The Perspective of a Tomato Greenhouse Company in the North-East United States

The Perspective of a Tomato Greenhouse Company in the North-East United States

Student: Michel Wesselink
Registration number: 860731-942-070
Supervisor: Dr. Grigorios Emvalomatis
Business Economics Group, WUR
Examinator: Prof. Dr. Ir. A.G.J.M Oude Lansink
Course: BEC-80433
Number of credits: 33 ECTS
Period: September 2010 – October 2011

Preface

This is the final thesis for my master Management, Economics and Consumer studies at Wageningen University. This report will give an overview about the current situation of the tomato sector in the United States (US). Several authors (e.g. Cook, 2006) identified that the present situation in the US is shifting from a importing, field produced industry to a sustainable, locally produced industry. Thus, a market for greenhouse tomatoes is expecting to arise. Therefore, the goal of this report is to acquire results that could be used as an instrument for individual tomato growers that have an intention to invest into greenhouses in the North-East of the US. Data for this thesis was collected during my internship at the Royal Netherlands Embassy in Washington DC.

I would like to thank my supervisor Dr. G. Emvalomatis for his effort to guide and motivate me in the process of writing this thesis. Moreover, I gratefully thank the interviewees who readily and openly gave their views, a list of interviewees is included in appendix 1. Lastly, special thanks to my girlfriend and family for their support during the whole study.

Michel Wesselink

Wageningen, October, 2011

Table of Contents

Preface iii
Table of Contents iv
List of Tables v
List of Figures vi
List of Abbreviations vi
Summary vii
1. Introduction 2
2 Current situation in the US tomato greenhouse sector 6
3. Materials and Methods 9
  3.1 SWOT analysis 9
  3.2 Stochastic simulation 9
    3.2.1 Low technology scenario 10
    3.2.2 Medium technology scenario 11
    3.2.3 High Technology scenario 12
    3.2.4 CHP scenario 13
    3.2.5 Data 14
    3.2.5.1 Variable inputs 17
    3.2.5.2 Fixed costs 19
4. SWOT Analysis 26
  4.1 Strengths 26
  4.2 Weaknesses 28
  4.3 Opportunities 28
  4.4 Threats 29
  4.5 Conclusion of SWOT analysis 30
5. Stochastic simulation results 31
  5.1 Results 31
  5.2Comparison between the different scenarios 32
  5.3 Sensitivity analysis. 34
Conclusion and Discussion 37
  Conclusion 37
  Discussion 37

7. References 39
Appendix 1. list of interviewed persons 40
Appendix 2. Ohio State University greenhouse model 41

List of Tables

Table 1 Variables from the low technology scenario 11
Table 2 Variables of the Medium technology scenario 11
Table 3 Variables of the high technology scenario 12
Table 4 Variables of the combined heat and power scenario scenario 13
Table 5 Variable price of inputs per 100 pound of greenhouse tomatoes 18
Table 6 Initial investment in Low technology scenario 20
Table 7 Initial investment in medium technology scenario 21
Table 8 Initial investment in High technology scenario 23
Table 9 SWOTanalysis of the NorthEast greenhouse tomato sector. 30

List of Figures

Figure 1 trade from vegetables in northern America 2
Figure 2 Population density in the US 3
Figure 3 Number of tomato growers in the US 4
Figure 4 Selected states and their number of tomato growers 5
Figure 5 greenhouse tomato consumption source of production 6
Figure 6 Greenhouse tomato consumption and price trends 14
Figure 7 Tomato prices 1980-2010 15
Figure 8 Field tomato prices 16
Figure 9 Price of different type of tomatoes 2003 16
Figure 10 Price prediction for greenhouse tomatoes. 17
Figure 11United States inflation rate. 19
Figure 11 Fit comparison for natural gas prices 22
Figure 13 Prices of natural gas 23
Figure 14 Average price of energy 27
Figure 15 NPV relative frequency for the different scenarios 32
Figure 16 The cumulative distribution functions for NPVs for all scenarios 33
Figure 17 The cumulative distribution functions for NPVs for all scenarios with discount rate -/+10% 34
Figure 18 The cumulative distribution functions for NPVs for all scenarios with tomato prices +/-10% 35
Figure 19 The cumulative distribution functions for NPVs for all scenarios with variable +/-10% 36

List of Abbreviations

CF	Cash Flow
CHP	Combined heat and power
FOB	free on Board
NPV	Net present value
NY	New York
STD Dev	Standard Deviation
SWOT	Strength, Weaknesses, Opportunities, Threats
SQ FT	Square feet
TOV	Tomato on the Vine
US	United States
USDA	United States department of agriculture

Summary

Tomatoes is one of the most consumed vegetables in the US. However, tomatoes are mostly produced in Mexico and Canada. Besides imports from these countries, national production is mostly field-produced that requires a significant amount of water especially in states with water scarcity (e.g. California), or in greenhouses which are located in low population density areas (e.g. Arizona). Nevertheless, production of tomatoes in high population density area is still underdeveloped compared to the consumption of this vegetable. Thus, this research focuses on the perspective to grow tomatoes in a high population density area like the North-East of the United States.

To reach the objective of this thesis, quantitative and qualitative analyses were conducted. First, a SWOT analyses is used to determine the Strengths, Weaknesses, Opportunities and Threats for growing greenhouse tomatoes in the North-East of the US. Second, a stochastic simulation model is developed to acquire a realistic simulation of future greenhouse results. This model is applied in @Risk, a simulation add-inn for excel. Moreover, the model was run with the highest number of 10.000 iterations to create the most reliable results. The first 3 scenarios are developed based upon the current situation in the US, the last scenario is constructed on sustainable techniques developed in the Netherlands. The different scenarios are compared based on the net present value (NPV) after a simulation that models the following 10 years. The following scenarios have been compared:

- A low technology greenhouse;
- A medium technology greenhouse;
- A High technology greenhouse;
- A High technology greenhouse with a Combined Heat and Power (CHP) installation.

Data for this thesis was collected from several universities in the United States and United States federal departments. The purpose of these data was to determine prices of inputs and outputs in the stochastic model. Because data was not always available to acquire a reliable overview of the distributions, therefore a sensitivity analysis was also used.

The results gained from the simulation showed that the medium technology scenario had the highest NPV and stochastically dominates in second order over other NPVs. Further, results from the stochastic simulation showed that NPVs are mostly driven by:

1. output price of tomatoes;
2. production capacity of tomatoes;
3. cost of initial investments.

Results from the sensitivity analysis showed that the medium and high technology scenario dominated in first degree over the low technology and CHP scenario. In the normal analysis and the

sensitivity analysis the medium technology greenhouse dominated in second degree over the high technology greenhouse.

Regarding the SWOT analysis, the following results could be observed. First, the opportunities for sustainable production seems to be attractive. Consumers are demanding for locally-produced vegetables which is produced with increased attention to food safety labels. Second, natural resources like water and gas are abundantly available within states located in the North-East of the US. Third, several threats regarding international competition (e.g. tomatoes produced in Mexico and field-produced tomatoes) were identified during this research. One of these threats consist of lower tomato prices due to minor labor costs in Mexico and superior weather conditions.

To conclude, the medium scenario has the best outcome for potential investors. However, within this scenario difficulties ascend on year round availability of tomatoes and maintaining long term relationships with employees. Moreover, it is recommended that potential investors conduct a throughout market research on input (e.g. gas and electricity) and output prices of tomatoes in their particular situation, before investing in a greenhouse.

1. Introduction

Tomatoes are one of the most consumed vegetable in the United States. To fulfill demand, domestic producers mostly located in California and Arizona are increasingly producing more of this vegetable. However, production cannot keep up with the increasing amount of consumption. Therefore, most tomatoes are imported from Canada and Mexico as can be observed in Figure 1 (see blue arrows). These imports are generally transported to the East coast of the US.

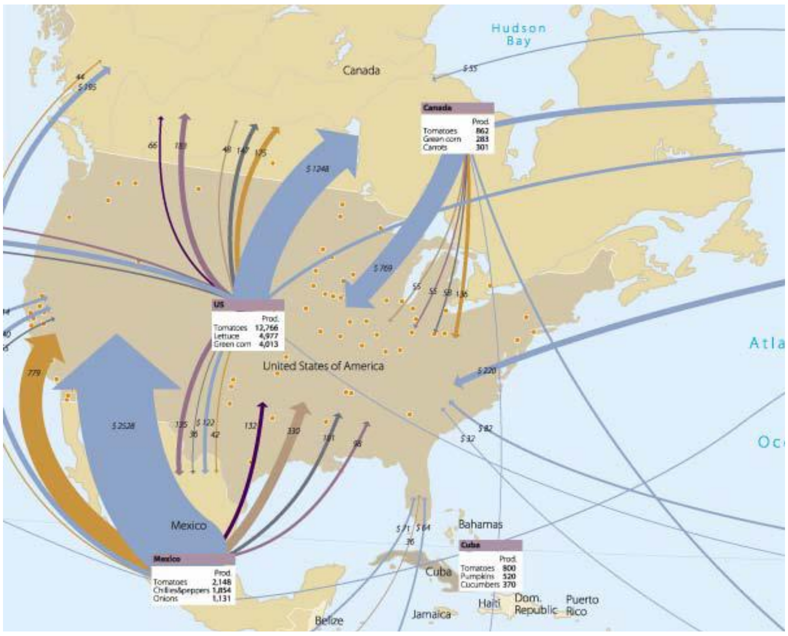

Figure 1 trade from vegetables in northern America 9 (source Modak, 2011)

Figure 2 shows the East coast to be a high density populated area. As a result, land available for agriculture is limited. Because of the limited amount of land, consumer demand towards more sustainable and locally produced products is difficult to fulfil in this area. Therefore, greenhouses can assist in making this area more self-sustaining by producing high volumes of vegetables on small quantities of land.

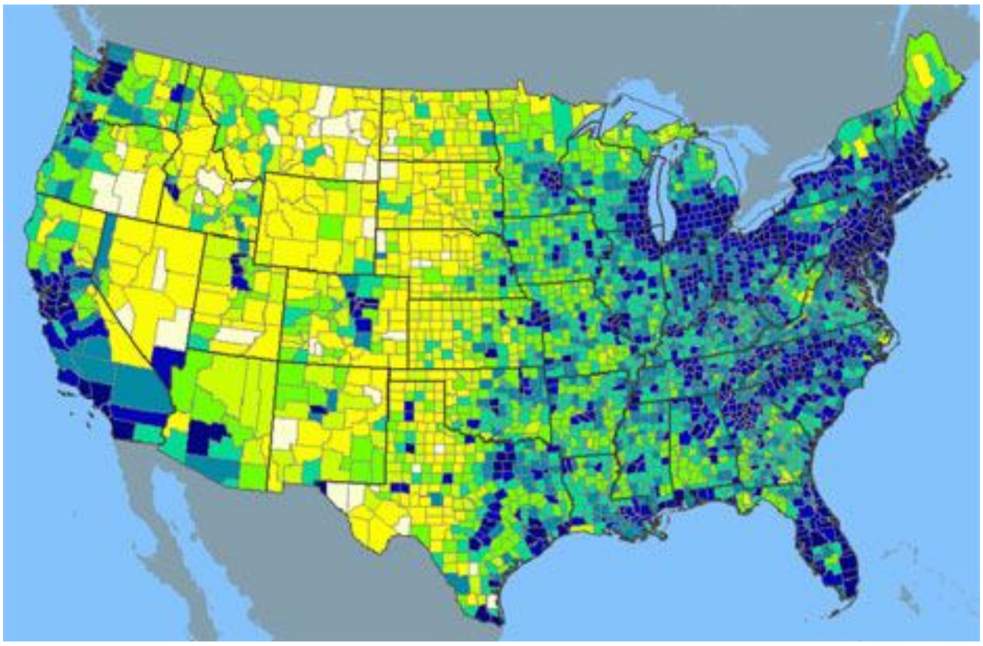

Figure 2 Population density in the US (source, Source: http://www.treehugger.com/files/2006/10/us_population_300.php)

Thus, this research is concerned with the question how to increase tomato production to meet the overall demand of consumers in the East coast. As shown in Figure 3, the number of greenhouse tomato growers differs significantly between states. It seems reasonable to select a state with low production which is located close to the area of interest. As a consequence, transportation costs will be lower. In order to realize the objective of this research the following main research question is formulated:

"What is the perspective for a tomato grower in the North-East of the US?"

In the following section, splitting up the main research question in several sub-questions will allow this study to approach the objective in a more structured method.

1. What is the current state of the tomato greenhouse sector in the North East of the US?
2. Are there opportunities for growing greenhouse tomatoes in the North East of the US?
3. What options are available in terms of greenhouse systems and what are their input and output factors?
4. What is the future prediction for the prices of inputs and outputs?

