

# Should you invest in a 6th generation TFT-LCD production facility?

*Final Document*

*May 19, 2020*

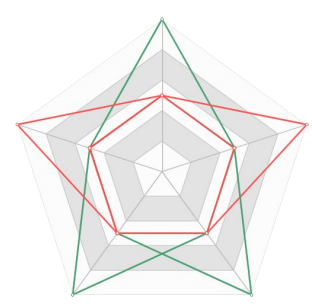
**PENTA**



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**LG.PHILIPS** Displays



# Management Summary

This document allows LG.Philips to make a well-informed decision on whether or not to invest in a 6th generation TFT-LCD production facility. The investment is considered worth taking if it leads to a positive Net Present Value (NPV). However, being market leader, customer satisfaction cannot be forgotten. Therefore, three options are presented, each taking a different position in this tradeoff. Option 1 solely focuses on maximizing profit; as a result, only products of one product market are produced in a single year. Option 2 chooses to produce the most profitable product in each market, if that market contains at least one profitable product in that year. Lastly, under option 3 every product is produced.

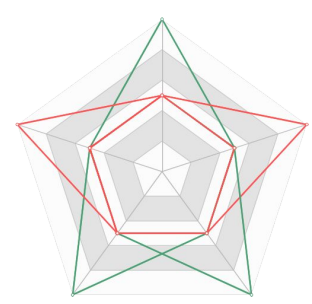
Due to the large uncertainty that the future holds, determining the profitability of an investment is not always straightforward. By employing a scenario simulation model, Penta Consultants is able to overcome this issue. The model determines the maximum NPV as well as the associated risk attached to each option. Taking a subset of scenarios, the risk is defined as the likelihood that a positive NPV is realized. Moreover, the model searches for the optimal substrate size and product portfolio for each option.

The risk, being the probability of a negative NPV, under option 2's production plan is **56%**. Because of this, the average NPV will be negative, **-\$133M**. Option 1 approximately has the same risk and only a small increase in the NPV, however, the level of customer satisfaction is far less. Relative to option 2, the risk of option 3 is 10% higher as well as a sizeable reduction in NPV. Therefore, option 2 has been shown to make the best tradeoff between maximizing the NPV and attaining customer satisfaction.

The corresponding optimal substrate size for option 2 is **1.84m by 1.08m**.

Even though option 2 provides the best mix between customer satisfaction and maximizing the NPV, the risk it brings along is still very high. The risk might be considered too high to invest at this moment in time. The model has shown that yield and product selling prices are the factors that most greatly determine whether a profit or a loss is realized. Therefore, LG.Philips could try to get a better hold on these factors to control the risks, for instance by advertisements.

**In conclusion, if LG.Philips chooses to invest, option 2 is the advised production plan. However, as more than half of the possible future scenarios result in a negative NPV, the risk of investing is considerable. If the risk of 56% is deemed too high, we recommend not to invest.**



# LG.Philips is looking to invest in a 6th generation TFT-LCD production facility

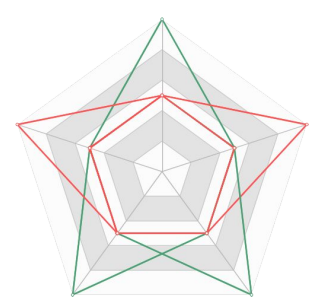
LG.Philips is the market leader in large scale thin-film transistor liquid crystal display (TFT-LCD) panels. To retain this position, LG.Philips is looking to innovate their production by utilizing 6th generation TFT-LCD panels for televisions, monitors, and notebooks. For this, a 6th generation TFT-LCD production facility has to be built in South Korea, where all the infrastructure is readily available.

## **Is it a wise decision for LG.Philips to invest in a 6th generation TFT-LCD production facility?**

The answer to this question depends on the effect that it has on LG.Philips' profits: will the revenue outweigh the resulting costs? Important cost components to consider are investment costs and glass loss. The latter will be caused by fixed substrate sizes and exclusions but also by uncertainties in the demanded TV size of the future. As LG.Philips focuses on the TV market, this is imperative to take into consideration.

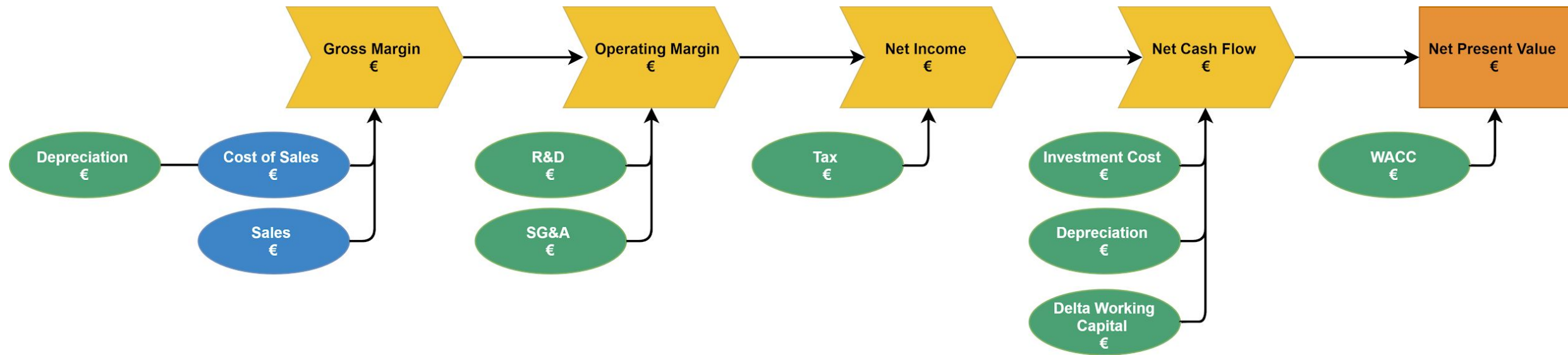
The composition of products in LG.Philips' portfolio has an impact on the maximum profit. Different composition scenarios will be displayed to look into. Due to these different scenarios and uncertainties, it is not directly clear whether the revenues will outweigh the costs. A complex approach is therefore necessary.

**In this document, Penta Consultants will provide all the tools necessary to make a well-considered decision on the investment choice.**

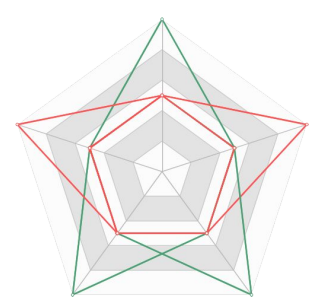


# An investment decision is worth considering when the associated Net Present Value (NPV) is positive

A common measure of profitability is the Net Present Value (NPV). When the NPV is positive, the revenues outweigh the costs, making an investment worthwhile. The flowchart shows how the NPV is determined.



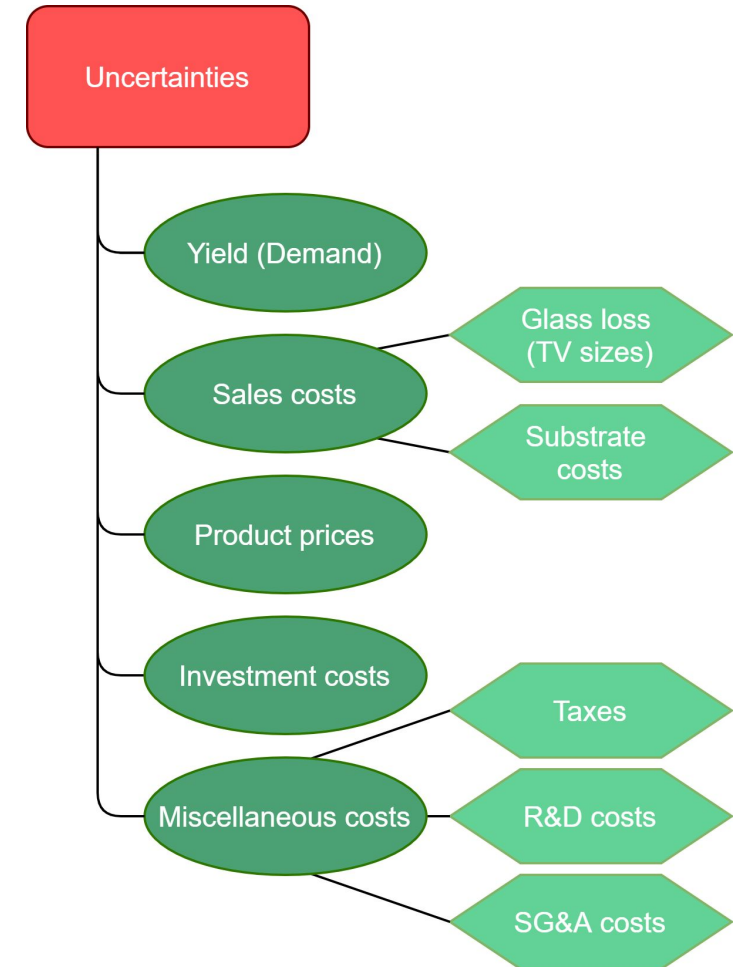
In **blue** the decision variables: These will be optimized such that the NPV is maximized.  
In **green** the other parameters: These cannot be chosen.

