency may decrease to these levels. In this case, evidently the facility would be able to determine consumers as their customers instead of retail chains, while competing with retail chains instead of suppliers. Nonetheless, this would still reflect risks highlighted in Scenario 1, combined with risks taken in this scenario.

The only promising factor in this scenario is that price sensitivity of lettuce is lower, compared to Scenario 1. With minor changes in annual yield, price of product went even up to 128% in earlier scenario.

However, in scenario 2, despite notable decreases in production efficiency, price increase appears between 36% to 100%, which enables founder to compensate price change easier in the market.

### 4.4.4 Founder as Marketing & Sales Responsible Scenario

Evaluating third and the final scenario, founder will replace marketing & sales responsible in operational scheme, in order to cut costs in sales & administrative expenses. Notably making changes to operational and fixed costs, a significant decrease is expected in production cost of lettuce in this scenario. Compared to the original scenario, there is no change taking place in variable and component costs for the project. Therefore, analysis of these costs for current scenario is skipped.

#### 4.4.4.1 Changes in the Project Cost

In earlier scenarios, the cost of establishing a SSIF and operating for a year was 1.062.000NOK for scenario 1, and 925.000NOK for scenario 2. With covering marketing & sales responsible in costs, project cost for scenario 3 is as follows:

| Project Cost | | |
|---|---|---|
| **Name** | **Value** | **Percentage** |
| CAPEX - Equipment Expenses | 89 398 | 12 % |
| CAPEX - Other Expenses | 191 724 | 26 % |
| Fixed Cost - Administrative Expenses | 15 870 | 2 % |
| Fixed Cost - Other Expenses | 201 725 | 27 % |
| Variable Costs - Production Labor | 136 264 | 18 % |
| Variable Costs - Other Expenses | 104 224 | 14 % |
| TOTAL (NOK): | **739 205** | |

Table 7. *Project cost of an indoor farm for scenario 3.*

Compared to the first number, this scenario indicates 323.000NOK lower budget required, in order to establish, and to operate the facility. This significant decrease in budget required, provides a promising overview to evaluation of the project.

For an indoor farm that can potentially provide annual earnings close to 200.000NOK, the risk in investment is diminished, and it can make investors more keen on to seriously consider investing for the project.

Regarding shares, administrative expenses lowered down to 2% only. Distribution of costs in general also quite equivalent, CAPEX is 38%, while fixed costs are 29% and variable costs are 32% of shares respectively. Closer distribution in costs indicate that further savings are likely to take place, in field that the project manager considers most viable. In other words, if the project manager able to provide savings in utility costs, or fixed costs, or other variable costs, it is possible to follow the one preferred, without considering the most savings possible.

#### 4.4.4.2 General Findings

Share of lighting cost within variable cost is equivalent to the one in scenario 1: 26%. However, this time share in product cost increases to 12% from 7%. This means, the money spent on lighting is more influential on price of the product. Therefore, compared to earlier scenarios, savings in electricity spent for lighting can provide greater economic benefits. In Scenario 1, labor costs accounted for 53% of costs, while in Scenario 2 same rate was 44%. In this scenario, the share of labor within production cost is similar 45%, as production labor takes great value within variable costs. However, it should be noted that production cost is decreased significantly. Therefore, despite similar amount in proportion, the amount a customer pays for labor in each product is considerably lower, compared to previous scenarios. Similarly in this scenario, it is also necessary to answer the question: “What is the production cost of each lettuce?”. With a significant decrease, cost of producing a lettuce is 11,26NOK in this scenario. By replacement of marketing & sales employee, it is possible to diminish costs by 6,73NOK per lettuce. Thanks to this remarkable saving, the indoor farm has the potential to locate itself in the market as an alternative to the producer. In other words, the facility can compete with farmers in Norway or in Spain, producing lettuces in bulk levels and selling their products to suppliers. In determination of the average price to compete in this market, both wholesale price average and import price average should be considered as a reference. Taking these both into account, 9,60NOK is estimated as an average price to compete with. In earlier scenarios, it was assumed that the facility will provide at least 200.000NOK annual earnings to the founder, so the project is feasible for an investor. In calculation of NPV, results indicate that at least 175% of market average (16,80NOK) should be determined as product price, in order to acquire such earnings. Even though this price can be competitive in other areas of the business process, in order to compete with producers and to consider suppliers as customers, this price is not viable to determine. Therefore, the only possibility of the facility is to provide lower earnings annually. With estimating 30% higher price than the market average, the facility provides only 44.000NOK earnings, annually. Thus, product cost is estimated as 12,48NOK. In this case, the overview of product price to market average monthly is as follows:

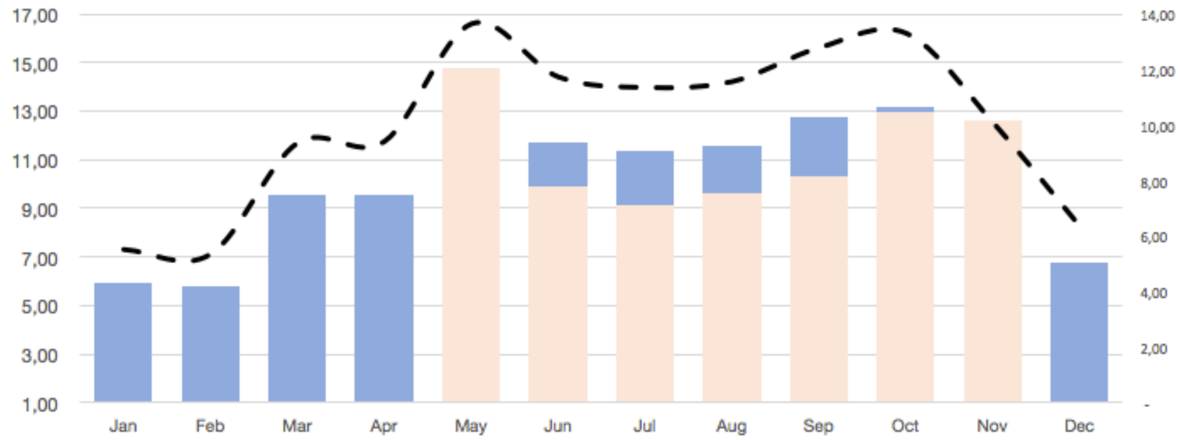


Figure 16. *Monthly average market price and product price for scenario 3.*
*Blue bars: import price of Spanish farmers. Mid-yellow bars: wholesale price of Norwegian farmers*
*Black line: product price of a SSIF. Currency: NOK*