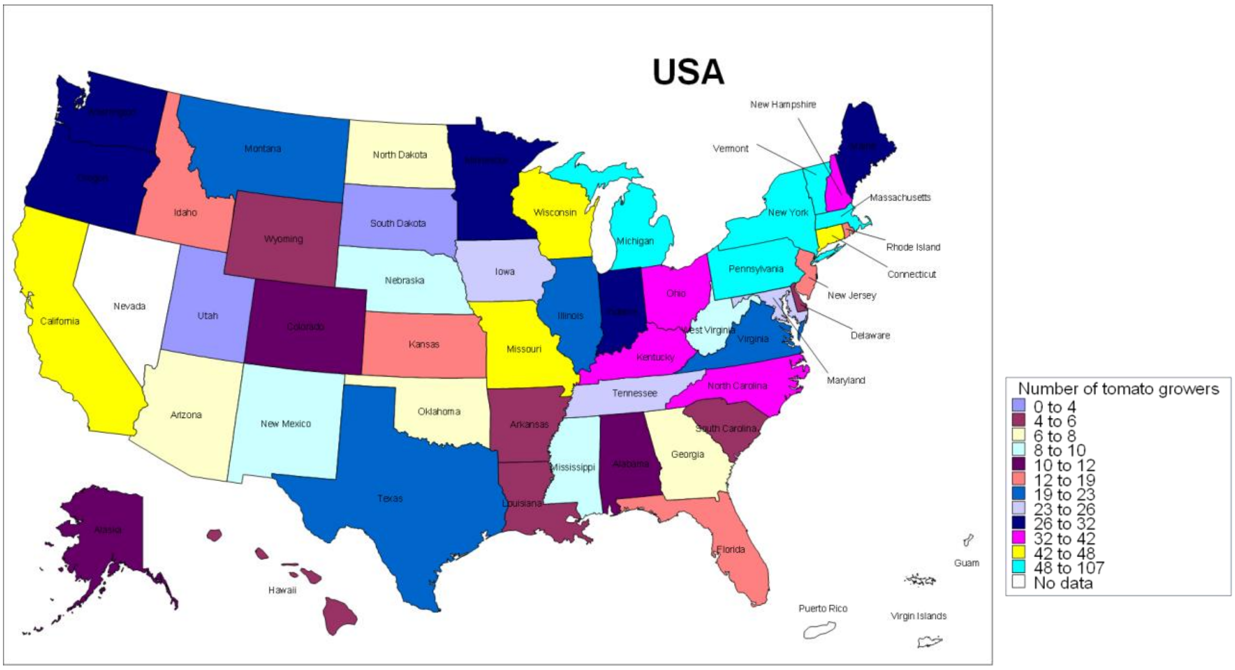

Figure 3 Number of tomato growers in the US (source Own figure based on USDA, 2010)

From initial interviews with several experts involved in the greenhouse sector, it was concluded that tomato production is mostly feasible in the northern part of the East coast. Suitable states could be Pennsylvania or New York, for instance (see Figure 4). In these states a limited number of greenhouses are already present. Nevertheless, due to high population density, a larger market should be available. Hence, this research provides results about the feasibility of starting greenhouse production in the North-East. Currently, most of the greenhouses are low technology and there seems to be opportunities for more advanced greenhouses with high technology. Therefore, a stochastic model was created with scenarios for:

- Low technology greenhouses;
- Medium technology greenhouses;
- High technology greenhouse;
- High technology greenhouses with a combined heat and power (CHP) installation.

This analysis will give information for an investor who desires to achieve a particular Return on Investment.

The assumptions included in the models are explained in chapter 3. These models are very suitable for a stochastic analysis. As a result, this report will give a decent overview about the level of uncertainties for potential investors.

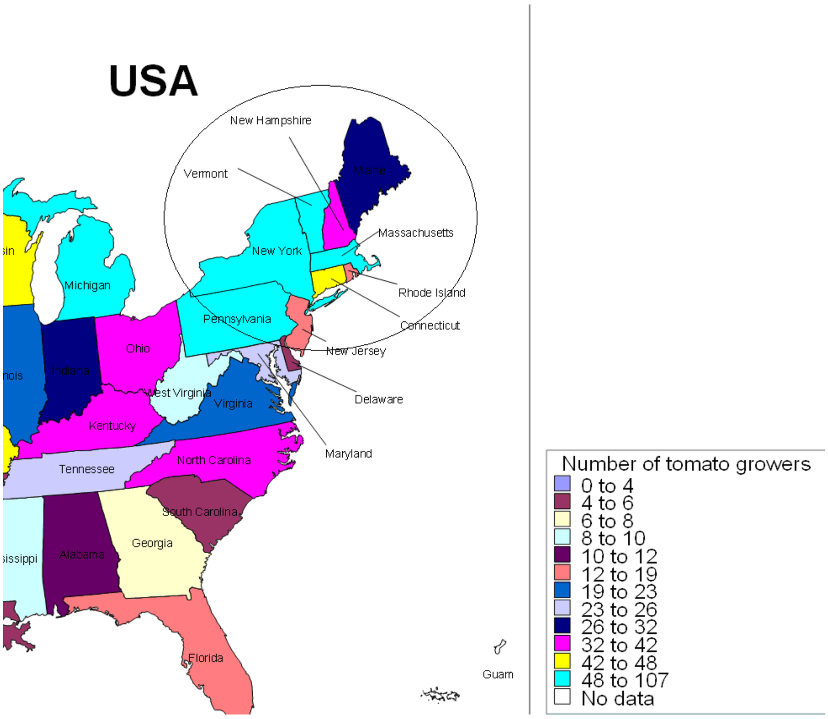

Figure 4 Selected states and their number of tomato growers (source Own figure based on USDA, 2010

To acquire a complete overview of the perspective for the tomato greenhouse sector, besides the results from stochastic simulation, it is important to understand the possibilities for a greenhouse grower in terms of the current situation and a prediction for the future. For this reason a SWOT analysis and a summary about the current situation in the greenhouse sector have been made.

2 Current situation in the US tomato greenhouse sector

In this chapter, an overview of the current tomato greenhouse sector and the most important trends and competitors is given. The results are based on literature study and interviews. Due to the large influence of Canada and Mexico, the US greenhouse tomato sector cannot be described without including these, as well as domestic field production. Hence, attention will be paid to these sources too.

Greenhouses in the United States are mostly found in the South-Western states. Currently, 20.9% of the greenhouses are located in the state of California (USDA, 2009). The arid Southwest provides strong light levels, low humidity, high altitude that gives warm days and cool nights, good water, and natural gas (Cook and Calvin, 2005). California's leading position in the $30.8 billion U.S. horticultural industry is also explained by technological and infrastructure advantages, as well as the market- and consumer driven orientation of its agribusiness managers (Carman *et al*., 2004). In this thesis the focus will be put on greenhouse tomatoes because it is the largest greenhouse vegetable crop with 43,949,871 sq ft where the total greenhouse vegetable area in the US is 61.765.935 sq ft (USDA.2009). Beside this production area, the United States still has to import around 365.5 $Million As shown in Figure 5, these imports come mostly from Canada and Mexico and are more than the domestic production (Cook and Calvin, 2005).

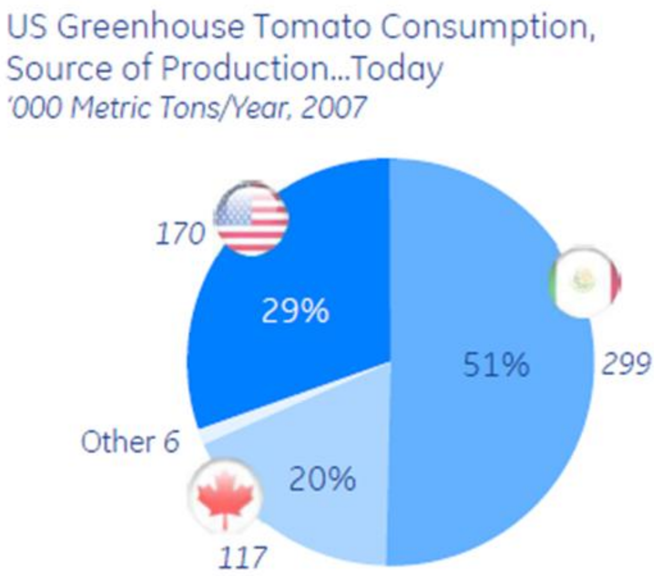

Figure 5 greenhouse tomato consumption source of production (source, Hickman 2009)

The US greenhouse tomato sub-sector is young compared to other agricultural sectors. It started to develop in the 1990's (Cook and Calvin, 2005) and it has a lot of interaction/competition with the greenhouse tomato sector in Mexico and Canada. Especially in summer, when production is at high levels, the prices tend to decrease. To maintain winter production, the largest area for greenhouse tomatoes is located in the west and southwest of the US due to the high amount of light in these states during winter. Further, summer is not too hot, hence cooling is still feasible with fan and pad cooling[1]. It is still attractive to build new greenhouses for tomatoes, for instance, recently the Dutch greenhouse builder Kubo build 2 greenhouses with a total acreage of 110 acre.

Competition with Mexico is difficult because they can produce at lower costs due to cheaper labor. Secondly, the climate makes it possible to use cheaper greenhouse systems. A difficulty with the import from Mexico is that not all tomatoes grown under protection are from greenhouses: Some are from shade houses. For the consumer it is hard to distinguish between those two. Canada is the largest producer of greenhouse tomatoes on the Northern American continent. It has limited field-production of tomatoes. However, Canadian growers invested largely in advanced technologies. High technology in combination with long day length in summer, and relatively mild weather results in the highest average yields in North America (Cook & Calvin, 2005). The Canadian production peaks at the time field-production of tomatoes is at a high level as well. Hence, prices are likely to fall in this period. For the region this report puts its focus on, this is a major issue because its own peak of production will mostly coincide with the Canadian one.

Besides international competition, domestic competition amongst different growers occurs as well. In North America no central distribution takes place. Growers compete at the buying agent from the supermarket. Similarly, this also occurs at the big greenhouse companies. For these companies it is hard to focus on the locally-produced food trend due to the scope of their production. These big growers cannot always benefit from economies of scale, or suffer from problems with plant-related diseases and/or availability of workers. Also the long distances transport of tomatoes from the West to the East provides issues due to the vulnerability of tomatoes as a product.

As described in the introduction, a trend to more sustainable locally-produced food can be found. Without the use of greenhouses it is impossible to achieve year round production in the selected region. The growing season will be too short and too cold for field- production. The advantage of this region is the latitude which provides enough light to enlarge the growing season in spring and autumn. This will result in comparable results as achieved in Canada. Besides the market for locally-produced food there is also a larger demand for high quality tomatoes. The taste of greenhouse tomatoes is often better than the taste of field-produced tomatoes due to the stage in which they are harvested. Tomatoes from greenhouses are harvested when they are ripe. Most field-produced tomatoes are harvested green and treated with ethylene gas to induce ripening. Vine ripe tomatoes are harvested at a slightly riper stage and ripen fully without ethylene treatments.

As previously mentioned, the largest tomato greenhouse area is located at the West of the US. Nevertheless, tomato greenhouse growers are present in the North East as well. This area consists of strong seasonal firms (Cook & Calvin, 2005) and companies are smaller than their Western counterparts. As the long distances between the West and the East provide vulnerability issues for tomato transport, this provides opportunities for growers in the East to compete.

[1] Fan and pad systems consist of exhaust fans at one end of the greenhouse and a pump circulating water through and over a porous pad installed at the opposite end of the greenhouse. If all vents and doors are closed when the fans operate, air is pulled through the wetted pads and water evaporates. (R. A. Bucklin, University of Florida)

The reason for difference in area between the different states is differentiation from the competitor ("Personal interview"). Most of these companies are near urban centres, which minimizes transportation costs and maximizes retail shelf life potential (Cook & Calvin, 2005). This can be seen as an advantage to promote locally-produced food. Also, some growers spread risk by not only producing vegetables in their greenhouses. For these growers a normal growing season consists of Easter lilies, tomatoes and poinsettias.

Finally, an important trend in the greenhouse tomato sector is the change in tomato item. The tomato on the vine (TOV) and the Beefsteak are still the most popular, but there are experiments with Romas, Grapes and Cocktail TOV's (Bareuther, 2010). At first the North American greenhouse tomato industry began with the beefsteak tomato, which looks similar to a field-produced tomato. The TOV was introduced in the 1990's during the big development of tomato greenhouses. Limitation of greenhouse tomatoes is that they are not used in the large food service sector because of their property of being a wet structure that Americans do not like on, for example, their hamburger. Breeding companies are trying to find a solution to this problem in order to also being able to use greenhouse tomatoes in the food service sector.

3. Materials and Methods

To answer the research questions and to find out the perspective for a tomato grower in the US two methods are used: the SWOT analysis and a stochastic simulation.

3.1 SWOT analysis

SWOT analysis stands for the analysis of strength, weaknesses, opportunities and threats. Performing the SWOT analysis on the perspective of tomato growers in the North East United States will give a good overview of the competitiveness of growers versus producers from Canada, Mexico and the South West of the US as well as field-production. SWOT analysis is concerned with the analysis of an organization's internal and external environment with the aim of identifying internal strengths in order to take advantage of its external opportunities and avoid external (and possible internal) threats, while addressing its weaknesses. (Panagiotou, 2003)

3.2 Stochastic simulation

To get a good perspective of a tomato greenhouse there was a need to develop an enterprise budget. This enterprise budget was adapted for the different scenarios.

In this master thesis different perspectives for US tomato growers were considered. Four Different scenarios are modelled by constructing stochastic simulation models. Monte Carlo Simulation is applied because entrepreneurs have to consider the high risk on tomato price, input price and level of production.

"The purpose of stochastic simulation in decision analyses is to determine the probability distribution of consequences for alternative decisions to enable the decision maker to make a good and well-informed choice." (Clemen,Reilly,2004).

The different scenarios will be evaluated based on NPV (Net present Value).

The formula for NPV:

$$\mathrm{NPV} = \sum_{t=1}^{T} \frac{\mathrm{CF_t}}{(1+\mathrm{r})^{\mathrm{t}}} - \mathrm{I} \qquad (1)$$

where I represents the investment expenses and CF represents the future cash flows in year 1 to T and r is the discount rate. The simulation is performed with a 10 year prediction.