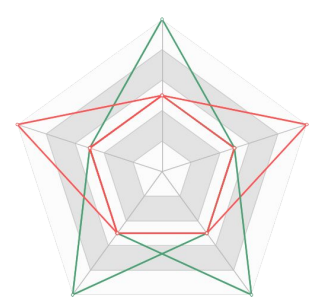


# There are, however, many uncertainties to take into account when maximizing the NPV

Uncertainties that may influence our calculations of the Net Present Value are:

- ◆ **Demand yield:** How much of our production can you actually sell?  
*E.g. 2017 for TVs: 65% to 82%*
- ◆ **Television demand:** What size of televisions will be in-demand in the future?  
*HDreadyTV or FullHDTV? 40 or 43 inch?*
- ◆ **Product prices:** What will be the market prices for our products?  
*E.g. FullHDTV 37 inch in 2006: €911,20 to €1366.80*
- ◆ **Sales costs:** How high are the costs per substrate?  
*E.g. in 2017: €357,- to €447,-*
- ◆ **Investment costs:** How much do you need to invest?  
*E.g. in 2004: €1.125 billion to €1.375 billion*
- ◆ **Miscellaneous costs:** How much tax do you need to pay? How much do you spend on R&D and SG&A? Etcetera.  
*E.g. R&D: 4% to 11% - tax from 20% to 30%*





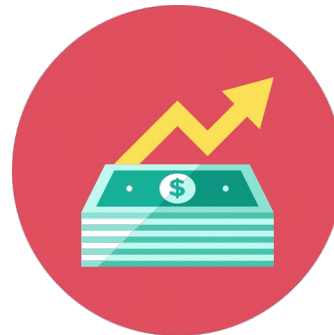
# Moreover, besides maximizing the NPV, having a diverse product portfolio is imperative

A diverse product portfolio entices new potential customers and enhances **customer satisfaction**



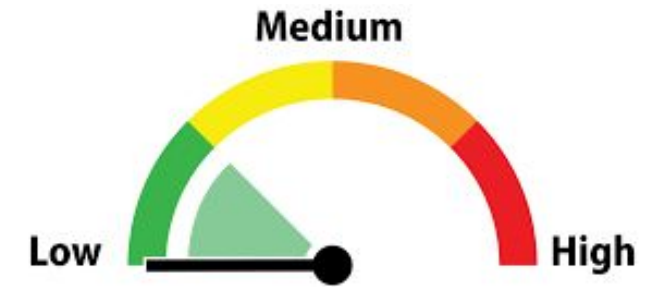
The highest NPV can be achieved by devoting the entire production capacity to the most profitable product in each year. While this approach will maximize the total revenue in each year, it will not be favorable to the customers of LG.Phillips.

A diverse product portfolio prevents **customer churn**, which leads to **greater sales**

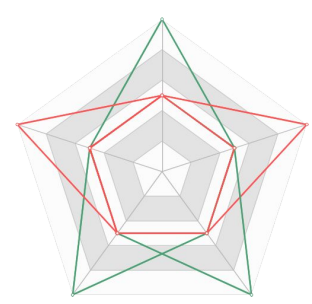


If customers are satisfied with the purchase of one of the products of LG.Phillips, they will be more likely to stay with the company, preventing churn. Additionally, satisfied customers will be more likely to buy again from LG.Phillips when looking for a different type of product.

A diverse product portfolio **reduces risks** from external factors

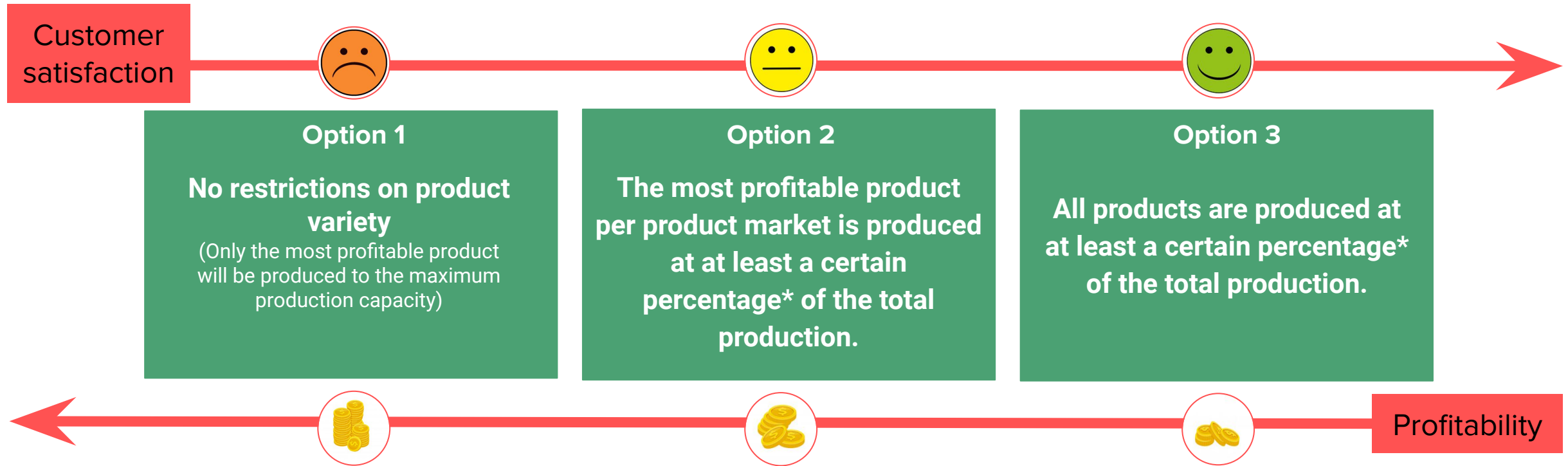


Having a limited number of product types in the production portfolio makes the production volatile to technological enhancements of competitors or market shocks.

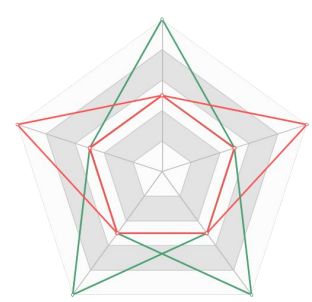


# 3 options representing the tradeoff between profitability and customer satisfaction are provided

The NPV value is maximized for three different options, varying in customer satisfaction and total profit:







# For each option the optimal substrate size is chosen



Given a particular substrate size, the model used by Penta Consultants determines the optimal product portfolio and the corresponding NPV value. This is done by determining the maximum number of products that fit on the substrate and the respective profitability of the substrate.

In order to determine the optimal substrate size, this process is repeated for all possible substrate sizes. Based on this, the optimal height and width of the substrate is selected. As shown to the right, the NPV for the baseline case is maximized using a substrate size of 1.84m x 1.08m, in height and width respectively.