It is essential to evaluate the competition for two seasons: when the lettuce is provided to Norwegian market dominantly from Spain (in December and from January until May) and when the lettuce is provided domestically (from May until December). In domestic-dominant season, most of the times product price in an indoor farm is at least 1,00NOK higher than the market average. Comparable to findings in previous scenarios, it is risky for a SSIF to find itself a place in the market, due to higher prices, as well as an ongoing quality and trust that are built between existing actors of the market. In import-dominant season, the facility may use the unique advantage of becoming the only domestic producer in the market. In cold winters of Norway, it is not possible to produce lettuces even in greenhouses. Therefore, the label of “made in Norway” can provide a significant advantage to the facility, and this may provide a great advantage. Furthermore, product price in this season is slightly closer to import prices, which makes products of indoor farms even more competitive to the market.

In evaluation of the NPV, initially annual income is calculated low as 44.054NOK annually.

Introduced earlier, this is a very major risk for a SSIF to be considered as a worthwhile project. Despite promising saving through decrease of marketing costs, from financial perspective any project is expected to provide further earnings.

Calculating NPV, the profit estimated in five years of operation is 226.762NOK. Compared to NPV results of previous scenarios (600.000NOK, 1.1MNOK respectively) the result is considerably lower. This would mean, in case the producer is determined as competitor, and supplier is determined as customer, it is likely to gain a position in the market. However, if the market requires the facility to compete with average prices in the market, there will not be satisfactory amount of profits acquired, in order to make project feasible. Therefore, it is crucial for the project manager to observe the changes and dynamics in the market, and consider increase in prices, in order to increase revenue, as well as yearly income.

One should consider the possibility of keeping production costs as is, yet locating the facility in the market to earlier options. For example, with production cost of 11,26NOK, competing with supplier and making sales to retail chains. Alternatively, competing with retail chains and providing sales to consumers. These alternative strategies are sensible for an indoor farm. Yet, initiating these scenarios would accumulate all risks and critical factors mentioned earlier to the scenario, besides two additional risk factors:

- In Scenario 2, the founder was demanded to have expertise necessary to provide certain amount of production efficiency to the facility, in order to replace production labor. Similarly, the expertise required to maintain marketing & sales tasks should not be underestimated. In case the founder lacks skills necessary to compensate such tasks, sales will decrease, which will escalate production cost and will diminish annual revenue.
- In order to provide goods to suppliers, a certain quality in products is expected from the producer. Therefore, further improvements in nutritional appearance and quality of the food (size, taste, crispiness and more) will have to be pursued. Once sales & marketing tasks are covered by the project leader, responsibilities of the production labor may increase. Therefore, additional workload may occur in production labor due to research and development efforts.

Break-even analysis of Scenario 3 indicates results as follows:

| BREAK-EVEN ANALYSIS | | | | | |
|---|---|---|---|---|---|
| NPV CURRENT | WHOLESALE PRICE PER PRODUCT | | | | |
| 226 762 | 11,37 | 12,48 | 16,24 | 18,94 | 22,73 |
| ANNUAL PRODUCTION VOLUME | | | | | |
| 47 952 | 0 | 226 787 | 991 239 | 1 541 928 | 2 312 891 |
| 43 670 | - 206 536 | 0 | 696 188 | 1 197 702 | 1 899 820 |
| 33 566 | - 693 867 | - 535 116 | 0 | 385 482 | 925 156 |
| 28 771 | - 925 156 | - 789 084 | - 330 413 | 0 | 462 578 |
| 23 976 | - 1 156 445 | - 1 043 052 | - 660 826 | - 385 482 | 0 |

Figure 17. *Break-even analysis results of Scenario 3.*

- If the facility is able to provide full yield (100% efficiency), any price given above 11,37NOK will return positive NPV. This amount is slightly (0,11NOK) higher than production cost. If the producer decides to follow a strategy to attract customers in the market, low amounts of income should be expected.
- With current price of 12,48NOK per lettuce, at least 43,670 lettuces should be produced annually, in order to maintain a positive NPV. This requires 91% efficiency in production minimum.
- If the production efficiency is low as 70%, 60% or 50%; price of lettuce should be increased to 16,24NOK, 18,94NOK and 22,73NOK respectively.

Compared to break-even analysis findings of previous scenarios, it is possible to underline once again that both production efficiency and marketing performance are crucial for a SSIF, in order to compete with local producers. Considering that the project leader is expected to dedicate an additional 30 hours of weekly workload as a marketing & sales responsible to the managerial role, the risk of maintaining such efficiency in both areas seems challenging. With respect to price and output changes proportionally in earlier scenarios, sensitivity of prices to annual output is equivalent to findings of scenario 2. In each 10% folds decrease of production efficiency, there is a 42%, 66% and 100% increase in prices to compensate the loss, respectively. This means that producer is able to compensate loss that may acquire due to production efficiency.

However, it should be noted that entrance to the market as a producer may be similarly challenging, as indoor farming is a new concept that may critically be questioned by suppliers to involve in acquisition of goods.