The four scenarios investigated are low technology greenhouse, medium technology system, high technology system and a high technology system that will make use of CHP installation. A low-technology greenhouse is defined here as involving only a fixed, permanent structure with limited or passive environmental control. A medium-technology system involves greater environmental control and/or the addition of hydroponics. A high-technology system requires both fully active environmental control and hydroponics (Cook and Calvin 2005). The last scenario is also a high technology greenhouse but this one makes use of a CHP installation and delivers the electricity to the grid.

The size of the greenhouse is representative for the area. This is achieved by paying attention to the locally-produced food trend. The average size of the greenhouses varies from 3000to 40.000 sq ft (USDA,2010). To build a greenhouse small enough to produce local produce and large enough to take advantage from economies of scale, a greenhouse of 30.000 sq ft of usable greenhouse area has been modelled. When using a normal 4 sq ft per plant, this will result in 7500 tomato plants. It is Assumed that the area has to be bought for $160.000. However land prices in the states vary a lot. Hence, investors have to implement this according to their personal situation.

To add value to the stochastic simulation, a sensitivity analysis is conducted. This analysis provides information about the effect in stochastic sequence when the price of tomatoes, variable inputs and the discount rate changes with -10% and +10% of the base value.

3.2.1 Low technology scenario

This scenario is the simplest scenario, where growers have the lowest investment. This scenario requires a start investment of a simple low technology greenhouse. This variable is denoted as I to calculate the NPV formula is used.

The r in equation(1) is the interest rate, based on the interest rate and the rate of return that an investor wants to achieve on his investments. To define this rate, the US interest rate from the last years has been looked at. The benchmark interest rate was last reported at 0.25%[2]. Historical data shows variation from 20% in March 1980 and 0.25% since December 2008. Of course there has to be an honest reward for the risk and capital that an entrepreneur puts in his investment. Some (almost) bankruptcies occurred in recent history. Subsequent a high reward of 7.5% is denoted in the NPV formula. An extra reward of 2.5% is added as correction for inflation. This makes a total r of 10%.

In this formula the CF is calculated using the following equation: CF=Ps*Q-Cvq*q-Cva*A –F

The Cvq are costs related to the amount of tomatoes produced, for instance packaging material or labor needed for harvesting. Cva are costs related to the greenhouse area, such as rock wool. F are the fixed costs such as accountancy, telephone and internet (overheads).

[2] http://www.tradingeconomics.com/united-states/interest-rate

The variables are described in the figure below. The explanation about the data sources is given in 3.2.5 section about data.

Table 1 Variables from the low technology scenario

Variable	Description	Distribution
I	Initial investment	Fixed
Ps	Selling price of tomatoes	Normal
Q	Quantity of tomatoes	Normal
Cvq	Variable costs per amount of tomatoes	Normal
Cva	Variable cost per SQ ft	Normal
A	Acreage in SQ ft	Fixed
F	Fixed costs	Normal

Source: Own table based on the literature review

3.2.2 Medium technology scenario

This scenario is created to give a good representation about the financial possibilities from a medium technology greenhouse. A medium technology greenhouse requires a higher investment than a low technology greenhouse and has more capabilities to produce higher yields than a low technology greenhouse. In this scenario use is made of the same formula for NPV: Cash flow used as an input in the NPV formula is different from the low technology CF equation. In this calculation an input for the use of gas and the price of gas is added. Also these prices are an outcome of historical data. Of course the initial investment in this scenario is higher due to the more advanced techniques that will be used. The initial investment in land is the same.

$CF=Ps*Q-Cvq*q-Cva*A-G*Pg-F$

Table 2 Variables of the Medium technology scenario

Variable	Description	Distribution
I	Initial investment	Fixed
Ps	Selling price of tomatoes	Normal
Q	Quantity of tomatoes	Normal
Cvq	Variable costs per amount of	Normal

	tomatoes	
Cva	Variable cost per SQ ft	Normal
A	Acreage in SQ ft	Fixed
G	Usage of Gas	Normal
Pg	Price of gas	Normal
F	Fixed costs	Normal

Source: Own table based on the literature review

In the medium technology scenario a negative correlation of -0.2 between the price of gas and its usage is assumed. A correlation is a single number which describes the degree of relationship between two variables. Its range is between +1 and −1. A correlation coefficient of +1 indicates a perfect positive relationship, while −1 shows a perfect negative relationship. The smallest correlation is 0. In this report the same correlation rates of -0.2 in the high technology and CHP scenario are assumed.

3.2.3 High Technology scenario

In this High technology scenario the formula that is used for NPV is the same as in the low and medium technology scenario.

The Cash flow is calculated by the following equation:

CF=Ps*Q-Cvq*q-Cva*A-G*Pg-F

This equation seems the same as in the medium technology scenario. However, the inputs and outputs have other values due to the more expensive techniques that increase production.

Table 3 variables of the high technology scenario

Variable	Description	Distribution
I	Initial investment	Fixed
Ps	Selling price of tomatoes	Normal
Q	Quantity of tomatoes	Normal
Cvq	Variable costs per amount of tomatoes	Normal
Cva	Variable cost per SQ ft	Normal

A	Acreage in SQ ft	Fixed
G	Usage of Gas	Normal
Pg	Price of gas	Normal
F	Fixed costs	Normal

Source: Own table based on the literature review

3.2.4 CHP scenario

The Cash flow is calculated by the following equation. An addition to the formula has been made for the sales of electricity and the price of electricity.

CF=Ps*Q-Cvq*q-Cva*A-G*Pg+Pkw*Qkw

The rest of the model makes use of the same numbers as the high technology scenario, so production and prices are the same. Of course the initial investment is higher because of the investment in a CHP installation.

Table 4 Variables of the combined heat and power scenario

Variable	**Description**	**Distribution**
I	Initial investment	Fixed
Ps	Selling price of tomatoes	Normal
Q	Quantity of tomatoes	Normal
Cvq	Variable costs per amount of tomatoes	Normal
Cva	Variable cost per SQ ft	Normal
A	Acreage in SQ ft	Fixed
G	Usage of Gas	Normal
Pg	Price of gas	Normal
Pkw	Price per Kw of electricity	Normal
Qkw	Quantity of electricity produced by the CHP	Normal
F	Fixed costs	Normal

Source: Own table based on the literature review

Likewise in this model a negative correlation between the price and the usage of gas are assumed. For the price of electricity and the use of gas a positive correlation of 0.2 is assumed as well as for the electricity production. This enhances the rise of price of electricity when more gas is used.

3.2.5 Data

Central in this paragraph is the data, which was used as input for the model about the different types of greenhouses. First, data about selling price of tomatoes was used in each scenario. It should be noted that limited amount of information about selling prices of greenhouse tomatoes is available. Nevertheless, Figure 6 gives an indication of the selling prices for greenhouse tomatoes between 2005 and 2009. It shows that the selling prices were rising significantly except in 2007. It seems that the prices in 2007 suffered from an outbreak of E. coli in Mexican tomatoes.

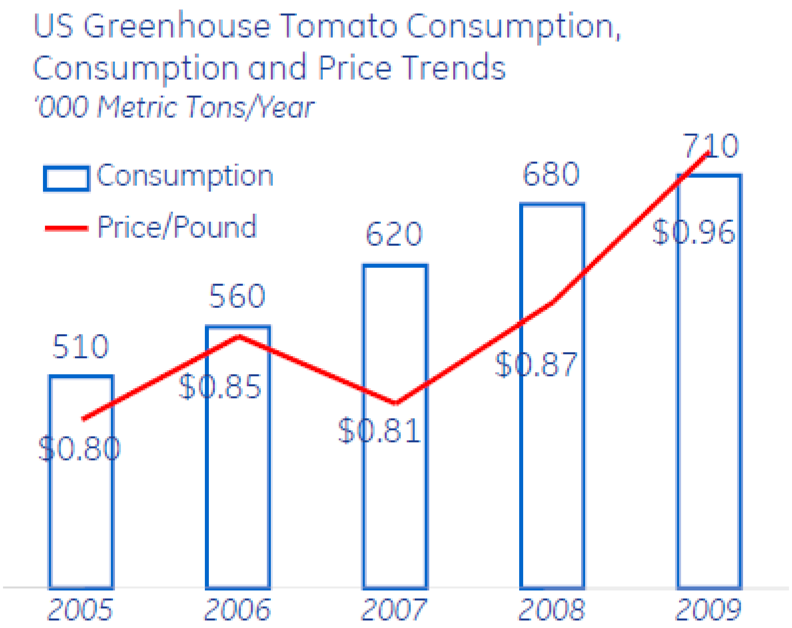

Figure 6 Greenhouse tomato consumption and price trends (source, Hickman, 2009)

It is assumed that greenhouse tomatoes and field grown tomatoes are products that have similar properties. As a result, it is assumed that selling prices of both commodities will respond in the same way. This is illustrated in Figure 7. This figure shows that the selling price for field grown tomatoes is correspondingly rising from the 1980's. The prediction (R^2) of the trend line is 0.7296. This means that 72% of the variance in this model can be explained by the variables and the estimated trend line.

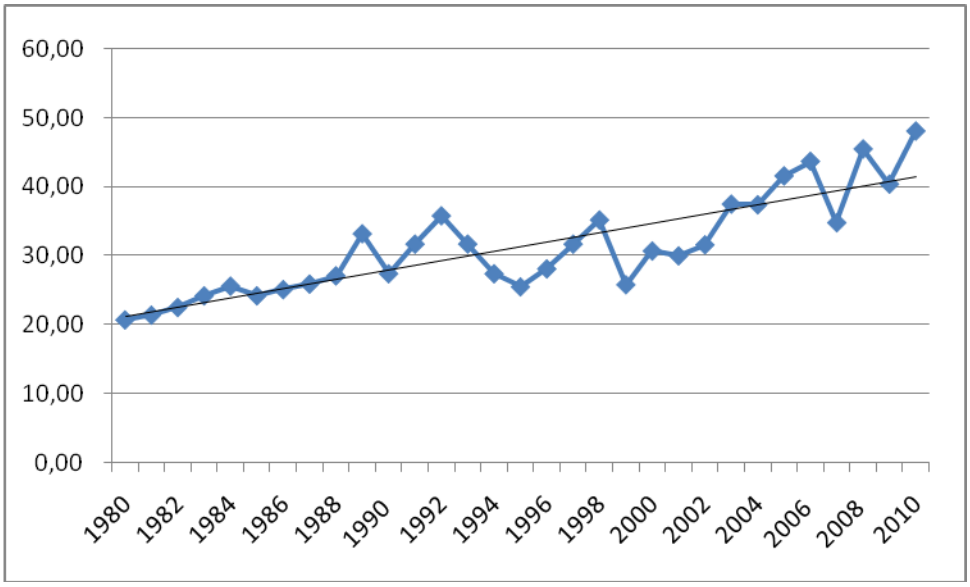

Figure 7 Tomato prices 1980-2010 (Source: Own figure based on vegetable outlook USDA 2011) ($ per 100 pound of tomatoes)

Moreover, it should be noted that fresh field grown tomatoes are seasonable. This means that the supply of these vegetables is fluctuating. Figure 8 shows monthly selling prices. One could see that these prices are relatively higher in the winter compared to the yearly average. However, due to the low quality of field grown tomatoes in December, selling prices are low. Hence, it is attractive for growers to anticipate on the higher prices by supplying more tomatoes to the market during the winter. As a consequence, it is beneficial for a grower to clean the greenhouse and plant a new crop during summer when selling prices are low.

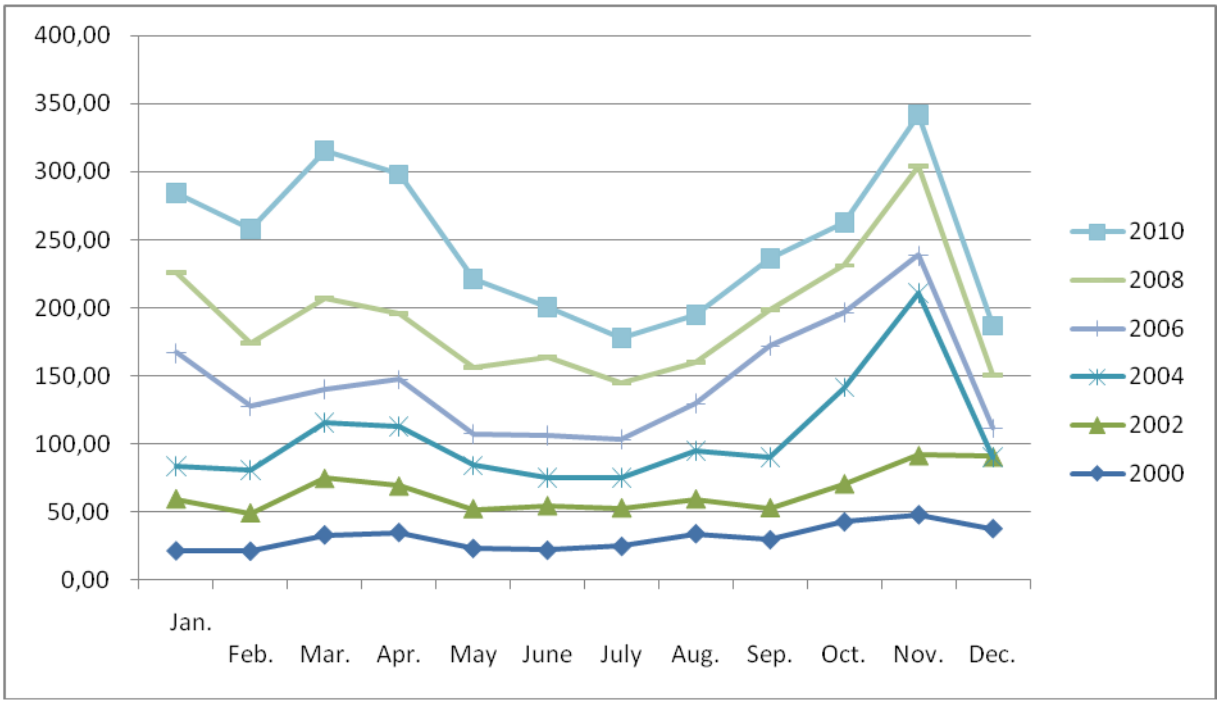

Figure 8 Field tomato prices (Source: Own figure based on vegetable outlook,. USDA 2011)($ per 1.000 pound of tomatoes)

Figure 9 shows a price comparison between Canadian greenhouse tomatoes and field grown tomatoes harvested on different stages in 2003. It seems that the selling price of greenhouse tomatoes is higher compared to field grown tomatoes except for the summer months.