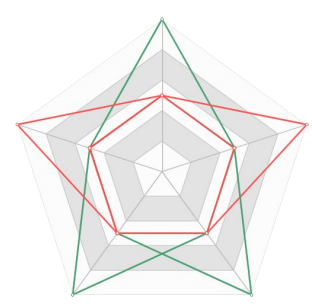
	1.85	1.84	1.83	1.82	1.81	1.8
1.15	417	443	-292	-267	-246	-220
1.14	456	481	-252	-231	-205	-180
1.13	497	516	-215	-190	-165	-140
1.12	532	557	-175	-150	-125	-100
1.11	573	598	-134	-109	-85	-60
1.1	614	639	-93	-69	-45	-20
1.09	655	680	-53	-29	-4	20
1.08	696	720	-12	12	36	60
1.07	656	677	-76	-53	-29	-5
1.06	-83	-59	-36	-12	11	35
1.05	-42	-18	5	28	52	70

NPV (hundred million USD) for different substrate sizes under option 2, width (horizontal) and height (vertical), for the baseline case



# Baseline

All uncertain variables are set to their most likely value.



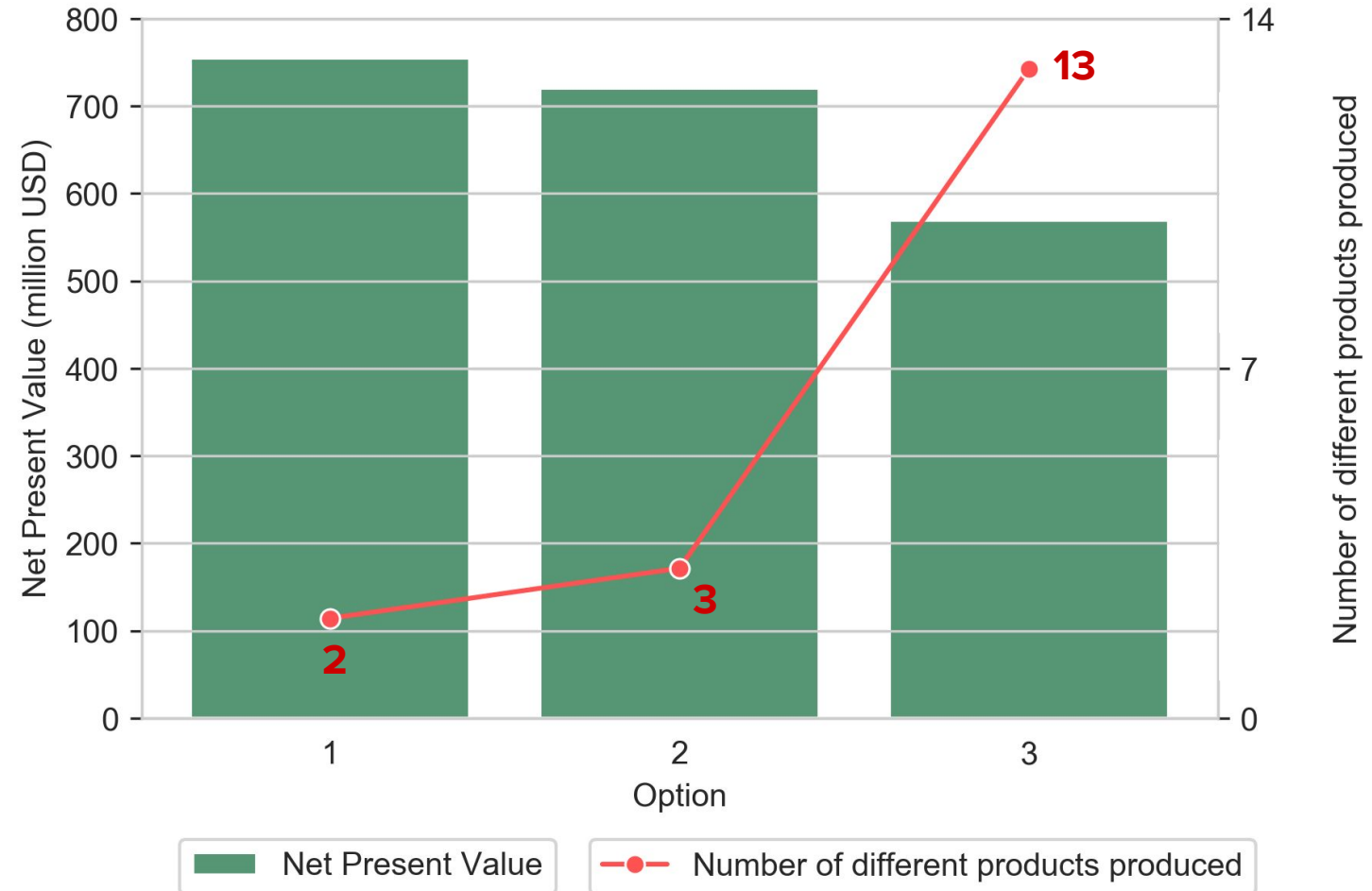
# Option 2 allows LG.Philips to cater to all 3 markets at a limited reduction to the NPV

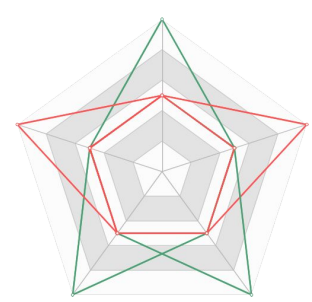
Option 1, despite delivering the largest baseline NPV of \$650 million, only produces products for two of the product markets over the entire timespan, namely notebooks and televisions.

Under option 2, LG.Philips is able to produce products within all three markets; notebooks, televisions and monitors, coming at only a slight cost to the NPV which is marginally lower at \$620 million.

Option 3, however, sees a large drop of \$160 million in the NPV. This represents the cost associated with producing all of the different products in each of the three markets.

Given the tradeoff between customer satisfaction and NPV, option 2 appears to be the preferred choice.



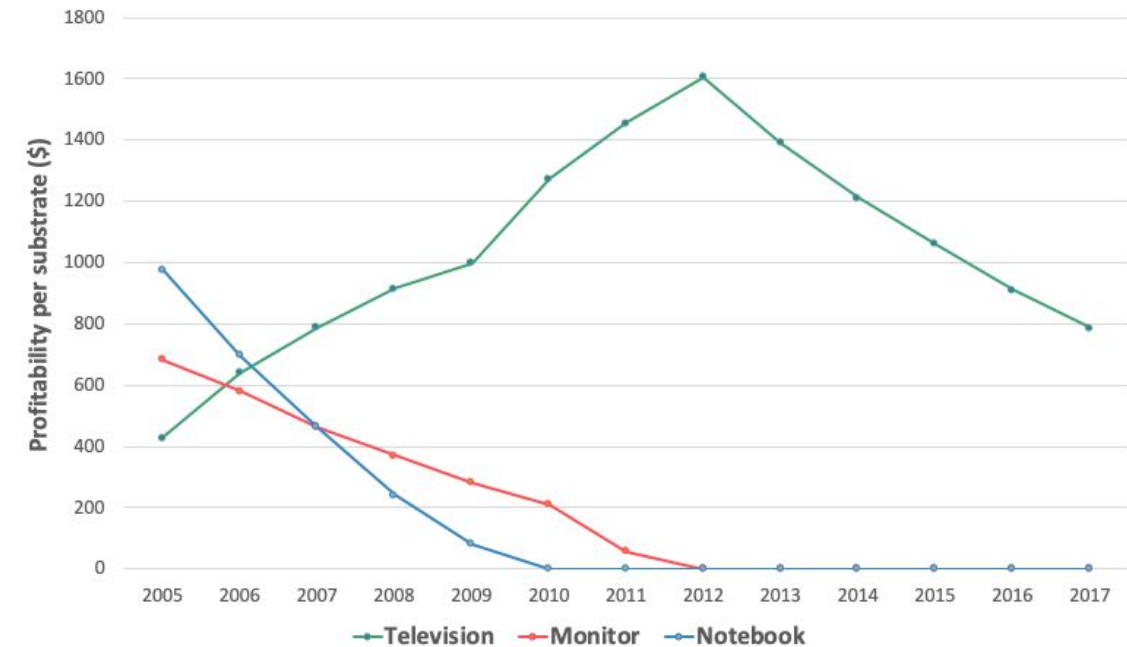


# Under option 2, the product portfolio changes over time proportional to the profitability of each product

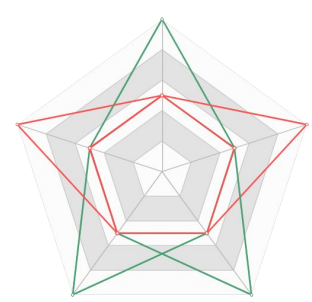
Under option 2, the product portfolio differs over time proportional to the relative profitability of each product. As shown on the right, the profitability of televisions increase significantly over time. In large part this is due to the rising yield rate.