# 5. CONCLUSION

## 5.1. Discussion of Findings

Since the literature review indicates, earlier studies mostly analyse indoor farms in large scale, and in countries with different characteristics. As result of this study, there have been multiple numbers of important findings, as elaborated in previous chapter. To sum up, as well as to summarise findings of the analysis, several bullet points can be written as follows:

- Under current conditions, a small-scaled indoor farm is either competitive but not profitable, or profitable but not competitive. Without further savings in operations, or additional support in earnings, the possibility of an indoor farm to compete with current market is rather challenging.
- Labor for marketing & sales, followed by production labor are the most dominant costs of a small-scaled indoor farm in a developed country as Norway. In order to diminish costs and become competitive in various markets, project leaders usually cover these tasks themselves. This attempt is quite common, yet leads further risks to the project.
- Compared to investment necessary for the project (between 700.000-1.100.000NOK), realistic amounts of income annually are not very satisfactory (40.000-200.000NOK). In a developed country as Norway, an individual with equivalent entrepreneurial and educational background can earn significantly greater amounts in different projects.
- Electricity used for lighting takes great value in utility costs. However, utility costs are not very influential to the production cost in general. Therefore, in contrast to common opinion, electricity is not very influential in price of the product.
- Changes in production efficiency lead to increase in prices, in order to compensate costs. Yet, this increases are likely to shift the customer segment of small-scaled indoor farm to further levels of the business process (*e.g.* from supplier to retail chain, or from retail chain to consumer).

Considering these facts, currently, there is a possibility to argue that an indoor farm can become both profitable and competitive in Norwegian agricultural market for iceberg lettuce. However, this would require either an almost perfectly efficient performance in production, or very minor economic benefits that investors will receive from the project.

Economic and financial evaluation of the project covered in this section. Following sections will evaluate the feasibility of the project from societal and environmental perspective, in light of motives elaborated at the beginning of the literature review chapter.

## 5.2. Theoretical Implications

As the background and history states, indoor farming is presented as a concept to overcome food scarcity in many occasions, besides an alternative application to transfer agriculture from outdoor lands to indoor buildings. However, current practices of indoor farming in Europe do not imply an interest to make these goals viable. In this study, a simulative small-scaled indoor farm is established, in accordance with existing practices and preferences of indoor farmers. Conclusively, the study reflects that attempts to cut costs and to make profits overrule the aim of tackling environmental issues, least by small-scaled indoor farmers. In case the evolution of indoor farming concept continues to expand in such direction, it is likely to argue several agricultural and environmental statements as follows:

- Current production model of indoor farms does not offer a solution to concern of lacking arable lands for agriculture in near future. Most of plants produced in indoor farms are not capable to recover the consumption satisfied by production of plants outdoors.
- As commodity prices are reluctant on oil prices today, with dominance of indoor farming, commodity prices are likely to become reluctant of prices of other scarce resources as labor, production equipment, water or electricity. Once these resources are insufficient, incidence of famine is still likely to happen.
- Current practices of indoor farming in small-scaled level do not aim to provide a practical alternative to solve previously mentioned environmental and agricultural concerns, albeit these problems are presented in realisation of the concept.

Considering these facts, there are several suggestions that can be addressed to indoor farmers of today.

## 5.3. Managerial Implications

In academia and in agricultural market, the awareness to the indoor farming is increasing. Nevertheless, people still have notable doubts and uncertainties regarding the concept. In clarification of these uncertainties, the message that is delivered by indoor farmers are vital, not only to influence perception of people accurately, but also to address the concept to an environmental friendly direction.

- If profitability is the primary concern for an operating small-scaled indoor farm, alike traditional farmers, indoor farmers are also encouraged to make efforts, in order to be acknowledged as part of agricultural policies. Through these efforts, it is possible to receive some incentives, that would enable indoor farmers to guarantee profts in their productions.
- Whether profitability is ensured or not, indoor farmers are suggested to take initiatives in providing a breakthrough motive to indoor farming, concerning environmental challenges mentioned earlier. In particular, indoor farmers are suggested to produce plants that are regularly consumed by local society, to attract attention to the concept and to let people practically experience that the concept can contribute to agricultural production.
- In order to determine the position in the market, indicating competitors and customers are crucial for an indoor farm to analyse its impact. A strategy deciding these factors may turn an indoor farm into a significant actor in tackling environmental issues. Contrarily, with additional waste and irrelevant motives, an indoor farm may boost environmental damages.
- As aimed by leading indoor farmers today, if the concept is aspired to provide food to those who lack food, ongoing efforts in lowering production costs aside, further research to vitalise indoor farming concept in developing countries should be also initiated by indoor farmers.

## 5.4 Limitations and Agenda For Future Research

To elaborate the final implication mentioned in previous sub-section, there are a few topics considered worth a further research for indoor farming that are noticed by the author throughout the period of study. Initially, standardisation of indoor farms is an important factor missing today. Even though the concept bears many standard specifications in application, there is no universally existing authority or a guideline to measure the practicability of these specifications. Recently, a non-profit organisation is established, which aims to build measurable standards for indoor farming (for more information, visit web site of Association for Vertical Farming). Nevertheless, settling primary needs and determinants to ensure an indoor farm, with specific environmental goals is a necessity for development of the concept.

Furthermore, this study attracts a small-scaled indoor farm from a financially economic perspective. Yet, resource management and waste management of a small-scaled indoor farm are also worth examining. The amount of $CO_2$ emitted in provision of goods from various lands, as well as during operation of an indoor farm throughout the year are an example to study of waste management. The amount of conventional or renewable resources used in production of plants in an indoor farm are also considerable for environmental studies.

Most notably, current indoor farms either in small or large scales display an idea to future agronomists, entrepreneurs and policy makers, elaborating under which conditions is it sensible to invest in indoor farms. For a land scarce country as Japan, or technology savvy country as U.S.A., there are different motives and benefits expected out of the concept. This study aims to provide economic grounds for future researchers and indoor farmers to consider the possibility of developing the concept in a country as Norway.

Not to avoid, this study limits its findings to discoveries that occur within an indoor farm. Nonetheless, changes that possibly occur in outdoor lands with expansion of indoor farms are equally important. In a simulative case that indoor farms succeed to cover the food demand that is satisfied by outdoor farms today, assumably outdoor farms are not used for agricultural production. Possible decisions relevant to environmental policies and economic output are also significantly important topics worth reviewing.

In final words, the sub-sentence that covers the title to this study: “Fancy concept, or environmental breakthrough?” is not a question that one can answer due to conditions of indoor farming today. Yet, strategies currently followed by indoor farmers, the way these strategies are described to the society are significantly critical in defining the perception of indoor farming to future generations. Keeping this fact in mind, every individual involved in process, from producer to leader, has responsibility to discover, evaluate, and improve the conception of indoor farming to a valuable direction.