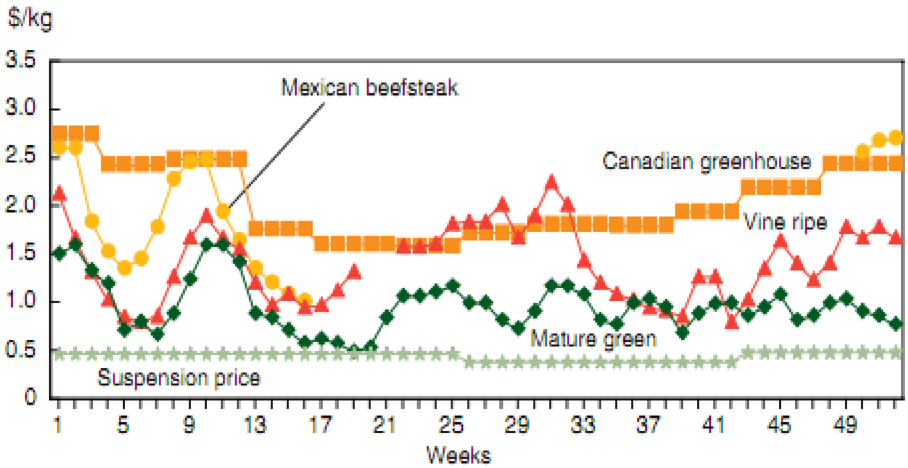

Figure 9 Price of different type of tomatoes 2003 (source Cook, 2006)

The previous result of tomato prices leads to the assumption that higher price of greenhouse tomatoes can be underpinned with reliable data. However, it is still difficult to determine the most reliable prediction of selling prices. In this research, the field grown tomato prices were selected and increased with the average price increase as shown in the trend line of Figure 7. This number is increased with the average price difference between greenhouse tomatoes and field grown tomatoes (see Figure 6 and 7). The variability in these distributions is the standard deviation of the field grown tomato price. This resulted in the following price prediction for the coming years.

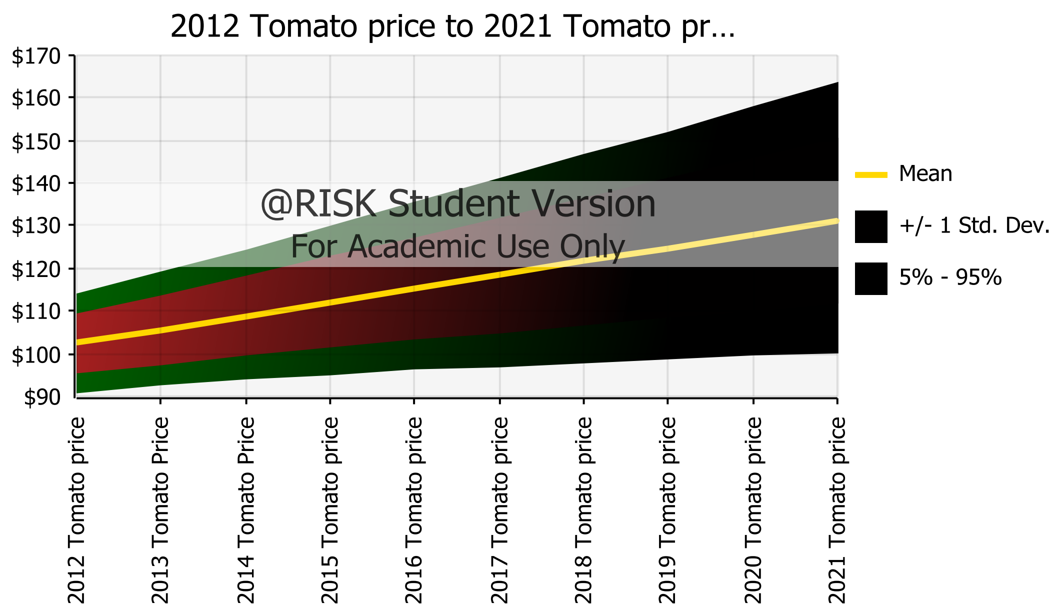

Figure 10 Price prediction for greenhouse tomatoes. (Source own figure based on different databases)

Figure 10 shows that the selling price of tomatoes assumed in the model is increasing. Moreover, this Figure also shows that the price uncertainty will rise over the years. Because of the absence of more data regarding greenhouse tomatoes prices, a sensitivity analysis with different tomato prices (+-10%) from the base level was conducted.

3.2.5.1 Variable inputs

It was also important to determine input prices per pound of tomatoes. This variable is set equal for all different scenarios. These costs are related to the amount of tomatoes produced. However, other costs are also present. These are related to the size/shape of greenhouses or are fixed.

Table 5 Variable price of inputs per 100 pound of greenhouse tomatoes

	per 100 pound tomatoes
Beneficial Insects	$2.50
Fertilizer	$3.20
Trays	$0.01
Sticky Traps[6]	$0.08
Clips	$0.21
Twine	$0.06
Tomahooks	$0.61
Deliveringto Market	$1.63
Marketing	$1.32
Seed / Transplant / Harvest / Package	$25.50
Production Management	$3.92
Maintenance	$0.26
Labels& Stickers	$2.51
Foam Trays	$10.35
Boxes	$6.50
total	$**58.66**

Source: Own table based on a greenhouse enterprise budget from Ohio State University.[3]

The enumeration mentioned in Table 5 are production prices that are variable and related to the amount of tomatoes produced. Prices are extracted from expert interviews and worksheets provided

[3] http://www.oardc.ohio-state.edu/hydroponics/drake/index.php?option=downloads&task=info&id=8&Itemid=50&-Hydroponic-Tomato-Budget-Analysis-single-bay

by universities in the US like Purdue University and Ohio State University. The budget of Ohio State University is included in Appendix 2. The sum of all separate cost pools is calculated at $58,66 per 100 pounds of tomatoes (see Table 5). This is based on data from Ohio State University. Because this budget consists of the most appropriate descriptions of variable prices, therefore it was used in this research. Other budgets had comparable outcomes of total variable costs but where not as accurate in distinction of prices per pound of tomatoes and price per unit of land as the model of Ohio State University. It is assumed that the price spreading of these inputs is normal distributed with a variation of 20%. This variation is depicted because experts could not provide actual numbers for variation in this distribution. But experts expect that this variation fluctuate not more than 20%. The price has been multiplied with the average inflation in the US from the last ten years. This number (inflation) is extracted from the average amount. This resulted in an average inflation of 2.5%. This number is used in future price calculations of different inputs. Because of certain data absence (e.g. missing of variability numbers of variable costs) a sensitivity analysis was implemented to acquire a possible change in prices which consequently could have an effect on the total outcome.

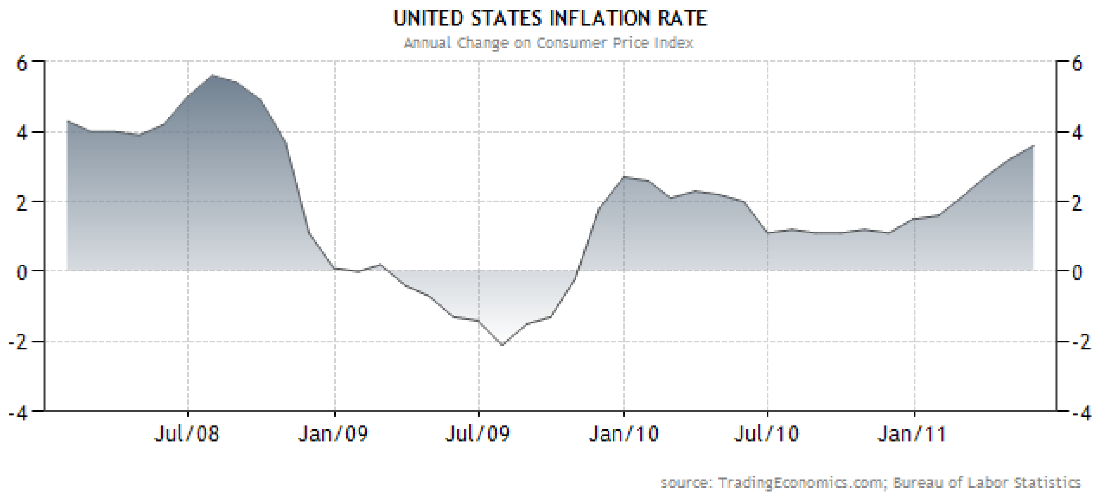

Figure 11United States inflation rate. (source: tradingeconomics.com; Bureau of labor statistics.

The Cva are the costs for rock wool and seed this is $3.18 per sq ft and is for all the scenario's equal. This number will be corrected for inflation every year in the model. Assumed is that prices are distributed normal and have a variation of 20%. Data for this is also extracted from a model developed by Ohio State University and does not contain actual information on price variability but assumed is that 20% is normal. Because of missing this variability a sensitivity analysis was implemented for all variable costs.

3.2.5.2 Fixed costs

Besides the variable costs there is also an input of fixed costs. This number is the same for all the models. The $2870 are costs for telephone, internet and accountancy and are extracted from an greenhouse enterprise budget from Ohio State University.

3.2.5.3 Data for the Low tech scenario

In the low technology scenario is already mentioned that this is a low technology greenhouse. The walls are from plastic. The total investment consists of $173.320. Main costs are land, site preparation, polyester and frame of the greenhouse. Although there is no heating there is cooling needed for the hot summer. The numbers are taken from a greenhouse budget developed by Ohio State University and adapted for size and circumstances required for the low technology greenhouse.

Table 6 Initial investment in Low technology scenario

Land	$160.000
Concrete-Material and Labor	$6.000
Frame, Poly, Ends, Door	$47.000
Ground Cover	$2.160
Permits	$3.000
Site Preparation	$90.000
House Construction	$6.400
Back Pack Sprayer	$100
Carbon Dioxide Generator	$480
Cooler	$8.000
Delivery Van with A/C	$6.000
Fertilizermixing Pump	$120
Feeding System	$3.200
Meters and Sensors	$235
Monitor	$625
Total	**$333.320**

Source: Own table based on a greenhouse enterprise budget from Ohio State University.[4]

The production in this greenhouse is around 30 pounds per plant per year. This number is obtained from expert interviews and data that is provided by Ohio State University.

3.2.5.3 Data for the medium technology scenario

Table 7 shows the initial investment for the medium technology scenario.

[4] http://www.oardc.ohio-state.edu/hydroponics/drake/index.php?option=downloads&task=info&id=8&Itemid=50&-Hydroponic-Tomato-Budget-Analysis-single-bay

Table 7 Initial investment in medium technology scenario

land	$160.000
Concrete-MaterialandLabor	$6.000
Frame, Poly, Ends, Door	$47.000
Glass greenhouses	
Energy/Shade Curtains	$40.500
Ground Cover	$2.160
Permits	$3.000
Site Preparation	$90.000
House Construction	$12.800
Back-up Generator and Transfer Switch	$4.000
Cooling System (fan, vent, & pad)	$1.850
Fanjets, 30" 1hp / Horizontal Air Fans (HAF)	$1.000
Electrical Panel	$1.500
Computer for Environmental Control	$2.500
Miscellaneous Building Supplies	$1.500
Poly Inflation Kit	$1.250
Low Voltage Wiring Package	$3.500
Protective Equipment (PPE)	$500
Back Pack Sprayer	$100
Carbon Dioxide Generator	$480
Cooler	$8.000
Delivery Van with A/C	$6.000
Fertilizer Mixing Pump	$120
Feeding System	$3.200
Meters and Sensors	$235
Monitor	$625
Total	**$397.820,00**

Source: Own table based on a greenhouse enterprise budget from Ohio State University.[5]

The production in this greenhouse is around 50 pounds per plant per year. This number is taken from expert interviews. The difference in production is caused by the Shade curtain that keeps heat in the greenhouse and sun out of the greenhouse in hot days. Also the production is higher by the heating that is done in spring what has a big influence on the start in the production season.

For heating natural gas is used. In the model gas prices from the US department of energy from the last ten years from the New York region are used. The observations are put into @Risk which created fit comparison analysis as shown in figure 11.