The profitability of notebooks and monitors, as opposed to televisions, however, is expected to suffer as the yield rate grows at a slower rate than the decrease in price.

The optimal product portfolio, as indicated in the previous slide, reflects this change in the respective profitability of each product. For example, as seen in the plot on the previous slide, after 2006 the product portfolio shifts from very notebook-heavy to television-heavy.



Market	Percentual change Yield Rate 2005-2017	Percentual change Price 2005-2017
Notebook	+20%	-93%
Monitor	+25%	-86%
Television	+50%	-75%

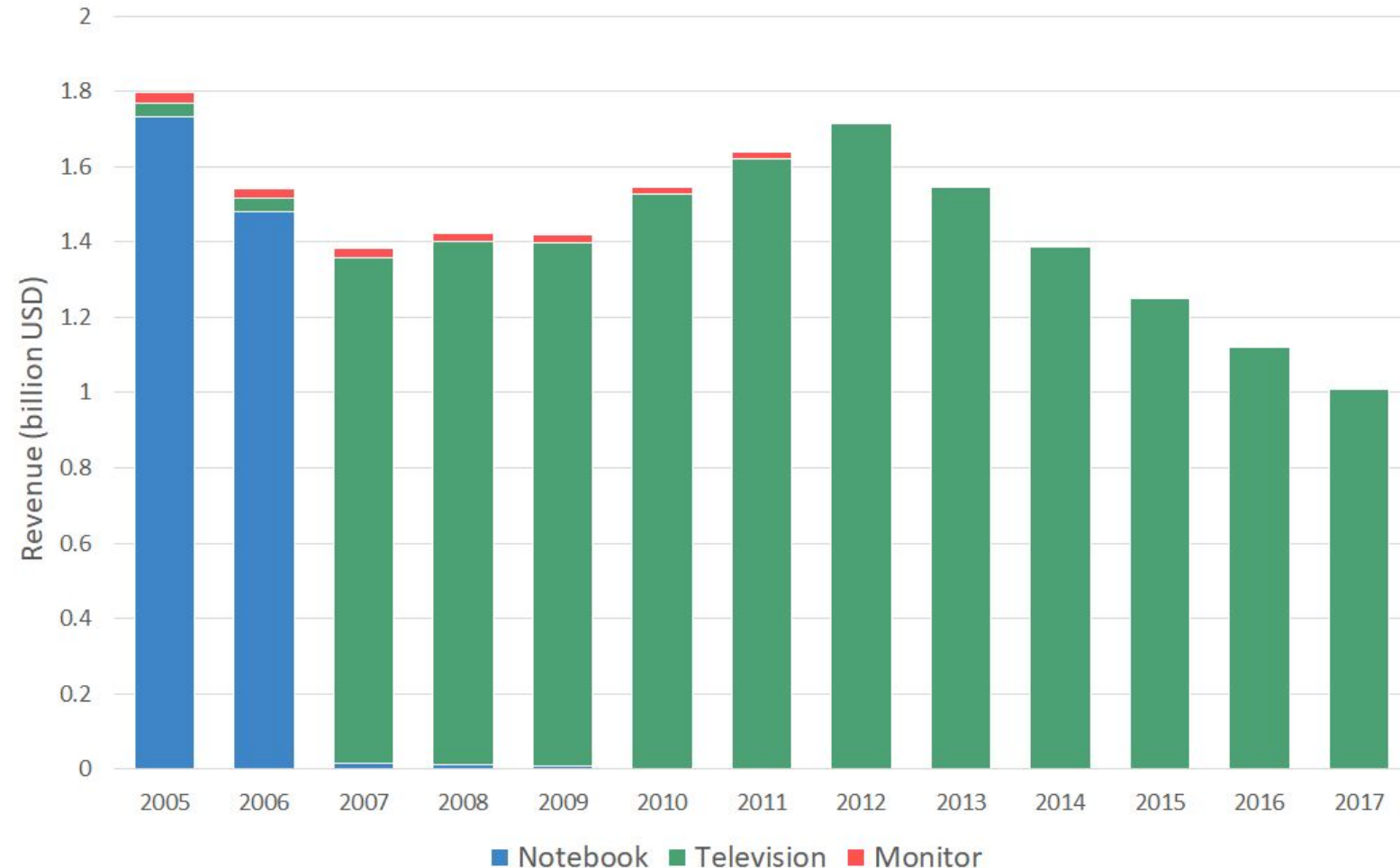


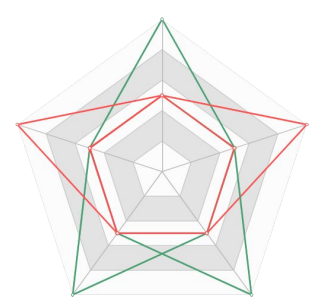
# The sale of televisions contribute $\pm 80\%$ of the total revenue

The product portfolio recommended under option 2 shifts from notebook-heavy in 2005 and 2006, to television-heavy from 2007 onwards.

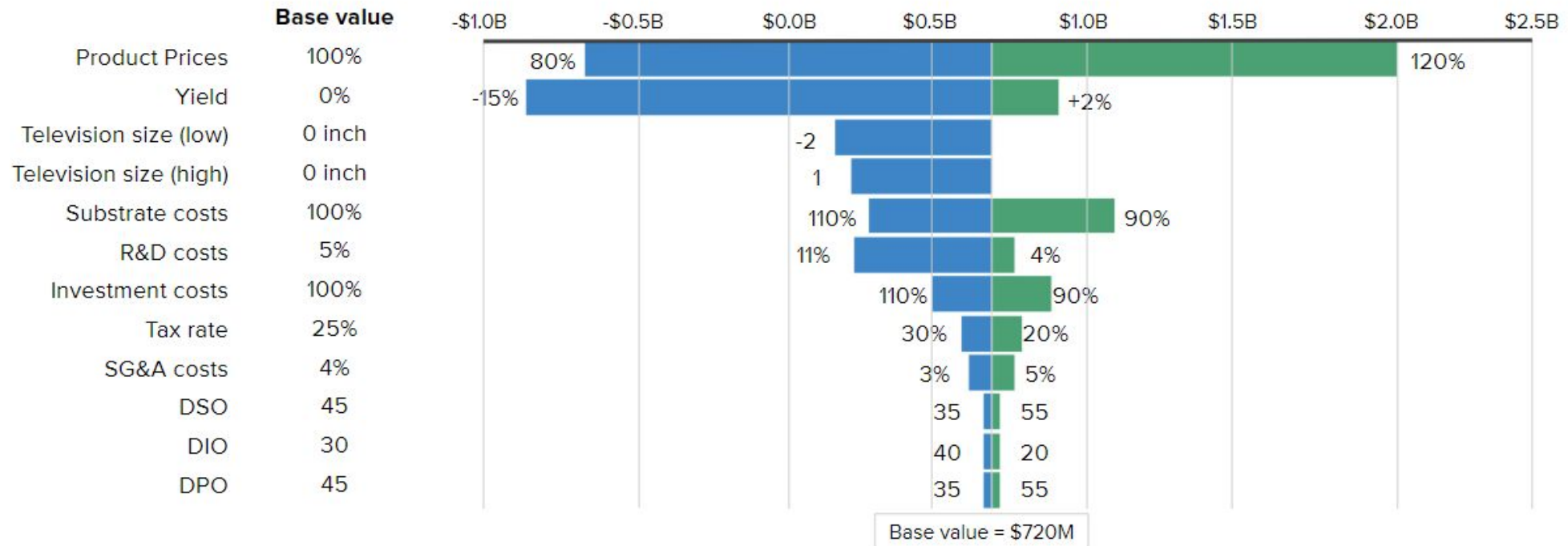
Indeed, over time and under option 2, the sale of televisions plays a greater role in LG.Philips' bottomline, accounting to 82% of total revenue over the whole time period, from 2005 until 2017.