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# APPENDICES A. PRODUCTION & UTILITY TABLES

## Appendix A.1. Production Labor Workload Table

| WORKLOAD | Expected workload per layer (m) | Expected periodic workload (h) | Expected annual workload (h) |
|---|---|---|---|
| Harvest of yield | 8 | 30 | 266 |
| Cleaning crop trays | 7 | 26 | 233 |
| General monitoring of the system | 3 | 11 | 100 |
| Placement of seedlings | 2 | 7 | 67 |
| Packaging of yield | 3 | 9 | 83 |
| Transportation of goods | 2 | 6 | 50 |
| TOTAL: | 24 | 89 | **799** |

## Appendix A.2.1 Annual Yield of Lettuce Per Item

## Appendix A.2.2 Average Yield of Lettuce Per Area

| ANNUAL YIELD | | |
|---|---|---|
| Item | Unit | Output Per Unit |
| Mini Tray | 8 | 3 |
| Layer | 6 | 24 |
| Rack | 37 | 144 |
| TOTAL PERIODIC YIELD: | | 5 328 |
| TOTAL ANNUAL YIELD: | | 47 952 |

| AVERAGE YIELD | | |
|---|---|---|
| Per: | Day(s) | Plant |
| Day | 1 | 131,4 |
| Month | 30 | 3996 |
| ANNUAL YIELD PER SQUARE METER: | | **959** |

## Appendix A.3. Production Details & Elements

| Production Details | |
|---|---|
| Product Weight(g) | 350-400 |
| Net Production Area (m2) | 50 |
| Annual production period: | 9 |
| Days of a period | 39 |

| Amount of: | |
|---|---|
| LED Light: | 888 |
| Mini tray: | 1776 |
| Layer: | 222 |

## Appendix A.4. Electricity Use Details of Equipment

| | | Light | Air Conditioner | Dehumidifer |
|---|---|---|---|---|
| UNIT | Unit power use (W) | 24 | 760 | 245 |
| | Amount of units | 888 | 1 | 1 |
| TIME OF USE & CONSUMPTION | Daily time of use (h) | 16 | 18 | 20 |
| | Periodic time of use (h) | 624 | 702 | 780 |
| | Daily consumption (kWh) | 341 | 14 | 5 |
| | Periodic consumption (kWh) | 13 299 | 534 | 191 |
| | Annual consumption (kWh) | 119 688 | 4 802 | 1 720 |
| COST | Daily cost (NOK) | 180 | 8 | 3 |
| | Periodic cost (NOK) | 7 012 | 282 | 101 |
| | Annual cost (NOK) | **63 100** | **2 532** | **907** |

| | | Water Pump | Air Pump | Storage |
|---|---|---|---|---|
| UNIT | Unit power use (W) | 21 | 10 | 230 |
| | Amount of units | 29 | 29 | 1 |
| TIME OF USE & CONSUMPTION | Daily time of use (h) | 12 | 20 | 24 |
| | Periodic time of use (h) | 468 | 780 | 120 |
| | Daily consumption (kWh) | 7 | 6 | 6 |
| | Periodic consumption (kWh) | 285 | 226 | 28 |
| | Annual consumption (kWh) | 2 565 | 2 036 | 248 |
| COST | Daily cost (NOK) | 4 | 4 | 3 |
| | Periodic cost (NOK) | 151 | 120 | 15 |
| | Annual cost (NOK) | **1 353** | **1 074** | **131** |

Appendix A.5. Water Consumption Cost Calculation

| WATER CONSUMPTION & COST | | |
|---|---|---|
| CONSUMPTION COST | Grow Racks | 380 000 |
| | Cleaning | 5 000 |
| | Administrative | 2 500 |
| | Other | 1 200 |
| | Annual Water Consumed (L): | 388 700 |
| | Use cost of water (NOK/L) | 0,0148 |
| | Annual Water Consumption Cost (NOK) | **5 753** |
| ABONNEMENT COST | Annual abonnement cost for water use (NOK/m2): | 10,05 |
| | Area estimated for abonnement (m2): | 65 |
| | Annual abonnement cost (NOK): | **653** |
| ANNUAL WATER USE COST (NOK): | | **6 406** |

# APPENDICES B. COSTS & EXPENSES

## Appendix B.1. Capital Expenditure Table

**CAPITAL EXPENDITURE**

| | Product | Unit Price ($) | Unit Price (NOK) | Quantity | Product Cost (NOK) | Freight Cost (NOK) | Customs Cost (NOK) | Total Cost (NOK) |
|---|---|---|---|---|---|---|---|---|
| LIGHT | LED Light | 6,5 | 52,52 | 888 | 46 638 | 1 616 | 11 659 | 59 913 |
| MEDIA | Flood Tray | 0,625 | 5,05 | 1776 | 8 969 | 2 343 | 2 242 | 13 554 |
| | Flood Tray Lid | 70 | 565,60 | 1 | 566 | 162 | 141 | 869 |
| | Net Pot | 0,055 | 0,44 | 5328 | 2 368 | 929 | 592 | 3 889 |
| NFT SYSTEM | Production Rack | 2329 | 18818,32 | 1 | 18 818 | 6 464 | 4 705 | 29 987 |
| | Water Tank | 400 | 3232,00 | 3 | 9 696 | 1 697 | 2 424 | 13 817 |
| | Water Pump | 73 | 589,84 | 29 | 17 105 | 404 | 4 276 | 21 786 |
| | Air Pump | 25,98 | 209,92 | 29 | 6 088 | 162 | 1 522 | 7 771 |
| | PVC Cable (plumbing) | 1,81 | 14,62 | 230 | 3 364 | 1 212 | 841 | 5 417 |
| | Pipe fitting per rack (plumbing) | 7,86 | 63,51 | 27 | 1 715 | - | 429 | 2 143 |
| | Pipe fitting (plumbing) | 0,63 | 5,09 | 385 | 1 960 | - | 490 | 2 450 |
| | Diverse mat. (plumbing) | 250 | 2020,00 | 1 | 2 020 | - | - | 2 020 |
| | Fan | 3 | 24,24 | 222 | 5 381 | 162 | 1 345 | 6 888 |
| SENSOR | Hygrometer | 295 | 2383,60 | 1 | 2 384 | 81 | 596 | 3 060 |
| | pH & EC meter | 352 | 2844,16 | 3 | 8 532 | 81 | 2 133 | 10 746 |
| | Thermometer | 110 | 888,80 | 3 | 2 666 | 81 | 667 | 3 414 |
| HVAC | Air Conditioner | - | 2700 | 1 | 2 700 | - | - | 2 700 |
| | Dehumidifier | - | 1300 | 1 | 1 300 | - | - | 1 300 |
| EQUIPMENT | Delivery Van | - | 40000 | 1 | 40 000 | - | - | 40 000 |
| | Packaging Machine | - | 9396 | 1 | 9 396 | - | 2 020 | 11 416 |
| | Storage | - | 10982 | 1 | 10 982 | - | - | 10 982 |
| | Furniture | - | 15000 | 1 | 15 000 | - | - | 15 000 |
| | Computers | - | 12000 | 1 | 12 000 | - | - | 12 000 |
| | | | | | Product Cost (NOK) | Freight Cost (NOK) | Customs Cost (NOK) | Total Cost (NOK) |
| | | | | SUM: | 229 647 | 15 392 | 36 082 | 281 122 |