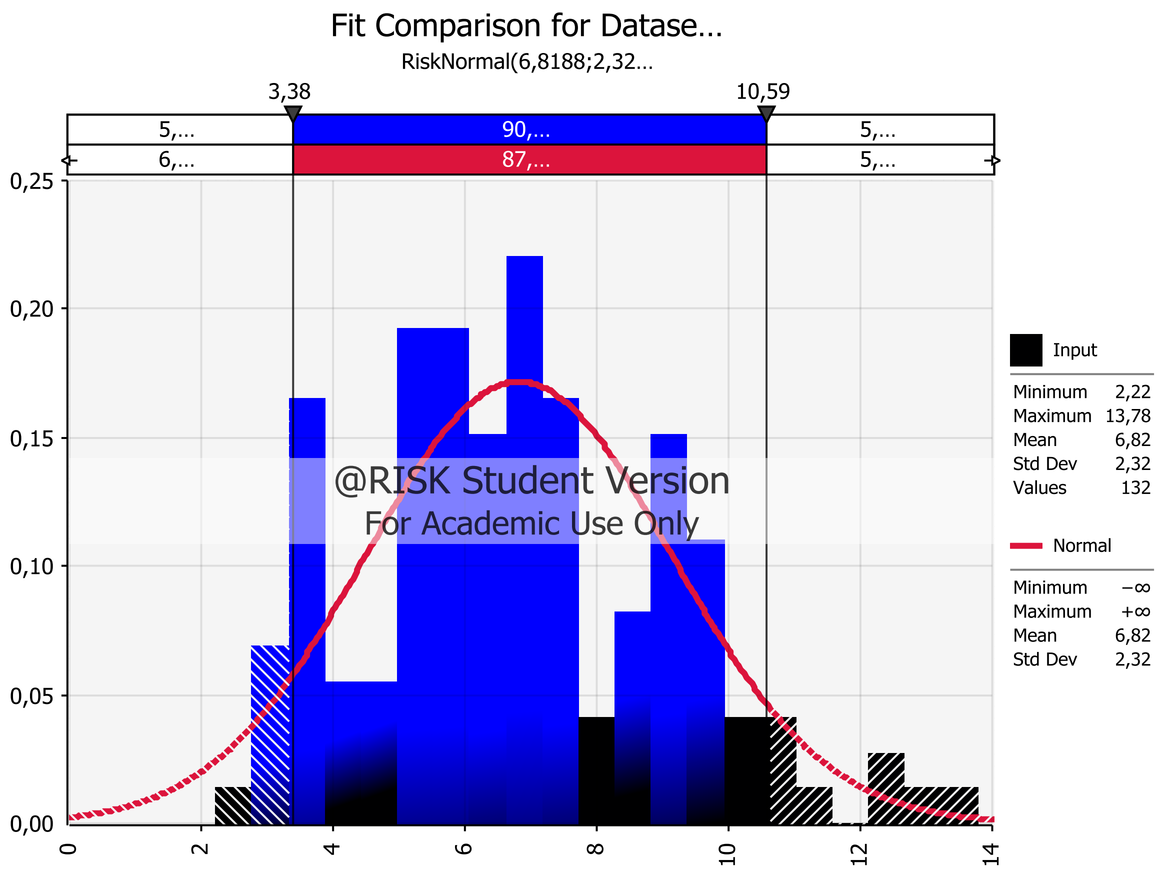

Figure 12 Fit comparison for natural gas prices(source, own figure based on data from the US energy information administration)

This turned out in a normal distribution with a standard deviation of 2.32. This price distribution is also used in the high technology model and the CHP model.

Besides the price of gas there is also the use of gas in a medium technology greenhouse, because the heating is only necessary in the beginning of the season, assumed is that the use of gas is 300 ft3.

[5] http://www.oardc.ohio-state.edu/hydroponics/drake/index.php?option=downloads&task=info&id=8&Itemid=50&-Hydroponic-Tomato-Budget-Analysis-single-bay

This input is because of different weather circumstances not fixed and has a normal distribution. Assumed is that prices of gas will rise the coming years, this is represented by figure 13.

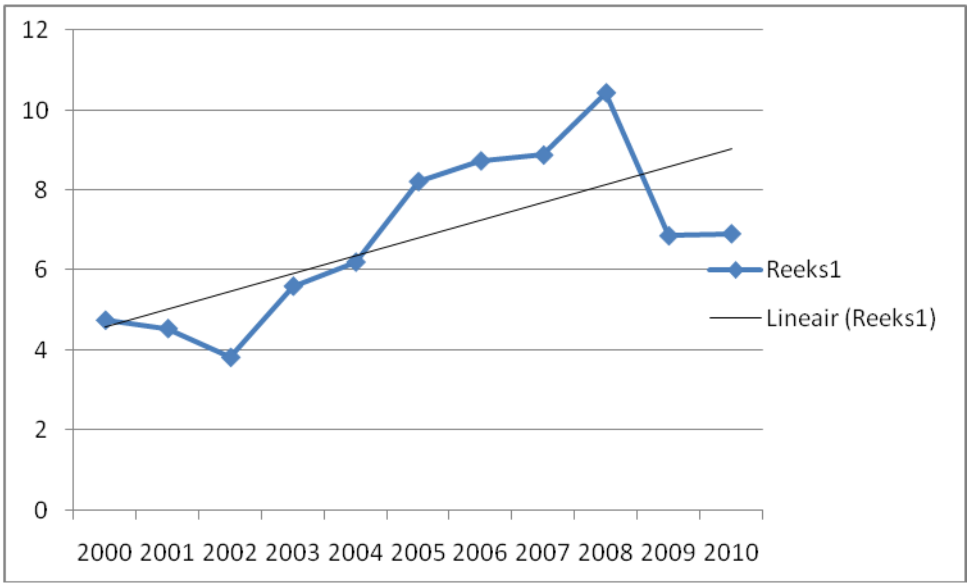

Figure 13 Prices of natural gas (own figure based on data from the US energy information administration www.eia.gov)

Figure 13 shows the average prices of natural gas in the New York region. This shows that there was a price increase the last years. Therefore, the natural gas price of the analysis was increased every year with the value that is represented by the trend line in figure 12. This R^2 in figure 13 is 0.5046 this tells that 50% of the variance can be explained by the trend line this is still strong enough to say that this line is correct and will be used in the model.

3.2.5.4 Data for the high technology scenario

In the following table is the initial investment for the high technology scenario based upon the Ohio State University greenhouse budget.

Table 8 Initial investment in High technology scenario

Ground	$160.000
Concrete-Material and Labor	$6.000
glass greenhouses	$112.500
Energy/ShadeCurtains	$40.500
Ground Cover	$2.160
Permits	$3.000
Site Preparation	$90.000
House Construction	$25.600
Back-up Generator and Transfer Switch	$4.000

Cooling System (fan, vent, & pad)	$1.850
Fanjets, 30" 1hp / Horizontal Air Fans (HAF)	$1.000
Electrical Panel	$1.500
Computer for Environmental Control	$.2500
Miscellaneous Building Supplies	$1.500
Poly Inflation Kit	$1.250
Low Voltage Wiring Package	$3.500
Protective Equipment (PPE)	$500
Grow Lights[10]	$368.000
Back Pack Sprayer	$100
Carbon Dioxide Generator	$480
Cooler	$8.000
Delivery Van with A/C	$6.000
FertilizerMixing Pump	$120
Feeding System	$3.200
Meters and Sensors	$235
Monitor	$625
heaters	$100.000
Total	**$944.120**

Source: Own table based on a greenhouse enterprise budget from Ohio State University.[6]

Total costs of this type of greenhouse are higher because of the higher investment that is required to produce in a glass greenhouse with full environmental control. The production in this greenhouse is assumed to be 100 pounds per plant per year. This number is erected from data that is provided by experts which have experienced with this type of greenhouse. The difference between other types of greenhouse is the possibility to produce year round. Also big differences are made with glass that gives better isolation and light distribution than plastic so that production will occur during winter. The high production requires higher inputs like gas and electricity for growing tomatoes. With the production of tomatoes during winter there should be opportunities to gain higher prices. It is not certain how this will work out so the same projected price for tomatoes as in the other scenarios is

[6] http://www.oardc.ohio-state.edu/hydroponics/drake/index.php?option=downloads&task=info&id=8&Itemid=50&-Hydroponic-Tomato-Budget-Analysis-single-bay

used. Big difference with the medium technology production is the extra inputs for gas and electricity to produce tomatoes of a good quality in winter.

3.2.5.5 Data for the CHP scenario.

This is the most expensive greenhouse because of the extra investment in a CHP installation. The input costs of $700.000 from this installation are obtained from expert interviews and a presentation from a CHP producer (Modak, 2011). Further, assumed is that the same initial investment as in the high technology greenhouse. Further, assumed is that production is the same as in the high technology greenhouse. There could be extra production if a CO_2 scrubber could be installed and the CO_2 would be used as fertilizer, however in this area the humid climate requires ventilation and the CO_2 will evaporate. The production of electricity by the CHP installation is extracted from data provided by producers of CHP installations. It is assumed that the production from those installations is normally distributed. Also prices of electricity are provided and calculated according to the prices of the last ten year obtained from the US energy department.

4. SWOT Analysis

As already mentioned in chapter 2, there are opportunities and threats for the tomato greenhouse sector in the North East of the US. In this chapter these will be defined better and analyzed according to the strength, weaknesses, opportunities, and threats and they will be summarized in a SWOT Model. The objective of the SWOT analysis is to provide the investor a summary of the internal and external factors concerning the greenhouse tomato industry and will help the investor in creating a successful tomato company.

4.1 Strengths

- Production in high population density area.

The region where the production should take place has a high population density. This in comparison to low density regions where the tomatoes are currently produced, therefore this means lower transportation costs and better quality due to lower transportation distances.

- High production in small area.

Greenhouses can produce high yields due to optimal conditions. This means that the space which is scarce in high population areas will be used more efficiently. A greenhouse is a good way to improve the yield in area where agricultural production land is scarce and expensive.

- Relative high electricity prices that are needed for CHP installation.

One of the upcoming techniques in the greenhouse sector is a combined heat and power installation. With the current techniques this can be beneficial. Especially in this region with high energy prices due to high population density this can gain high outcome prices for electricity. Also a CHP installation can deliver energy to power the artificial lightning that could be necessary in the dark winter. The following figure shows that the average prices in New York (NY) are higher than US average.

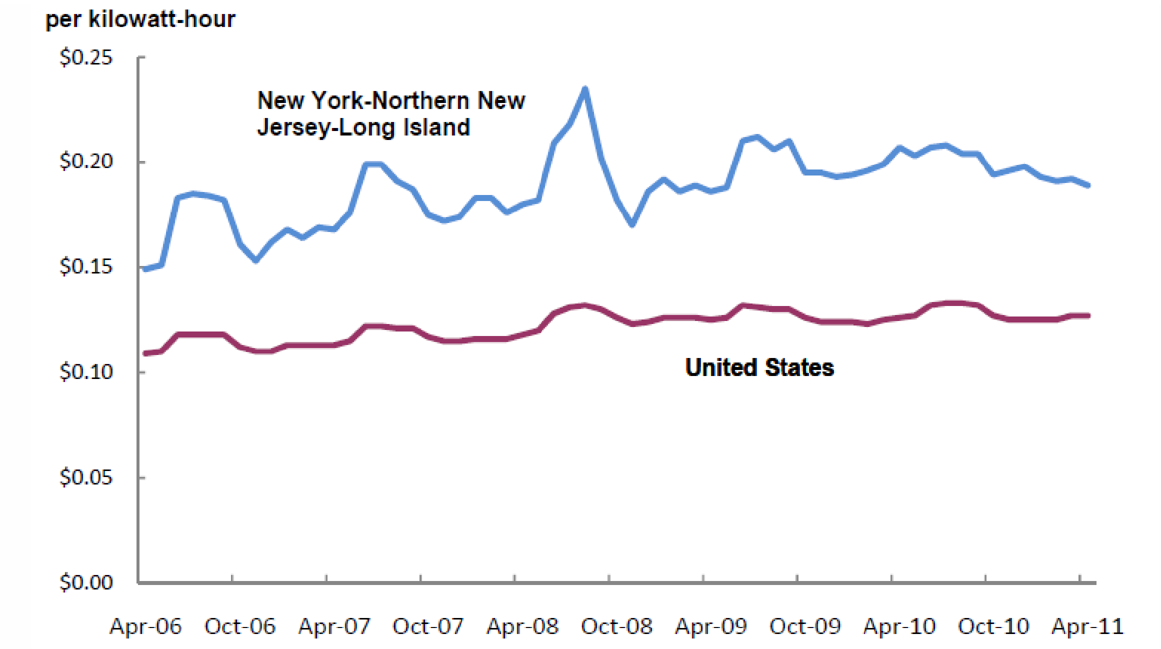

Figure 14 Average price of energy (source: bureau of labor statistics, 2011).

- Less use of pesticides than field-production.

Greenhouse tomatoes are grown with few, if any, pesticides. Greenhouse tomatoes are produced in optimal controlled exposed to fewer environmental hazards than open-field tomatoes (Cook and Calvin, 2005), reducing or eliminate the use of pesticides. Beside the financial benefits of this reduction the consumer in the US has an increasingly affluent with food. For example Whole Foods is a chain of stores that are successfully due to their differentiation in sustainable products.

- Production is possible year round.

The production in greenhouses is better to control than open field-production. In high technology greenhouses it is possible to produce year round. This is very beneficial because growers can supply their buyers year round. This is especially attractive in winter when tomato supply from field-production is low and prices are relatively high for fresh tomatoes. The benefit is not that attractive for low technology greenhouses that are only fit to have an earlier start and a longer end of the tomato season.

- Small sector with small growers.

The area has not a lot of growers and they are mostly small because of the large distances between growers there is not a lot of infection from diseases. For example the tomato yellow leaf curl virus is one of the viruses that are not as active in these regions as it is in regions that also contain a lot of field-production ("Personal interview").