The production of monitors, albeit only contributing \$155 million in revenue over the whole time period, is consistent, generating roughly \$20 million of sales every year from 2005 until 2011.





# Negative NPVs can be individually realized by uncertainties in product prices and yield



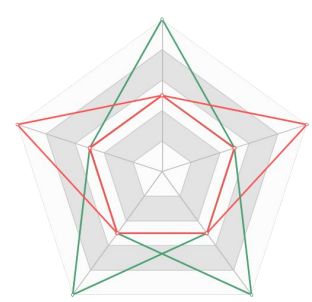
## The tornado chart above shows how uncertainty affects the investment opportunity

- ◆ **Product prices** and **yield** have a large effect on NPV and can individually create a hugely non-profitable scenario. For instance, when product prices drop to 80% of the base value, keeping everything else at the base value, there is a drop in the baseline NPV of **\$1 billion!**
- ◆ Any change in the **television size** drops the NPV. For smaller screens, this is because this is not enough to fit another television on the substrate while the selling price does decrease (note that this also increases *glass loss*, which is not incorporated in the NPV). However, a larger television size can mean that one television screen less can be produced *per substrate*.

# Simulation

All uncertain future scenarios are taken into account.

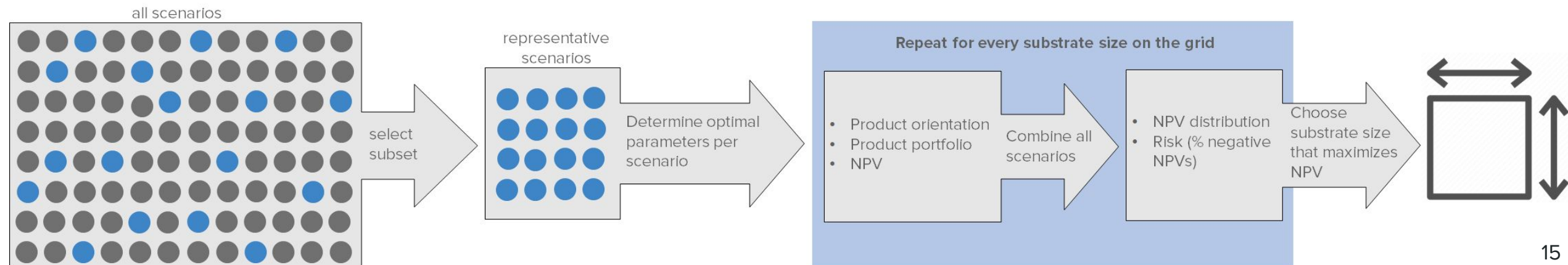


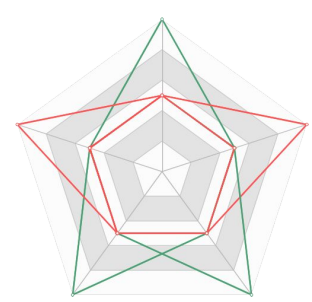


# Different uncertainty scenarios are used to simulate the optimal NPV

For the baseline scenario all parameters were set to their most likely value. However, since there are uncertainty bandwidths around each stochastic parameter, there are a lot of different scenarios possible. In fact, the total number of possible scenarios is  $1.64 \times 10^{110}$ , more than the number of atoms in the universe!

Computationally it will not be possible to calculate the NPV for each and every scenario in a human lifetime. Therefore, a smart algorithm is built that is able to take a large and representative subset out of the enormous number of scenarios. After this, it will determine the NPV for each scenario as well as the product orientation, product portfolio, and the optimal substrate size. After combining the scenarios for each substrate size on a grid, it is determined what the risk of investment (probability of a negative NPV) is for each of the options.

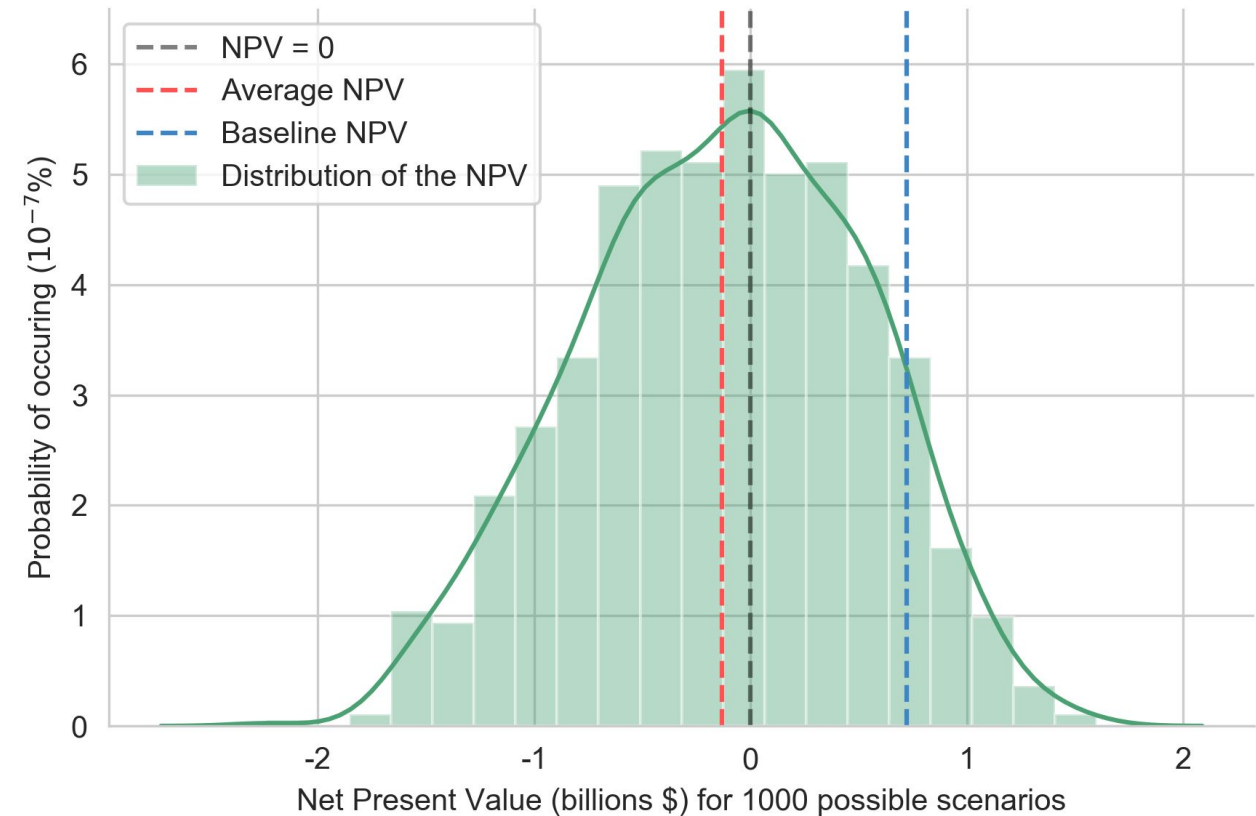


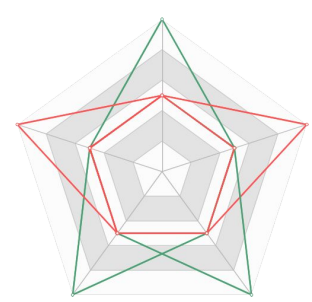


# Despite a positive baseline NPV, the average NPV for option 2 is negative

The histogram shows the distribution of the NPVs under option 2 for the optimal substrate size. It can be seen that the distribution is slightly skewed towards the left, resulting in a negative average NPV of the simulation, -\$133 million. This is in contrast to the baseline NPV, which turned out to be positive at \$720 million. The reasons for this are the asymmetric uncertainties of the input parameters, which tend to be more negative than positive, as can be seen in the tornado chart. For example, the yield has a 25% chance to be 15% lower, and a 25% chance of being just 2% higher. Averaging over multiple scenarios will thus yield a lower NPV in comparison to the baseline scenario.

The histogram clearly shows the huge differences between the best-case and worst-case scenarios. Although not very likely, it is possible to make a loss or profit close to \$2 billion. The probability of making a loss is 56%, which means that more than half of the possible future scenarios yield a negative NPV.