## Appendix B.2 Depreciation Costs Table

| DEPRECIATION | | | | | |
|---|---|---|---|---|---|
| | Product | Unit Price (NOK) | Lifetime Value (Year) | Salvage Value (NOK) | Yearly Depreciation Value (NOK) |
| LIGHT | LED Light | 59 913 | 3 | 1500 | 19 471 |
| MEDIA | Flood Tray | 13 554 | 3 | 500 | 4 351 |
| | Flood Tray Lid | 869 | 1 | 50 | 819 |
| | Net Pot | 3 889 | 3 | 500 | 1 130 |
| NFT SYSTEM | Production Rack | 29 987 | 10 | 5000 | 2 499 |
| | Water Tank | 13 817 | 3 | 100 | 4 572 |
| | Water Pump | 21 786 | 2 | 0 | 10 893 |
| | Air Pump | 7 771 | 2 | 0 | 3 886 |
| | PVC Cable (plumbing) | 5 417 | 3 | 250 | 1 722 |
| | Pipe fitting per rack (plumbing) | 2 143 | 3 | 100 | 681 |
| | Pipe fitting (plumbing) | 2 450 | 3 | 100 | 783 |
| | Diverse mat. (plumbing) | 2 020 | 3 | 0 | 673 |
| | Fan | 6 888 | 1 | 0 | 6 888 |
| SENSOR | Hygrometer | 3 060 | 5 | 0 | 612 |
| | pH & EC meter | 10 746 | 5 | 0 | 2 149 |
| | Thermometer | 3 414 | 5 | 0 | 683 |
| HVAC | Air Conditioner | 2 700 | 2 | 0 | 1 350 |
| | Dehumidifier | 1 300 | 2 | 0 | 650 |
| EQUIPMENT | Delivery Van | 40 000 | 5 | 5000 | 7 000 |
| | Packaging Machine | 11 416 | 4 | 250 | 2 792 |
| | Storage | 10 982 | 5 | 200 | 2 156 |
| | Furniture | 15 000 | 4 | 1500 | 3 375 |
| | Computers | 12 000 | 3 | 4500 | 2 500 |
| | | | | Total Yearly Depreciation (NOK): | 81 635 |

# Appendix B.3. Operating Expenses Tables

**SELLING & ADMINISTRATIVE EXPENSES**

| Title | Description | Service Cost (NOK) | Hourly Salary (H/NOK) | Hours in a week (H) | Hours in a year (H) | Yearly Salary (NOK) | Tax (NOK) | Total Cost (NOK) |
|---|---|---|---|---|---|---|---|---|
| Marketing Salary | Brand management (CI, Website, Social Media), Networking (Events and fairs), Market research (prices,products and competitors, fundraising), Sales (Customers and retention) | 0 | 180 | 30 | 1 560 | 280 800 | 42 120 | 322 920 |
| Accounting Salary | One time installation of accounting files, maintenance and follow up monthly and annually. | 6000 | 150 | 1 | 52 | 13 800 | 2 070 | 15 870 |
| Delivery Salary | Estimated 25 delivery per period. Employment with minimum salary. | 0 | 0 | 5 | 43 | - | - | - |
| | | | TOTAL: | Hours in a week (H) | Hours in a year (H) | Yearly Salary (NOK) | Tax (NOK) | Total Cost (NOK) |
| | | | | 36 | 1 655 | 294 600 | 44 190 | **338 790** |

**INDIRECT LABOR**

| Title | Description | Startup Service Cost (NOK) | Hourly Salary (H/NOK) | Hours in a month (H) | Hours in a year (H) | Annual Cost (NOK) | Tax (NOK) | Total Cost (NOK) |
|---|---|---|---|---|---|---|---|---|
| Legal Expenses | Regulations and patenting. General counselling for maintenance, patent protection and other subjects. | 5000 | 1000 | 1/3 | 4 | 9 000 | 1 350 | 10 350 |
| Plumbing Services | Installation of NFT systems, water and air pumps. General support for maintenance, further suggestions for water use efficiency. | 3517 | 879,25 | 1 | 12 | 14 068 | 2 110 | 16 178 |
| Electricity Services | Installation of light bulbs, electric sockets and cables. General support for maintenance, provision of additional material if needed. | 7434 | 929,25 | 2 | 24 | 29 736 | 4 460 | 34 196 |
| | | | | TOTAL: | Hours in a year (H) | Annual Cost (NOK) | Tax (NOK) | Total Cost (NOK) |
| | | | | | 40 | 52 804 | 7 921 | **60 725** |

**OTHER OPERATING EXPENSES**

| | |
|---|---|
| Office Supplies | 6 500 |
| Utilities (Phone bill, internet ect.) | 8 500 |
| Insurance | 32 000 |
| TOTAL (NOK) | 47 000 |