- Enough water to produce

In current tomato production areas as California and Florida water scarcity is becoming a big issue. The question is when the government will intervene in water use of the field-production. The area where this research on focused is less sensitive for water scarcities than current regions. This will be positive when the production in the current region will decline.

4.2 Weaknesses

- Area that has long dark winters.

The focus area has long dark winters to enable a long and productive season supplemental lightning is needed in the winter season. This will increase cost of the tomatoes. Benefit is that this cost increase is also in the season with high prices for tomatoes.

- Price of greenhouse tomatoes is higher than field-produced tomatoes.

For greenhouse producers those higher prices are necessary to produce. For the consumer it is not always clear that the higher price is beneficial for the quality and safety of the greenhouse tomato compared to the cheaper field-tomato.

4.3 Opportunities

- Consumer demands more locally-produced food.

Besides the demand for more sustainable grown products there is also a rising demand for products that are grown in the local area. This is because American people notice that the world stock of oil will come to an end. Also people recognize financial problems in their regions and try to support local companies so that the local economy can become stronger.

- Production of tomatoes that contain less liquid for the food service industry.

The foodservice which represents about half of U.S. fresh tomato consumption is not yet an important market for greenhouse. There are breeders actively seeking for new varieties that will contain less liquid. For example Nunhemm has a variety that does not lose their liquid when they are sliced. If the foodservice industry recognizes this development, the demand for greenhouse tomatoes could be increased significant.

- The US is very careful with imports from other countries that can contain bacteria's for example EHEC or E. coli.

The US is very carefully with imports from other countries to fur fill their tomato demand. Now there are still new diseases in the EU for example EHEC and earlier problems with E. coli in Mexico, the US will be more dependent form US produced tomatoes. This means the production of tomatoes in the US has to increase.

- Development of LED lightning can be very beneficial to light the tomatoes in winter.

There is a lot of research done trough the large-scale introduction of LED lightning in commercial greenhouses for example by Philips or at Purdue University. When this will become profitable for the tomato greenhouses the region where this research will be focused could be very attractive because of the dark winters.

- Greenhouse tomatoes are still a niche market in some states.

Greenhouse tomatoes generally have better cosmetic appearance and redder color than field-tomatoes. This can result in higher prices if they can differentiate enough from field-production.

4.4 Threats

- Competition of field-production.

One of the big threats for greenhouse tomatoes is the competition of field-production. Field-production is still cheaper than greenhouse production. Besides the negative elements of field-production and higher water use this sector is still larger than greenhouse grown tomatoes. The big question is if the marketing of greenhouse tomatoes can be efficient enough to enlarge the demand for greenhouse tomatoes.

- Competition from Mexico.

Besides the competition from field-production there is also large competition from tomatoes produced in Mexico and marked as protected produced; that production is mostly done in low technology greenhouses or even in shade houses. For consumers it is hard to distinguish greenhouse produced from protected produced. That protection is not a complete controlled environment and the use of pesticides and fertilizer is often higher than greenhouse produced tomatoes.

- Availability of employees.

The availability of employees that are willing to work in the greenhouse sector is becoming an issue. Last years this work was mostly done by employees from Mexican origin. Due to stricter federal rules these employees are not available to do greenhouse work anymore.

- Not known if consumers consider greenhouse grown as sustainable.

Consumers in the US are not that familiar with greenhouse produced tomatoes; it is not known if they will see the benefits for environment and water use and mark the production as sustainable. This is one of the questions for large scale introduction of greenhouse tomatoes in the US.

4.5 Conclusion of SWOT analysis

Table 9 SWOT analysis of the North East greenhouse tomato sector.

Strengths	**Weaknesses**
• Production in high population density area. • High production in small area. • Relative high electricity prices that are needed for CHP installation. • Less use of pesticides than field-production. • production is possible year round • enough water to produce	• Small sector with small growers. • Area that has long dark winters. • Price of greenhouse tomatoes is higher than field-produced tomatoes.
Opportunities	**Threats**
• Consumer demands more locally-produced food. • Production of tomatoes that contain less liquid for the food service industry. • The US is very carefully with imports from other countries that can contain bacteria's for example EHEC or E. coli. • Development of LED lightning can be very beneficial to light the tomatoes in winter. • Greenhouse tomatoes are still a niche market in some states.	• Competition of field-production • Competition from Mexico • Availability of employees • Not known if consumers consider greenhouse grown as sustainable.

Source: Own table based on the literature review.

5. Stochastic simulation results

The result of the stochastic simulation was obtained by running the stochastic simulation models with 10.000 iterations using @Risk, a simulation add-in for excel.

5.1 Results

- Low technology scenario

The results of the model are presented in terms of the net present value. The mean value from the low technology scenario is $259.110,45 with a standard deviation of $140.899,37. The minimum is -$269.921,75 and the maximum is $721.973,39. 90% of the outcomes are between $29.951 and $491.583. The possibility of a negative outcome is 3.3%.

- Medium technology scenario

The simulation of the medium technology gave a mean NPV of $1.382.371,34 with a standard deviation of $384.519,25. The minimum outcome of this situation is -$39.606,03 and a maximum of $2.719.740. the 90% range is from 0.753 $million to 2.015 $million. The change for a negative outcome is very low with 0.01%

- High technology scenario

The high technology scenario has a mean outcome of $1.283.475,31 with a standard deviation of $469.088,76. The minimum outcome is -$445.583,32 and the maximum outcome is $2.808.658,17. The 90% range is from 0.514$million 2.060 $million. the possibility of a negative outcome is 0.3%

- CHP scenario

the mean outcome of the CHP scenario is $833.597 with a standard deviation of $469.216,57. The minimum outcome is -$923.435,96 and the maximum is $2.377.624,32. 90% of the outcomes are between 0.062 $million and 1.611 $million. The chance for a negative outcome is 3.9%

5.2 Comparison between the different scenarios

The following paragraph compares the results from the stochastic simulation. The graph of figure 15 shows that the highest mean results are for the medium technology scenario.

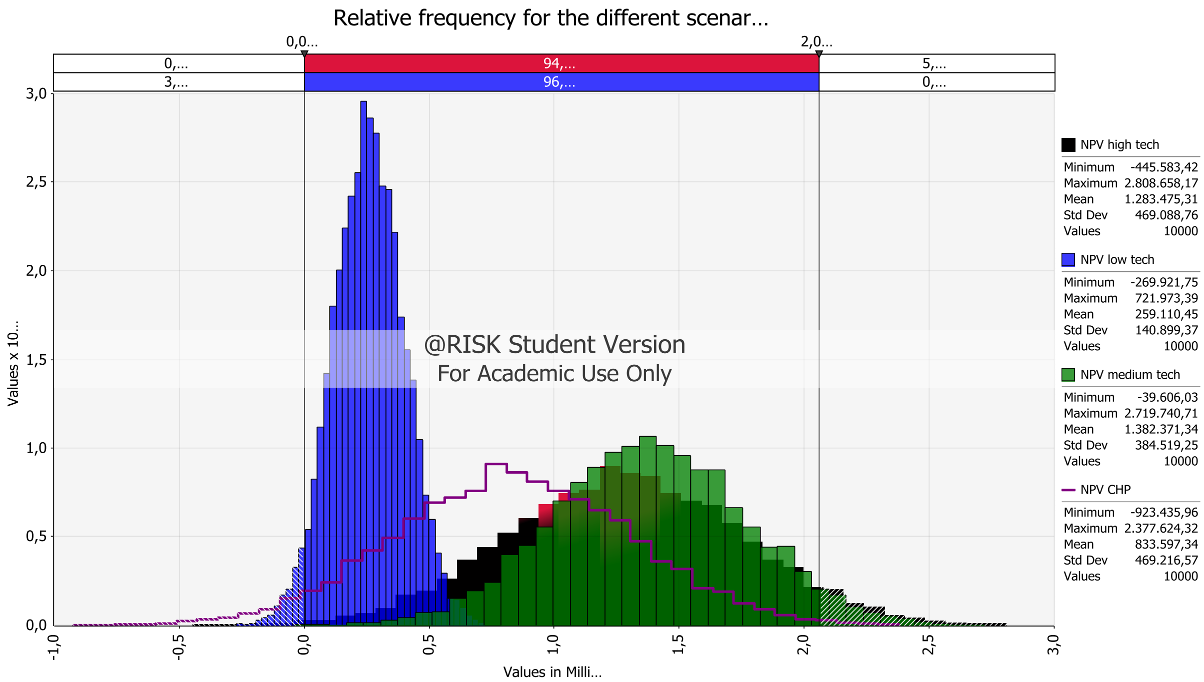

Figure 15 NPV relative frequency for the different scenarios

Source: Own figure based on different databases, 2011

Almost all cumulative distribution functions of the stochastic simulation have a comparable shape. Only the function of the low technology scenario has a more steep line. This is because of the lower variance compared to the other functions. Stochastic dominance is a term which refers to a set of relations that may hold between a pair of distributions. In order to determine whether a relation of stochastic dominance holds between two distributions, the distributions are characterized by their cumulative distribution functions. According to that figure they are ranked on first order stochastic dominance and second order stochastic dominance. First order stochastic dominance assumes monotonicity: investors like more money rather than less money and are non-satiated so no corner solution is possible. Second order stochastic dominance adds risk aversion to first order degree stochastic dominance. Second order stochastic dominance is comparing the area (integrals) below the cumulative density function[7].

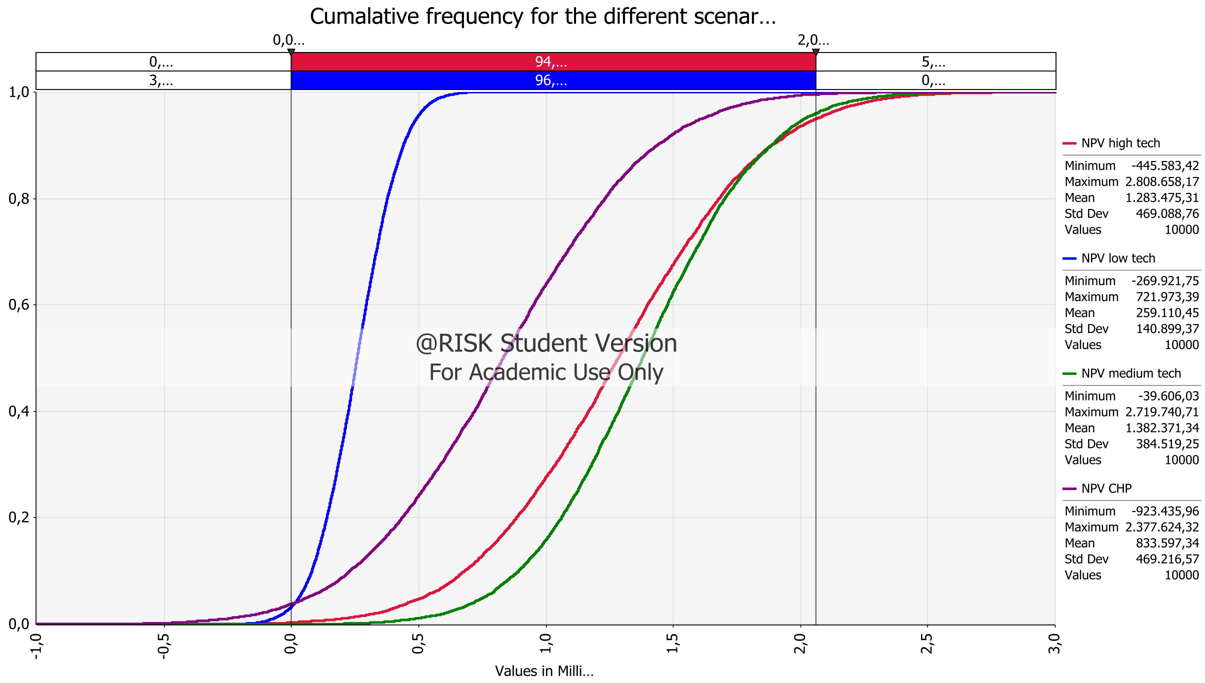

Figure 16 The cumulative distribution functions for NPVs for all scenarios

Source: Own figure based on different databases, 2011

Figure 16 shows that the medium and high technology scenario dominates in first stochastic degree the low technology and CHP scenario. Including risk the medium technology scenario dominates in second stochastic degree over the high technology scenario. From the Low technology and CHP scenario the CHP scenario dominates in second stochastic degree over the low technology scenario.

It shows that the CHP scenario has a lower probability for a high outcome than the medium and high technology scenario. Because of this outcome it can be concluded that the investment in a CHP installation is not beneficial compared to a normal high technology greenhouse. This analysis shows that if the US wants more greenhouse CHP installations, the incentives should be higher and/or the price of CHP installations should be lower. The analysis shows what can be seen in practise. The North East needs greenhouses with heating either medium or high technology greenhouse.

[7] http://www.andreassteiner.net/performanceanalysis/?External_Performance_Analysis:Other_External_Measures:Stochastic_Dominance

5.3 Sensitivity analysis.

Because of some uncertain inputs it was nessecery to do a sensitivity analysis. This analysis will show if the results differ if the following inputs will change with 10% of base vallue: Discount rate of tomatoes, price of tomatoes and price of variable inputs.