# The negative average NPV is caused by 56% of the possible future scenarios resulting in a loss

With the large subset of scenarios, the risk can be estimated, which is defined as **the probability of realizing a negative NPV**:

$$\text{Risk} = \frac{\text{Number of scenarios with negative NPV}}{\text{Total number of scenarios}} \times 100\%$$

This is used to comparatively weigh the Net Present Value against the risk of making a loss. Penta Consultants believes that a large decrease in the risk is worth a small drop in the average NPV.

As seen on the right, the maximum average NPV of **-\$133 million** as well as the minimal risk of **56%** is realized at the same substrate size: **1.84m by 1.08m**. Therefore, this is determined to be the best substrate size.

	1.85	1.84	1.83	1.82	1.81
1.15	72%	71%	95%	94%	94%
1.14	70%	69%	94%	93%	93%
1.13	68%	67%	93%	92%	91%
1.12	66%	65%	91%	90%	89%
1.11	64%	64%	89%	88%	87%
1.1	62%	61%	87%	86%	84%
1.09	60%	59%	85%	83%	82%
1.08	57%	56%	82%	81%	79%
1.07	62%	60%	87%	86%	84%
1.06	87%	84%	85%	83%	82%
1.05	85%	84%	83%	81%	79%

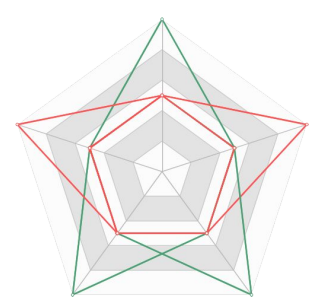
Probability of negative NPV

	1.85	1.84	1.83	1.82	1.81
1.15	-430	-404	-732	-707	-681
1.14	-389	-363	-692	-666	-641
1.13	-347	-322	-651	-626	-602
1.12	-306	-281	-612	-587	-562
1.11	-265	-251	-571	-546	-522
1.1	-235	-211	-530	-510	-485
1.09	-194	-174	-494	-469	-445
1.08	-157	-133	-453	-429	-405
1.07	-216	-192	-519	-495	-471
1.06	-525	-502	-478	-455	-433
1.05	-484	-461	-439	-416	-392

Average NPV (million USD)

# Conclusion

How does this knowledge translate into making a decision?



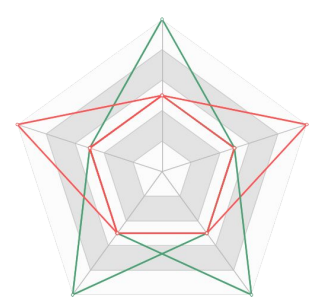
# When comparing the three investment options, it is clear that option 2 is the best choice

Option	Profitability (Average overall NPV)	Customer satisfaction	Risk	
1: Invest and focus only on maximizing profitability	-\$106M	Only one product market is utilized	54%	Very good
2: Invest and take both profitability and customer satisfaction into account	-\$133M	Customers can buy products from all (profitable) markets	56%	Good
3: Invest and focus mainly on customer satisfaction	-\$255M	All products are produced	64%	Okay
				Poor
				Very poor

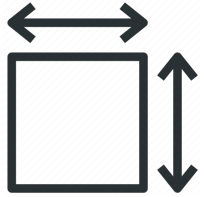
The **decision matrix** shows us the following interesting conclusions:

- ◆ Even though option 2 is less profitable than option 1, it is just as risky while ensuring a good supply of products for customer satisfaction.
- ◆ Despite option 3 providing the best customer satisfaction, it is highly risky and it causes a drop of \$230 million in the average overall NPV compared to option 1.

Option 2 is clearly the preferred option to choose when considering an investment.



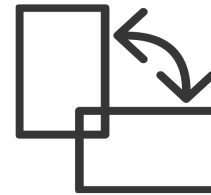
# For option 2 the optimal substrate size is 1.84m by 1.08m, returning an average NPV of -\$133M



**Substrate size (w x h):**  
1.84m x 1.08m



**Product portfolio:**  
**Notebooks:** XGA  
**Monitors:** UXGA  
**Televisions:** FullHDTV (40 inch)



**Product orientation:**  
**Notebooks:** Vertical  
**Monitors:** Vertical  
**Televisions:** Depends on scenarios;  
74% horizontal, 26% vertical.

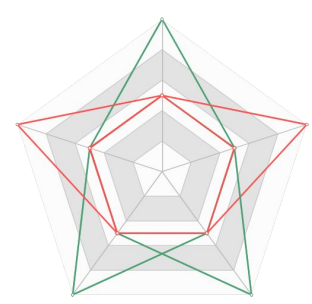


**Expected profitability:**  
**Average NPV:** -\$133M  
**Risk:** 56%

## **Number of substrates for each product:**

Product type	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
XGA Notebook	686,533	686,533	7,200	7,200	7,200	0	0	0	0	0	0	0	0
UXGA Monitor	13,115	13,115	13,115	13,115	13,115	13,115	13,115	0	0	0	0	0	0
FullHDTV Television (40 inch)	203,52	203,52	699,685	699,685	699,685	706,885	706,885	720,000	720,000	720,000	720,000	720,000	720,000
Total Production	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000





# If the risk of making a loss is acceptable then the investment is worth considering

The decision if LG.Philips should invest in the new 6th-gen production facility is, considering the conclusion of the research, not an easy one. There is a real chance that investing in the facility will not yield any profit. Even worse, it might also result in a huge loss when the worst case scenarios are considered. Our recommendations are two-fold:

## Recommendation 1



Option 2 provides the best mix of a diverse product portfolio and maximizing the NPV. If it is acceptable that, for this option, 56% of the scenarios will lead to making a loss, then **make the investment but focus on the following:**

- ◆ Try to avoid the lower bounds of the yield forecast by e.g. investing more money into product advertisement;
- ◆ Attempt to keep the product prices as high as possible;
- ◆ Enable facilities to produce adaptable substrate sizes.

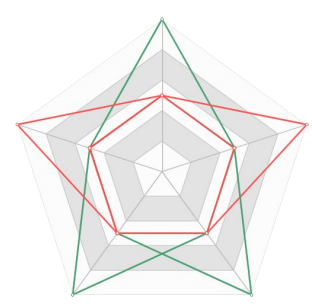
The simulations have shown that these three factors mostly determine whether the investment will yield a profit or a loss. Therefore, minimizing the impact of them should be the highest priority if the investment is made.

## Recommendation 2



If the risk of making a loss is considered to be too high, then **do not make the investment.**

Take the main points from the sensitivity analysis that have the highest impact on the NPV as key factors when deciding on any future investments.



# This investment advice is based on many different assumptions

## General assumptions

- ◆ The market research conducted on the price and demand projections for each product, as well the projections on the costs of the substrate, are an accurate representation of what will actually happen.
- ◆ Production of 6th generation is essential to stay market leader.
- ◆ Investment costs will be paid from 2003 to 2005. There are no costs like facility deconstruction costs after 2017 which have to be taken into account.
- ◆ There are uncertainty bandwidths around certain values, where the high and low values are both attained 25% of the time and the base value is attained 50% of the time. Moreover, these uncertainties are independent over time.
- ◆ Rates, like tax and R&D costs, are uncertain yet constant over time.

## Sales assumptions

- ◆ There are no political, economical, or competitive factors that influences the demand for LG.Philips. In general, under uncertainties, the yield percentage of production can always be sold. Hence, there is always enough demand to satisfy this.
- ◆ Sales of other generations (before or after the 6th) are not influenced by the 6th gen products and the 6th generation products are not influenced by their sales and will therefore not be taken into consideration.
- ◆ If a different television screen size become the standard, the price can be scaled by the area change.

## Production assumptions

- ◆ Machines cut the substrates correctly, up to an exclusion.
- ◆ Machines can only handle one size of substrate.
- ◆ Products can only be placed in either horizontal or vertical direction on a substrate.
- ◆ Out of one substrate, only one product type can produced.
- ◆ The maximum substrate size is constrained as 1.55 by 1.85 meters.
- ◆ The capacity is constrained by 60,000 substrates per month.
- ◆ There will be no logistical issues (i.e. transport or construction delays). Moreover, no supply disruptions will happen, i.e. there are always enough resources to produce 60,000 substrates per month.
- ◆ There will be no extraordinary political/labor/environmental influences on the production rate.