**OPERATING EXPENSES**

| Name | Amount (NOK) | % in Annual OPEX | % in Annual Fixed Costs |
|---|---|---|---|
| S&A Expenses | 338 790 | 76 % | 54 % |
| Indirect Labor | 60 725 | 14 % | 10 % |
| Other Operating Expenses | 47 000 | 11 % | 8 % |
| **OPEX SUM (NOK):** | **446 515** | 100 % | 72 % |

## Appendix B.4. Variable Costs Table

**VARIABLE COSTS**

| | Product | Unit Price ($) | Unit Price (NOK) | Quantity | Product Cost (NOK) | Additional Cost (NOK) | Total Cost (NOK) |
|---|---|---|---|---|---|---|---|
| MEDIA | Coco Coir Plug | 0,022 | 0,178 | 47 952 | 8 524 | 2 131 | 10 655 |
| | Seedling | 95 | 768 | 1 | 768 | 596 | 1 364 |
| | Fertilizer | 50 | 404 | 2 | 808 | 606 | 1 414 |
| | | | | | | MEDIA: | 13 432 |
| UTILITY | Electricity Use | - | 0,527 | - | - | - | 71 597 |
| | Water Use | - | 0,015 | - | - | - | 6 406 |
| | | | | | | UTILITY: | 78 003 |
| DELIVERY | Package | 0,020 | 0,162 | 47 952 | 7 749 | | 7 749 |
| | Transportation | - | 140 | 36 | 5 040 | | 5 040 |
| | | | | | | DELIVERY: | 12 789 |
| LABOR | Production Labor | - | 155 | 799 | 123 876 | 12 388 | 136 264 |
| | | | | | | LABOR: | 136 264 |
| | | | | SUM: | Product Cost (NOK) 146 765 | Additional Cost (NOK) 15 720 | Total Cost (NOK) **240 488** |

## Appendix B.5. Product Cost Calculations Of Scenarios

| SCENARIO 1 - BUSINESS AS USUAL | |
|---|---|
| **Cost of Production** | |
| Total Variable Cost: | 240 488 |
| Total Fixed Cost: | 622 150 |
| Operational Expenses: | 446 515 |
| Depreciation: | 81 635 |
| Rent: | 94 000 |
| Total Cost of Production: | 862 638 |
| **Marginal Cost of a Plant** | |
| Unit Output: | 47 952 |
| Variable Cost: | 5,02 |
| Fixed Cost: | 12,97 |
| Product Cost: | **17,99** |

| SCENARIO 2 - FOUNDER AS PRODUCTION LABOR | |
|---|---|
| **Cost of Production** | |
| Total Variable Cost: | 104 224 |
| Total Fixed Cost: | 622 150 |
| Operational Expenses: | 446 515 |
| Depreciation: | 81 635 |
| Rent: | 94 000 |
| Total Cost of Production: | 726 374 |
| **Marginal Cost of a Plant** | |
| Unit Output: | 47 952 |
| Variable Cost: | 2,17 |
| Fixed Cost: | 12,97 |
| Product Cost: | **15,15** |

| SCENARIO 3 - FOUNDER AS MARKETING & SALES RESP. | |
|---|---|
| **Cost of Production** | |
| Total Variable Cost: | 240 488 |
| Total Fixed Cost: | 299 230 |
| Operational Expenses: | 123 595 |
| Depreciation: | 81 635 |
| Rent: | 94 000 |
| Total Cost of Production: | 539 718 |
| **Marginal Cost of a Plant** | |
| Unit Output: | 47 952 |
| Variable Cost: | 5,02 |
| Fixed Cost: | 6,24 |
| Product Cost: | **11,26** |

## Appendix B.6. NPV Result for Scenario 1

### NET PRESENT VALUE CALCULATION

**Model Inputs**

| | |
|---|---|
| Terminal Growth Rate | 1,00 % |
| Explicit Growth Rate | 1,00 % |
| Depreciation Rate | 25,00 % |
| CAPEX / Net Income | 2,75 % |
| WACC | 2,25 % |
| Tax Rate | 25,00 % |

**Profit,Price & Revenue**

| | |
|---|---|
| Sales Volume: | 47 952 |
| Marginal cost: | 17,99 |
| Profit margin: | 17 % |
| Profit per product (NOK): | 3,02 |
| Market Price per product (NOK): | **21,01** |
| Annual Revenue (NOK): | **1 007 651** |

**Net Income Calculation**

| | |
|---|---|
| Annual Revenue | 1 007 651 |
| - Total Fixed Cost | 622 150 |
| - Total Variable Cost | 240 488 |
| EBIT | 145 014 |
| - Tax | 36 253 |
| Net Income | **108 760** |

**NPV CALCULATION**

| Year | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|
| Net Income | 108 760 | 109 848 | 110 946 | 112 056 | 113 176 | 114 308 |
| Depreciation | 81 635 | 61 226 | 45 920 | 34 440 | 25 830 | 19 372 |
| - CAPEX | 2 991 | 3 021 | 3 051 | 3 082 | 3 112 | 3 143 |
| Free Cash Flow | 187 405 | 169 734 | 155 353 | 144 848 | 137 253 | 131 842 |
| Discount Factor | 100 % | 98 % | 96 % | 94 % | 91 % | 89 % |
| Discounted Cash Flow | 187 405 | 165 999 | 148 591 | 135 495 | 125 565 | 117 961 |
| - Initial Outlay | 281 122 | | | | | |
| **Net Present Value (NOK)** | **599 894** | | | | | |

## Appendix B.7. NPV Result for Scenario 2

### NET PRESENT VALUE CALCULATION

**Model Inputs**

| | |
|---|---|
| Terminal Growth Rate | 1,00 % |
| Explicit Growth Rate | 1,00 % |
| Depreciation Rate | 25,00 % |
| CAPEX / Net Income | 2,75 % |
| WACC | 2,25 % |
| Tax Rate | 25,00 % |

**Profit,Price & Revenue**

| | |
|---|---|
| Sales Volume: | 47 952 |
| Marginal cost: | 15,15 |
| Profit margin: | 37 % |
| Profit per product (NOK): | 5,57 |
| Market Price per product (NOK): | **20,72** |
| Annual Revenue (NOK): | **993 653** |