First there is made an analysis if the discount rate will increase or decrease of 10%. This analysis projected in figure 17 shows that the order in distribution is only shifting between the high technology and medium technology greenhouse when the discount rate increases 10%. In this analysis the medium technology scenario dominates in first stochastic degree over the other scenarios. This is because of the higher outputs of the high technology scenario which has a lower NPV because of the higher discount rate.This explanation can also be reversed when the discount rate is decreased with 10%. In this case the net present value of future cash flows is higher and this results in a relatively higher NPV for the high technology scenarios. Also the CHP scenario shows outcomes that are higher than in the base situation. This outcome shows the medium and high technology scenario still dominate in first stochastic degree over the other scenarios. However, in this scenario the high technology scenario dominates in second stochastic degree over the medium technology scenario. This analysis showed that a change in discount rate of -10% and +10% of the base vallue does not influence the order of scenarios a lot. The analysis also shows that the change of a negative outcome is higher for all scenarios when the discount rate increases with 10%.

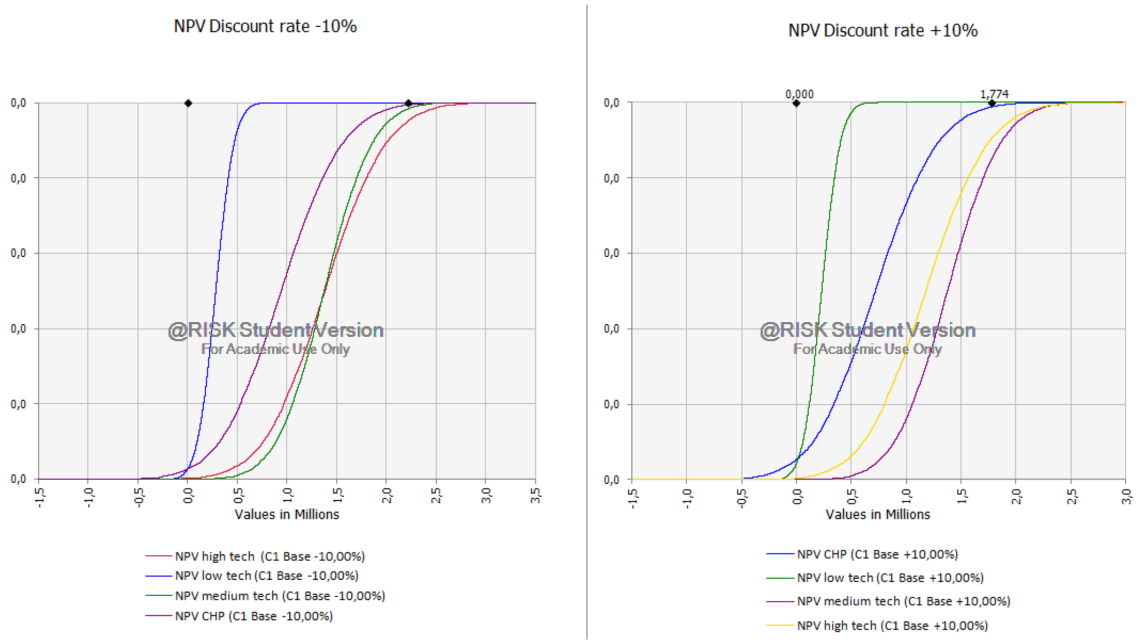

Figure 17 The cumulative distribution functions for NPVs for all scenarios with discount rate -/+10%

Source: Own figure based on different databases, 2011

Next a sensitivity analysis is conducted when the prices of greenhouse tomatoes change with +10% and -10%. Figure 18 show that the CHP and high technology scenario have the highest impact of these changes this is because of their higher number of outputs than in the other scenarios. The simulation with tomato prices -10% showed that the medium technology greenhouse dominates in first stochastic degree over the other scenarios. This analysis also showed lower outcomes and so higher probabilities for a negative outcome than the base scenario.

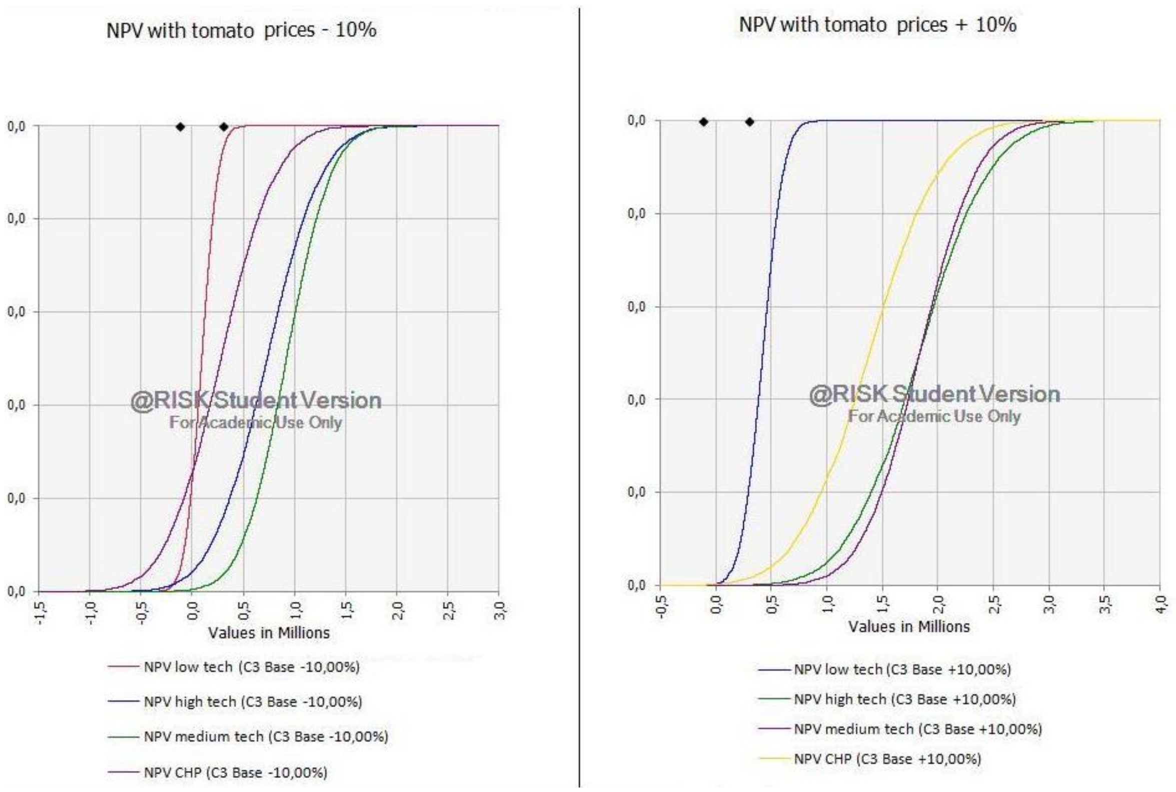

Figure 18 The cumulative distribution functions for NPVs for all scenarios with tomato prices +/-10%

Source: Own figure based on different databases, 2011

However, when the tomato price increase with 10% it shows that again that the medium and high technology scenario still dominate in first degree over the other scenarios. In this case the medium technology scenario dominates in second degree over the high technology scenario and will be the best option for a risk averse person.

Figure 19 show the difference when the price of variable inputs will change +10% and -10% of the base value of variable prices, this enhances variable inputs per pound of tomatoes and variable input per sq ft. It shows that the differences are small compared to the base situation.

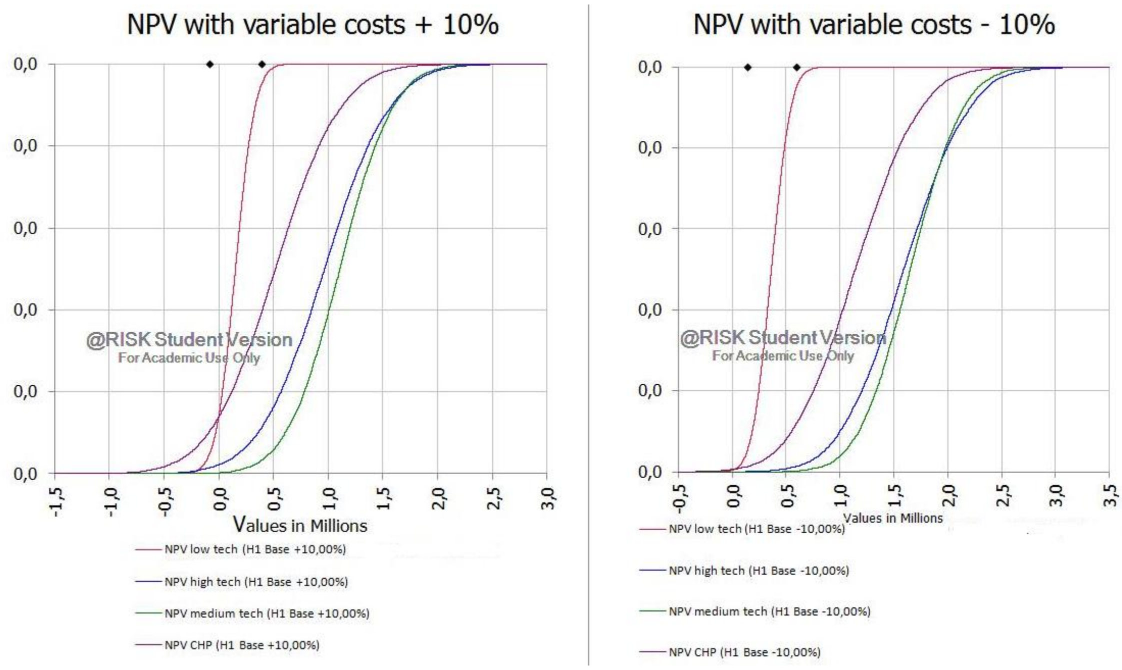

Figure 19 The cumulative distribution functions for NPVs for all scenarios with variable +/-10%

Source: Own figure based on different databases, 2011

This simulation also includes the medium and high technology greenhouse stochastically dominant in first degree over the other variables. This simulation did not change the base order because the medium technology scenario dominates in both cases in second degree. In the simulation with the variable inputs +10% the probability for a negative outcome increased but not that much as in the other sensitivity analysis.

This sensitivity analysis showed that from the uncertain inputs the tomato prices and discount rate do not have an important influence on the ideal level of technique in the greenhouse. It also showed that the prices of variable inputs have not such a large influence on the actual result of the comparison between the different scenarios. These analyses also showed that the results based on stochastic dominance will stay the same except with the analyses of the discount rate. It can be seen that the medium technology greenhouse in most cases dominates in second degree over the other scenarios.

Conclusion and Discussion

Conclusion

The purpose of this thesis was to find out if there are opportunities for the tomato greenhouse sector in the North East of the US. Therefore a literature study is conducted resulting in a SWOT analysis. Also a stochastic model is created to distinguish the difference in NPV for different greenhouse systems and which suit best in the hot and humid summer and dark and cold winter. For these goals both qualitative and quantitative analyses where conducted. It is good to notice that some of the results from the stochastic analysis can be explained by facts from the literature study.

The SWOT analysis showed opportunities for greenhouse tomatoes because of the high attention to sustainable products. Also the willingness of the US to be less dependent on food imports could be an opportunity for future greenhouse tomato growers. Also production in an area with high population density gives good opportunities for the marketing of locally-produced food. This high population density also results in high prices for utilities. This is beneficial for the growers that want to use a CHP installation and are able to deliver their produced electricity to the grid. But it is a disadvantage for growers that require a high input for utilities such as natural gas.

The best result in the stochastic analysis where for the medium technology scenarios. The medium and high technology scenario dominated in first stochastic degree over the other scenarios. From those scenarios the medium technology scenario dominated in second stochastic degree over the high technology scenario. Because of uncertainty in tomato price, discount rate and variable input prices a sensitivity analysis was conducted. The sensitivity analysis showed that the high technology scenario is more sensitive for changes than the medium technology scenario.

From this report can be concluded that the low production is one of the biggest disadvantages of the low and medium technology scenarios. In practise year round production will also be beneficial because of the availability of employees that will be better if they are hired year round.

One of the most important conclusions is that tomato growers are dependent on a good price for their tomatoes. It seems more important than the price for inputs. Conclusion from the SWOT analysis is that this high price could be one of the weaknesses of the greenhouse tomato industry compared with the competition with Mexico and field-produced tomatoes.

Discussion

The report has provided an overview for potential investors for the greenhouse tomato sector. The results are appropriate for comparing scenarios among each other. Although the results of the report give a good starting point to invest in the greenhouse tomato sector, investors always have to consider the sector can be subject to fluctuations. In the case of large greenhouse grower in Arizona the cooperation with the external financer did not worked well and after an almost bankruptcy this cooperation stopped.

In the report average prices for greenhouse tomatoes were used. However, when there are plans to invest, it should be investigated if those prices are feasible. Especially when the greenhouse grower has a small area, the dependency of a niche market is very important.

In the report it is assumed that it is possible to get a connection to the grid and supply the surplus power from the CHP installation. This is in fact not always the case and is mostly dependent on the need from utility companies to produce electricity. For this reason not all states will be suitable for electricity production. For example, South Carolina has low electricity prices because of nuclear power and is not interesting for CHP installations. Also one of the constraints of greenhouse tomatoes is the unfamiliarity from the consumers with greenhouse tomatoes.

As a recommendation to the greenhouse grower it is suggested to collect more data on prices of inputs and outputs in the specific regions. Especially input of utilities can variety a lot in different regions. Also it is good to do market research if there is a market for greenhouse tomatoes and if there the market will pay extra for greenhouse tomatoes that are produced on this more sustainable way. Besides the difference in input costs there could also be specific variables that are not included in the current model. More specific and accurate data will provide the greenhouse grower a result that is more applicable.