## Product assumptions

- ◆ Television sizes remain constant over the years.
- ◆ There will be no other 6th generation products than known in 2003 produced by LG.Philips up to 2017.

# PENTA



# CONSULTANTS

## Contact

Steffie van Poppel (CEO)

[s.j.a.b.vanpoppel@tilburguniversity.edu](mailto:s.j.a.b.vanpoppel@tilburguniversity.edu)

Mike Weltevrede (Data Engineer)

[m.weltevrede@tilburguniversity.edu](mailto:m.weltevrede@tilburguniversity.edu)

# Appendix

# Profit and Loss Statement Option 2 (1/2)

(in \$)			2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Format	Market																
VGA	Notebook	# Product	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Price	132.3	106.1	85.3	67.1	54.4	43.1	35.1	27.8	22.1	17.9	13.9	10.9	9.0	7.0	6.0
		Product Revenue	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
XGA	Notebook	# Product	0	0	1.57E+07	1.69E+07	1.89E+05	2.00E+05	2.12E+05	0	0	0	0	0	0	0	0
		Price	171.1	137.9	110.7	87.6	70.9	56.0	45.4	36.1	29.0	23.0	17.9	13.9	11.0	10.0	8.0
		Product Revenue	0	0	1.73E+09	1.48E+09	1.34E+07	1.12E+07	9.60E+06	0	0	0	0	0	0	0	0
SXGA	Monitor	# Product	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Price	243.8	206.8	175.0	148.5	126.7	108.0	91.0	78.9	66.0	55.7	48.1	40.8	34.9	30.1	25.2
		Product Revenue	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WXGA	Monitor	# Product	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Price	238.7	202.0	170.9	146.2	123.7	105.5	88.5	76.2	64.4	54.3	47.0	39.9	34.0	29.0	24.8
		Product Revenue	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UXGA	Monitor	# Product	0	0	7.01E+04	7.56E+04	8.07E+04	8.60E+04	9.13E+04	9.68E+04	9.60E+04	0	0	0	0	0	0
		Price	580.2	491.2	420.3	352.9	299.8	256.2	219.3	184.9	157.2	132.6	113.9	96.5	82.9	70.2	60.3
		Product Revenue	0	0	2.95E+07	2.67E+07	2.42E+07	2.20E+07	2.00E+07	1.79E+07	1.51E+07	0	0	0	0	0	0
SDTV	Television	# Product	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Price	367.9	321.1	283.6	249.4	219.6	192.4	171.4	149.0	131.7	116.1	102.3	88.7	79.8	69.8	61.2
		Product Revenue	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HDreadyTV	Television	# Product	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Price	609.2	533.8	473.5	412.9	365.2	322.1	284.3	247.8	218.9	192.2	169.4	150.7	132.1	115.7	101.3
		Product Revenue	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HDreadyTV	Television	# Product	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Price	660.8	583.6	508.6	454.0	398.0	350.0	307.7	272.3	240.9	210.2	184.3	163.1	142.8	126.5	112.3
		Product Revenue	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HDreadyTV	Television	# Product	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Price	1185.5	1046.9	921.2	813.9	717.1	633.2	558.7	485.5	431.2	377.6	332.6	293.0	258.6	227.8	199.9
		Product Revenue	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FullHDTV	Television	# Product	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Price	1647.1	1449.9	1271.5	1119.1	995.4	868.2	766.6	676.6	591.2	521.8	463.2	402.7	359.0	314.1	277.9
		Product Revenue	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FullHDTV	Television	# Product	0	0	2.04E+04	2.38E+04	9.61E+05	1.09E+06	1.23E+06	1.49E+06	1.77E+06	2.07E+06	2.08E+06	2.08E+06	2.07E+06	2.07E+06	2.07E+06
		Price	2121.0	1918.6	1718.2	1556.0	1400.0	1269.1	1131.6	1025.3	917.8	827.3	744.5	666.7	604.9	541.7	487.3
		Product Revenue	0	0	3.51E+07	3.71E+07	1.35E+09	1.39E+09	1.39E+09	1.53E+09	1.62E+09	1.71E+09	1.55E+09	1.39E+09	1.25E+09	1.12E+09	1.01E+09
FullHDTV	Television	# Product	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Price	2429.0	2186.0	1974.3	1766.6	1586.6	1429.5	1296.6	1164.5	1046.6	939.1	853.1	764.6	690.3	617.2	556.3
		Product Revenue	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Revenues			0	0	1.80E+09	1.54E+09	1.38E+09	1.42E+09	1.42E+09	1.55E+09	1.64E+09	1.71E+09	1.55E+09	1.39E+09	1.25E+09	1.12E+09	1.01E+09



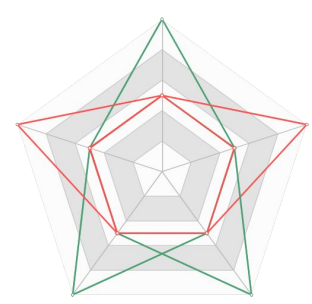
# Profit and Loss Statement Option 2 (2/2)

<b>Revenues</b>	<b>0</b>	<b>0</b>	<b>1.80E+09</b>	<b>1.54E+09</b>	<b>1.38E+09</b>	<b>1.42E+09</b>	<b>1.42E+09</b>	<b>1.55E+09</b>	<b>1.64E+09</b>	<b>1.71E+09</b>	<b>1.55E+09</b>	<b>1.39E+09</b>	<b>1.25E+09</b>	<b>1.12E+09</b>	<b>1.01E+09</b>
# Substrates	0	0	720000	720000	720000	720000	720000	720000	720000	720000	720000	720000	720000	720000	720000
Cost per substrate	0	0	1.66E+03	1.55E+03	1.47E+03	1.37E+03	1.29E+03	1.20E+03	1.14E+03	1.06E+03	1.01E+03	9.47E+02	8.89E+02	8.40E+02	7.89E+02
Depreciation costs	4.01E+07	1.65E+08	2.85E+08	2.85E+08	2.85E+08	2.85E+08	2.85E+08	2.85E+08	2.85E+08	2.85E+08	2.45E+08	1.20E+08	0.00E+00	0.00E+00	0.00E+00
<b>Cost of sales</b>	<b>4.01E+07</b>	<b>1.65E+08</b>	<b>1.48E+09</b>	<b>1.40E+09</b>	<b>1.34E+09</b>	<b>1.27E+09</b>	<b>1.21E+09</b>	<b>1.15E+09</b>	<b>1.11E+09</b>	<b>1.05E+09</b>	<b>9.73E+08</b>	<b>8.02E+08</b>	<b>6.40E+08</b>	<b>6.05E+08</b>	<b>5.68E+08</b>
<b>Gross Margin</b>	<b>-4.01E+07</b>	<b>-1.65E+08</b>	<b>3.15E+08</b>	<b>1.39E+08</b>	<b>3.85E+07</b>	<b>1.47E+08</b>	<b>2.03E+08</b>	<b>3.98E+08</b>	<b>5.32E+08</b>	<b>6.64E+08</b>	<b>5.74E+08</b>	<b>5.84E+08</b>	<b>6.10E+08</b>	<b>5.16E+08</b>	<b>4.41E+08</b>
Gross Margin (%)	0%	0%	18%	9%	3%	10%	14%	26%	32%	39%	37%	42%	49%	46%	44%
R&D (%)	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
SG&A (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
<b>Operating Margin</b>	<b>-4.01E+07</b>	<b>-1.65E+08</b>	<b>1.31E+08</b>	<b>-2.07E+07</b>	<b>-1.10E+08</b>	<b>-3.93E+06</b>	<b>5.28E+07</b>	<b>2.34E+08</b>	<b>3.57E+08</b>	<b>4.83E+08</b>	<b>4.09E+08</b>	<b>4.36E+08</b>	<b>4.77E+08</b>	<b>3.98E+08</b>	<b>3.33E+08</b>
Operating Margin (%)	0%	0%	7%	-1%	-8%	0%	4%	15%	22%	28%	26%	31%	38%	35%	33%
Tax (%)	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
Tax	0	0	3.27E+07	0	0	0	1.32E+07	5.85E+07	8.95E+07	1.21E+08	1.03E+08	1.09E+08	1.19E+08	9.95E+07	8.32E+07
<b>Net Income</b>	<b>-4.01E+07</b>	<b>-1.65E+08</b>	<b>9.78E+07</b>	<b>-2.07E+07</b>	<b>-1.10E+08</b>	<b>-3.93E+06</b>	<b>3.96E+07</b>	<b>1.75E+08</b>	<b>2.68E+08</b>	<b>3.62E+08</b>	<b>3.07E+08</b>	<b>3.27E+08</b>	<b>3.57E+08</b>	<b>2.98E+08</b>	<b>2.49E+08</b>
Net Income (%)	0%	0%	5%	-1%	-8%	0%	3%	11%	16%	21%	20%	24%	29%	27%	25%