**Net Income Calculation**

| | |
|---|---|
| Annual Revenue | 993 653 |
| - Total Fixed Cost | 622 150 |
| - Total Variable Cost | 104 224 |
| EBIT | 267 278 |
| - Tax | 66 820 |
| Net Income | **200 459** |

**NPV CALCULATION**

| Year | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|
| Net Income | 200 459 | 202 463 | 204 488 | 206 533 | 208 598 | 210 684 |
| Depreciation | 81 635 | 61 226 | 45 920 | 34 440 | 25 830 | 19 372 |
| - CAPEX | 5 513 | 5 568 | 5 623 | 5 680 | 5 736 | 5 794 |
| Free Cash Flow | 276 581 | 258 066 | 244 728 | 235 236 | 228 634 | 224 205 |
| Discount Factor | 100 % | 98 % | 96 % | 94 % | 91 % | 89 % |
| Discounted Cash Flow | 276 581 | 252 388 | 234 076 | 220 046 | 209 164 | 200 599 |
| - Initial Outlay | 281 122 | | | | | |
| **Net Present Value (NOK)** | **1 111 733** | | | | | |

## Appendix B.8. NPV Result for Scenario 3

# NET PRESENT VALUE CALCULATION

**Model Inputs**

| | |
|---|---|
| Terminal Growth Rate | 1,00 % |
| Explicit Growth Rate | 1,00 % |
| Depreciation Rate | 25,00 % |
| CAPEX / Net Income | 2,75 % |
| WACC | 2,25 % |
| Tax Rate | 25,00 % |

**Profit,Price & Revenue**

| | |
|---|---|
| Sales Volume: | 47 952 |
| Marginal cost: | 11,26 |
| Profit margin: | 11 % |
| Profit per product (NOK): | 1,22 |
| Market Price per product (NOK): | **12,48** |
| Annual Revenue (NOK): | **598 457** |

**Net Income Calculation**

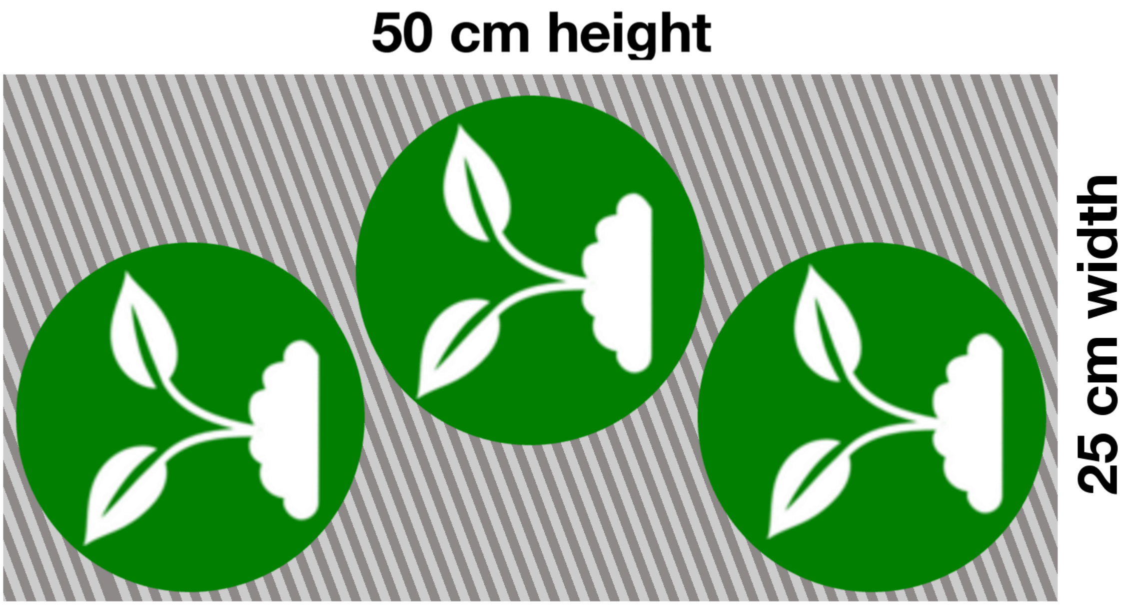
| | |
|---|---|
| Annual Revenue | 598 457 |
| - Total Fixed Cost | 299 230 |
| - Total Variable Cost | 240 488 |
| EBIT | 58 739 |
| - Tax | 14 685 |
| Net Income | **44 054** |