Another recommendation is to focus on tomatoes with less liquid so that the food service industry will be reluctant to buy greenhouse tomatoes. The year round availability of greenhouse tomatoes could be beneficial above field-tomatoes. Greenhouse tomatoes could have the advantage of the locally-produced food trend that will be more important in the food service industry.

7. References

Bucklin, R. A., J. D. Leary, D. B. McConnell, E. G. Wilkerson, 2004, Fan and Pad Greenhouse Evaporative Cooling Systems, University of Florida, IFAS extension

Clemen R.T., Reilly T., 2004. Making Hard Decisions with Decision Tools. Cengage Learning Inc

Cook R and Linda Calvin, 2005, Greenhouse Tomatoes Change the Dynamics of the North American Fresh Tomato Industry, Economic Research Report No. (ERR2)

Cook R and Linda Calvin, 2005, Greenhouse Tomatoes Emerge as a Major Market Force, AMBER WAVES ECONOMIC RESEARCH SERVICE/USDA.

Getachew Abate, 2006, The Market for Greenhouse-Grown Tomatoes, The Strategic Marketing Institute Working Paper.

Hickman, Gary. 2009, Greenhouse Vegetable Production Statistics, July 09 Survey. Cuesta Roble Greenhouse Consultants

Hoy F. Carman, Roberta Cook and Richard J. Sexton, 2004, Marketing California's Agricultural Production,

Modak Shonodeep, 2010, Greenhouse Cogeneration for the US heat, light and CO2fertilization = sustainable food production, Presentation for EPA.

Panagiotou G, 2003, Bringing SWOT into focus. Business Strategy Review, Volume 14 Issue 2 pp 8-10

USDA, 2009, 2007 Census of agriculture United states summary and state data. AC-07-A-51

USDA 2010, Census of Horticultural specialties (2009) AC-07-SS-3

USDA,2010 Agricultural Income and Finance Outlook / AIS-90 / December 2010 Economic Research Service/USDA

Population density US: Online available
http://www.treehugger.com/files/2006/10/us_population_300.php

Greenhouse enterprise model available online:
www.oardc.ohio-state.edu/hydroponics/drake/index.php?option=downloads&task=info&id=8&Itemid=50&-Hydroponic-Tomato-Budget-Analysis-single-bay

Energy prices available online:
www.eia.gov

Appendix 1. list of interviewed persons

Anthony R Martin	Windset farms
Arend Jan Both	Rutgers University
Bas Denbraver	Twin oaks growers
Charlotte Smit	MPS
Chieri Kubota	University of Arizona
Ciaran Long	Cleangrow
Dennis van Alphen	Total energy group
Dick Kramp	GE Power and Water
Erik Runkle	Michigan state university
Neil Mattson	Cornell University
Stephanie Burnett	University of Maine
Eduard van Wingerden	Ever bloom
Frank Brock	Braam young plants
Gene A Giacomelli	University of Arizona
Heinerlieth	UC Davis
Jose Choc Chen Lopez	University of Arizona
KeesRodenburg	Eurofresh
Lou Vergeer	VTC
Lucia Villavicenco	Center for applied Horticultural research
Mark Elzinga	Elzinga & Hoeksema Greenhouses
Mark Schermer	Fides North America
Michael Keyes	SCS
Murat Kacira	University of Arizona
Patrick Beare	Growstone
Rob Osterbauer	Rabobank America
Roberto Lopez	Purdue University
Roberta Cook	UC Davis
Shonodeep Modak	GE Power and Water
Wim de Bruyn	Mountain view wholesale nursery

Appendix 2. Ohio State University greenhouse model

Return on Investment: 31638,69

THE OHIO STATE UNIVERSITY EXTENSION

HYDROPONIC GREENHOUSE TOMATO ENTERPRISE BUDGET
BASED ON QUONSET STYLE HOUSE
INDIVIDUAL BAY DIMENSIONS ARE 24' X 128' = 3072 sq. ft.
4 square feet per plant

HOUSE CONFIGURATION

NUMBER OF BAYS		BAY WIDTH (ft)		BAY LENGTH (ft)	TOTAL AREA
4	x	24	x	128	12288

RECEIPTS[1]

% Space Utilized	Number of plants		Pounds of fruit per plant per year		Packout	Marketable Pounds per Year[2]		Price[3]	Unit	TOTAL RETURN / YEAR
90%	2.764	Plants	30	pounds	95%	78.774	lbs	1,80	/pound	141793,20

ITEM		Description		Quantity per year	Unit	Price ($) / Unit		Total Cost per Year
VARIABLE COSTS		Variable Cost Auto-Adjust[4]:	☑ On ☐ Off					
Production Supplies								
	Beneficial Insects							
		Lacewing (650 lacewing larvae/package; 1000 insects/900 sc		22	packages	36,00	/package	792,00
		Encarsia Formosa (1500 eggs/package; 1 egg/sq. ft.)		9	packages	23,00	/package	207,00
		Aphidius Colemani (500/package; 500-3000/acre)		1	packages	48,00	/package	48,00
		Bees		12	hive	75,00	/hive	900,00
	Fertilizer							
		Blended Mix		1.714	pounds	1,00	/pound	1714,29
		$CaNO_3$		1.714	pounds	0,46	/pound	788,57
		Additions	Iron Chelate or $MgSO_4$	27	pounds	1,00	/pound	27,00
	Fungicide/Pesticide[5]			27	gallons	7,00	/gallon	189,00
	Sanitizer			3	gallons	35,00	/gallon	105,00
	Rockwool cubes	1" cubes	6000/case	1	cases	159,00	/case	159,00
	Growth Medium							
	◉	Rockwool slabs	3"x6"x36" 12/bag	116	bags	62,00	/bag	7192,00
	○	Perlite	4 cu. Ft./bag (requires Bato Buckets under	0	bags	8,35	/bag	0,00
	Seed	5% overseeding	1,000 seeds/package	3	packages	107,00	/package	321,00
	Heated seedling support mat		22"x96"	4	mats	114,00	/mat	456,00
	Trays			10	trays	1,00	/tray	10,00
	Sticky Traps[6]	3 x 5" trap	100/package	2	packages	30,00	/package	60,00
	Clips	7500/case		2	cases	83,00	/package	166,00
	Twine			2	boxes	22,00	/box	44,00
	Tomahooks			3.200	hooks	0,15	/package	480,00
	Total Production Supplies cost							**13658,86**

Production Labor										
Delivering to Market	0,14	min/pound	3,5	hrs / wk	183,8	hrs / year	7,00	/hour	1286,64
Marketing	0,079	min/pound	2,0	hrs / wk	103,7	hrs / year	10,00	/hour	1037,19
Seed / Transplant / Harvest / Package	1,8	min/pound	45,4	hrs / wk	2.363,2	hrs / year	8,50	/hour	20087,37
Production Management	0,277	min/pound	7,0	hrs / wk	363,7	hrs / year	8,50	/hour	3091,22
Maintenance	0,018	min/pound	0,5	hrs / wk	23,6	hrs / year	8,50	/hour	200,87
Total Production Labor		**Weekly Hrs**	58,4	**Annual Hrs**	3.038,1				**25703,30**

Packaging Costs							
	Labels & Stickers	1000 labels/roll	66	rolls	30,00	/roll	1980,00
	Foam Trays	4 tomatoes/tray; 1000 trays/case	263	cases	31,00	/case	8153,00
	Boxes	10lb boxes	7.878	boxes	0,65	/box	5120,70
	Total Packaging Costs						**15253,70**
Utilities							
	Fuel Choice (choose one)[7]						
		○ Fuel Oil	16.361	gallons	3,70	/gallon	0,00
		○ Liquid Propane	26.181	gallons	1,80	/gallon	0,00
		◉ Natural Gas	2.181	1000 cu. ft.	10,00	/1000 cu. ft.	21810,00
	Electricity (general - non fans)		2.001	kilowatt-hr	0,08	/kilowatt-hr	160,08
	Electricity (fans and pads)		40.001	kilowatt-hr	0,08	/kilowatt-hr	3200,08
	Electricity (fanjets/Horizontal Air Fans)		8.001	kilowatt-hr	0,08	/kilowatt-hr	640,08
	Electricity (lights)		0	kilowatt-hr	0,08	/kilowatt-hr	0,00
	Water and Sewer		400.001	gallons	0,00	/gallon	680,00
	Telephone		12	months	50,00	/month	600,00
	Cell Phone		12	months	40,00	/month	480,00
	Total Utilities Costs						**27570,24**
Miscellaneous Costs							
	Advertising, Mailings, Flyers		1	campaigns	200,00	/campaign	200,00
	Continuing Education		1	meetings	75,00	/meeting	75,00
	Internet Service		12	months	20,00	/month	240,00
	Laboratory Fees						
		Leachate Analysis	12	tests	20,00	/test	240,00
		Tissue Analysis	12	tests	20,00	/test	240,00
		Nutrient Solution Analysis	12	tests	20,00	/test	240,00
	Office Supplies		12	months	25,00	/month	300,00
	Postage		12	months	15,00	/month	180,00
	Marketing Materials & Promotions		1	promos	300,00	/promo	300,00
	Record Keeping		12	months	50,00	/month	600,00
	Software		3	programs	50,00	/program	150,00
	Subscriptions		3	subscriptions	35,00	/subscription	105,00
	Marketing & Trade Shows		0	trade show	500,00	/show	0,00
	Total Miscellaneous Costs						**2870,00**
Professional Services							
	Accountant		5	hours	50,00	/hour	250,00
	Lawyer		4	hours	125,00	/hour	500,00
	Total Professional Services						**750,00**
TOTAL VARIABLE COSTS							**85806,10**

FIXED COSTS[8]								
Greenhouse Structure								
	Concrete-Material and Labor	10% of floor is 4" concrete		1228,8	sq. ft.	2,00	/sq. ft.	2457,60
	Frame, Poly, Ends, Door			4	houses	#######	/house	18800,00
	Energy/Shade Curtains			11059,2	sq. ft.	0,00	/sq. ft.	0,00
	Ground Cover			11059,2	sq. ft.	0,08	/sq. ft.	829,44
	Permits			4	permits	75,00	/permit	300,00
	Site Preparation			4	houses	#######	/house	4000,00
	House Construction	(cost for house construction and installation of components)		1600	hours	15,00	/hour	24000,00
	Total Greenhouse Structure Costs							**50387,04**
	Total Annual Greenhouse Stucture Costs (Annual costs of owning the greenhouse includes depreciation and/or principal payments, interest, repairs, taxes, and insurance)			20%	Annual Fixed Costs[9]			**10077,41**
Greenhouse Environmental Control Equipment								
	Back-up Generator and Transfer Switch			4	bays	#######	/bay	16000,00
	Cooling System (fan, vent, & pad)			4	systems	#######	/system	7400,00
	Fanjets, 30" 1hp / Horizontal Air Fans			4	fanjets / HAF	#######	/fanjet / HAF	4000,00
	Electrical Panel with Computer Relays			4	panels	#######	/panel	6000,00
	Computer for Environmental Control			1	computers	#######	/computer	2500,00
	Miscellaneous Building Supplies			4	bays	#######	/bay	6000,00
	Heating System (reflects utility choice from above)							
		Fuel Oil	200,000 BTU Heaters	4	heaters	#######	/heater	0,00
		Liquid Propane	200,000 BTU Heaters	4	heaters	#######	/heater	0,00
		Tank Lease		12288	sq. ft.	0,70	/sq. ft.	0,00
		Natural Gas	200,000 BTU Heaters	4	heaters	#######	/heater	8000,00
	Poly Inflation Kit			4	kits	125,00	/kit	500,00
	Low Voltage Wiring Package			4	packages	350,00	/package	1400,00
	Protective Equipment (PPE)			4	sets	50,00	/set	200,00
	Grow Lights[10]							
		(•) None						
		( ) Metal Halide	1000 W Lights (with Wiring)	80	lights	460,00	/light	0,00
		( ) Sodium	1000 W Lights (with Wiring)	80	lights	520,00	/light	0,00
	Annual Hours of Light Usage			1800	hours			
	Total Greenhouse Environmental Control Equipment Costs							**52000,00**
	Total Annual Equipment Costs (Annual costs of owning the equipment includes depreciation and/or principal payments, interest, repairs, taxes, and insurance)			20%	Annual Fixed Costs[11]			**10400,00**
Growing & Delivery Equipment								
	Back Pack Sprayer			1	sprayers	100,00	/sprayer	100,00
	Carbon Dioxide Generator			1	generators	480,00	/generator	480,00
	Cooler			4	bays	#######	/bay	8000,00
	Delivery Van with A/C			1	vans	#######	/van	6000,00
	Fertilizer Mixing Pump			4	bays	30,00	/bay	120,00
	Feeding System			1	unit	#######	/unit	3200,00
	Bato Buckets	(required for perlite growth medium)		0	buckets	3,00	/bucket	0,00
	Meters and Sensors	EC		1	meters	160,00	/meter	160,00
		pH		1	sensors	50,00	/sensor	50,00
		Thermometer		1	thermometers	25,00	/thermometer	25,00
	Monitor	Humidity		1	sensors	120,00	/sensor	120,00
		CO_2		1	sensors	500,00	/sensor	500,00
	Scale			1	scales	100,00	/scale	100,00
	Total Other Equipment							**18855,00**
	Total Annual Growing & Delivery Costs (Annual costs of owning the greenhouse includes depreciation and/or principal payments, interest, repairs, taxes, and insurance)			20%	Annual Fixed Costs[9]			**3771,00**