**NPV CALCULATION**

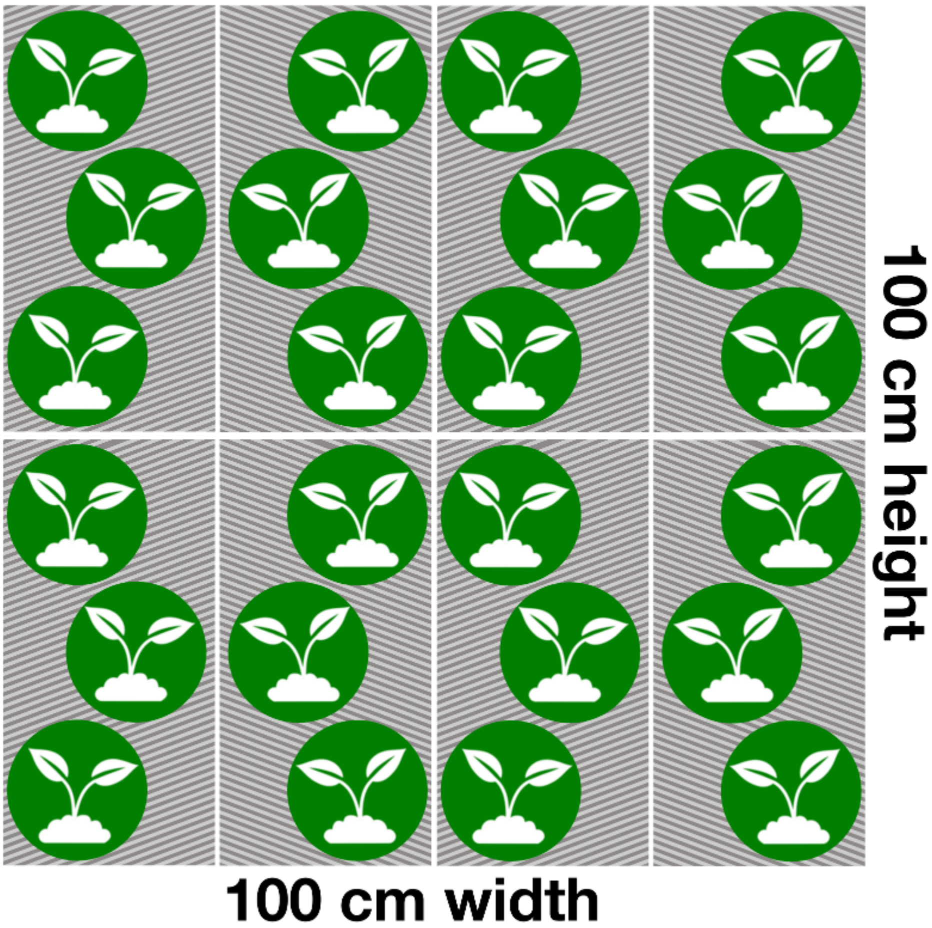
| Year | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|
| Net Income | 44 054 | 44 495 | 44 940 | 45 389 | 45 843 | 46 302 |
| Depreciation | 81 635 | 61 226 | 45 920 | 34 440 | 25 830 | 19 372 |
| - CAPEX | 1 211 | 1 224 | 1 236 | 1 248 | 1 261 | 1 273 |
| Free Cash Flow | 124 478 | 104 486 | 89 611 | 78 568 | 70 400 | 64 388 |
| Discount Factor | 100 % | 98 % | 96 % | 94 % | 91 % | 89 % |
| Discounted Cash Flow | 124 478 | 102 186 | 85 711 | 73 495 | 64 405 | 57 609 |
| - Initial Outlay | 281 122 | | | | | |
| **Net Present Value (NOK)** | **226 762** | | | | | |

# APPENDICES C. TECHNICAL DETAILS

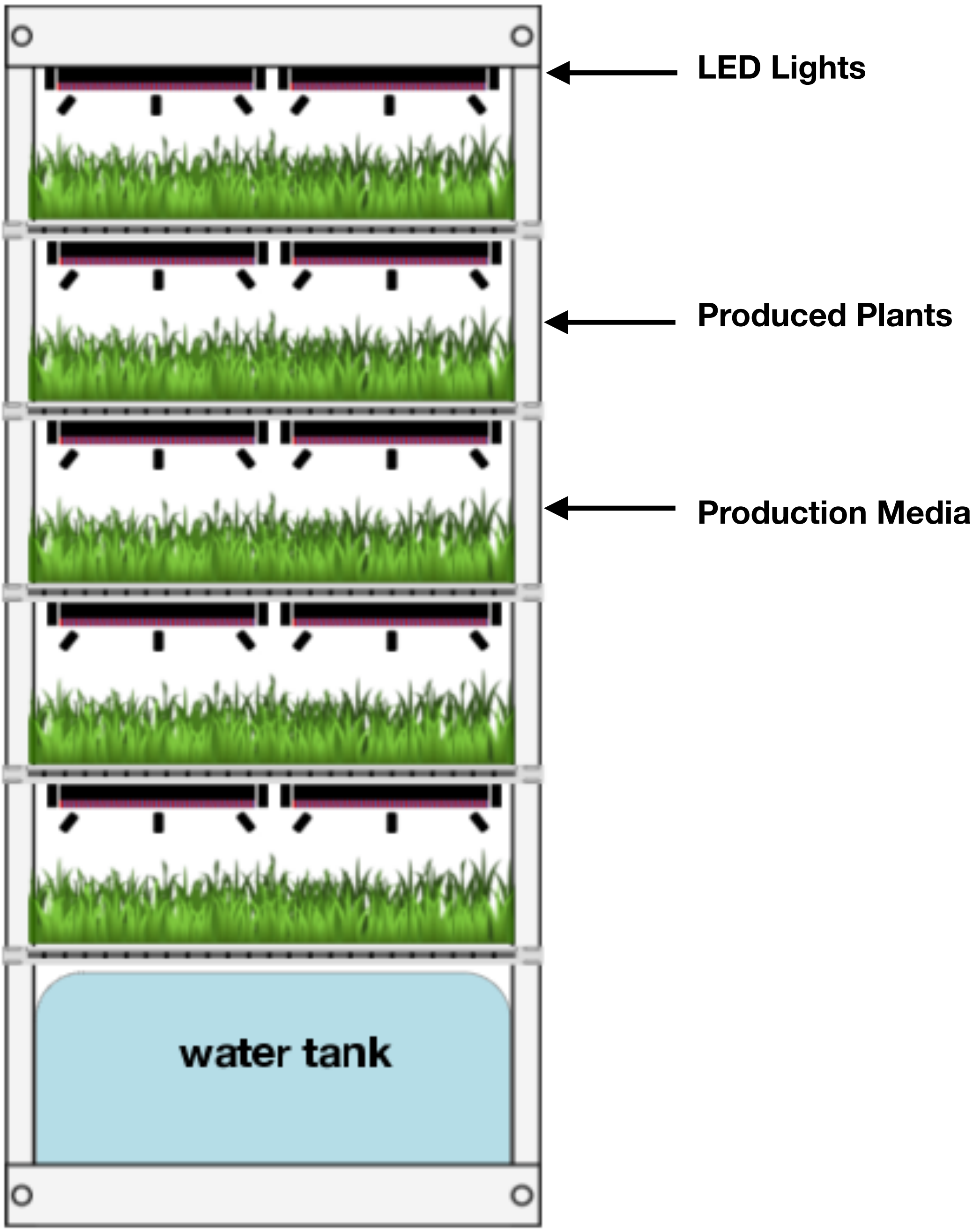
Appendix C.1. Sketch of a Small Tray With 3 Lettuces




Appendix C.2. Sketch of a Layer With 24 Lettuces



Appendix C.3. Sketch of a Rack With 5 Layers



Appendix C.4. Production Facility Overlook