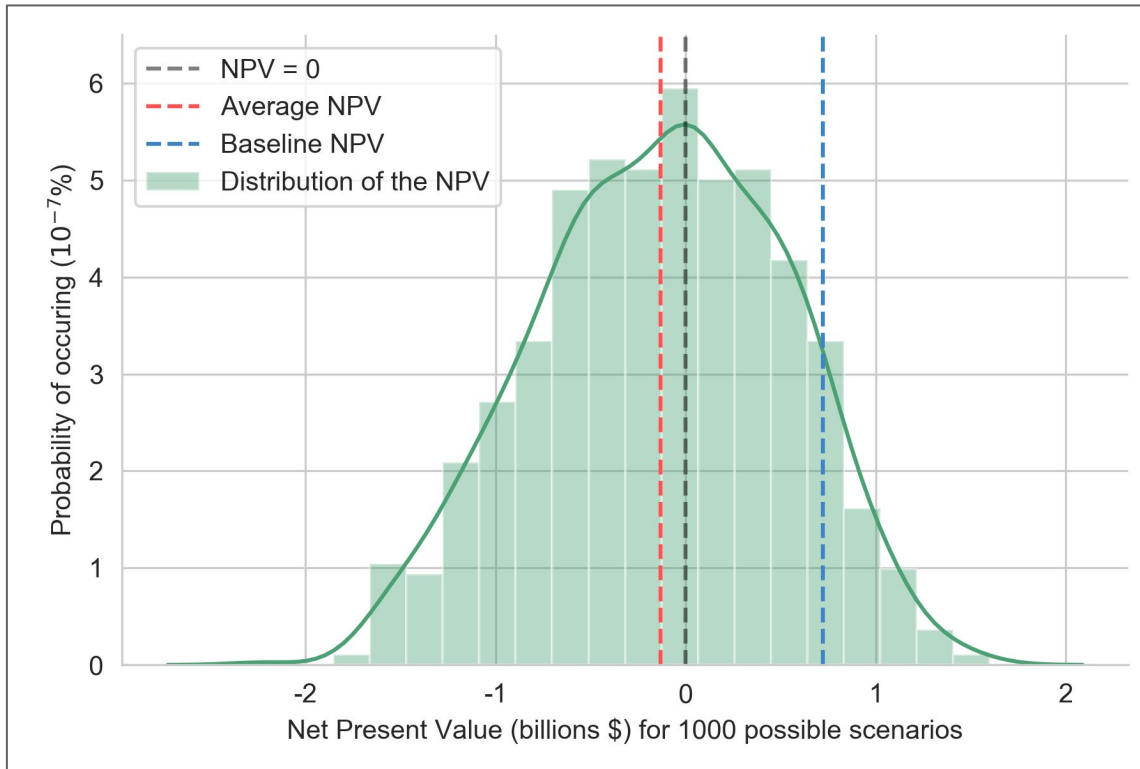
## Cash flow statement

(in \$)	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Net Income	-4.01E+07	-1.65E+08	9.78E+07	-2.07E+07	-1.10E+08	-3.93E+06	3.96E+07	1.75E+08	2.68E+08	3.62E+08	3.07E+08	3.27E+08	3.57E+08	2.98E+08	2.49E+08	
Depreciation costs	4.01E+07	1.65E+08	2.85E+08	2.85E+08	2.85E+08	2.85E+08	2.85E+08	2.85E+08	2.85E+08	2.85E+08	2.45E+08	1.20E+08	0	0	0	
Capex	4.01E+08	1.25E+09	1.20E+09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Delta Working capital investments	0	0	1.47E+08	-2.11E+07	-1.36E+07	3.09E+06	-1.64E+05	1.09E+07	6.71E+06	7.10E+06	-1.40E+07	-1.32E+07	-1.12E+07	-1.00E+07	-9.46E+06	-8.17E+07
<b>Net cash flow</b>	<b>-4.01E+08</b>	<b>-1.25E+09</b>	<b>-9.65E+08</b>	<b>2.86E+08</b>	<b>1.89E+08</b>	<b>2.78E+08</b>	<b>3.25E+08</b>	<b>4.50E+08</b>	<b>5.47E+08</b>	<b>6.40E+08</b>	<b>5.66E+08</b>	<b>4.60E+08</b>	<b>3.69E+08</b>	<b>3.08E+08</b>	<b>2.59E+08</b>	<b>8.17E+07</b>

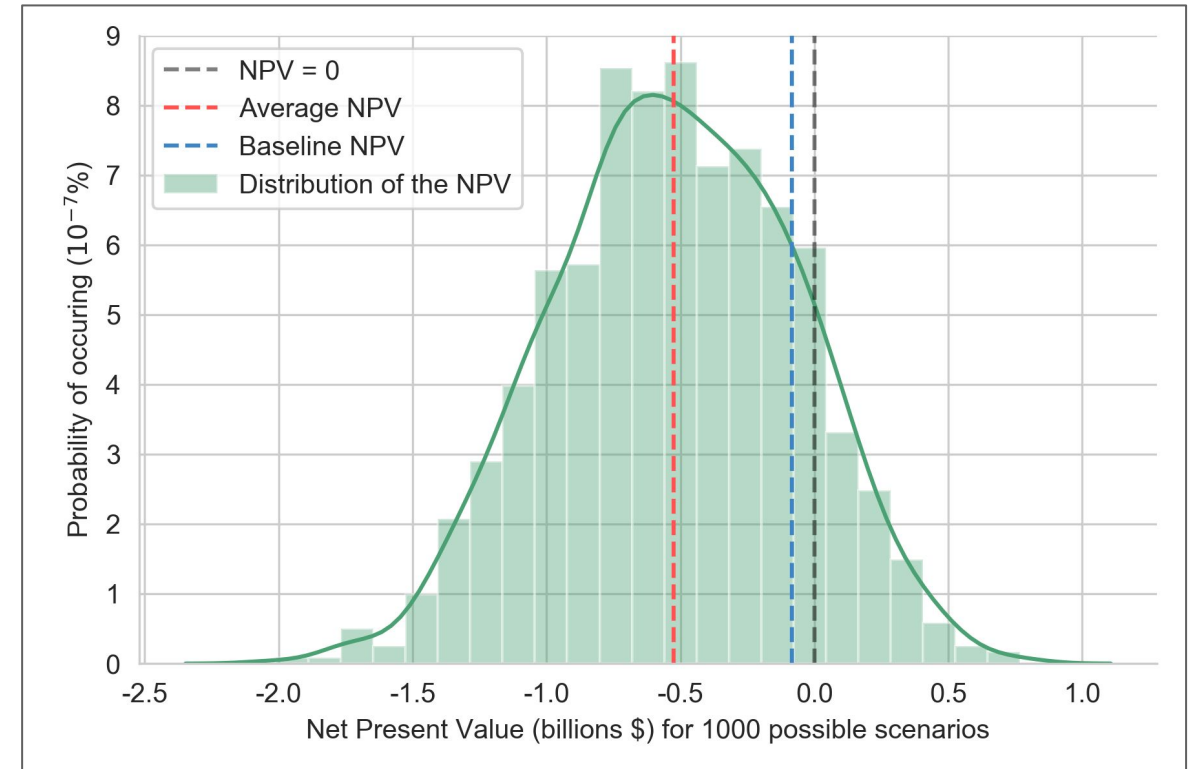




# Choosing a suboptimal substrate size can substantially increase risk from 56% to 87%



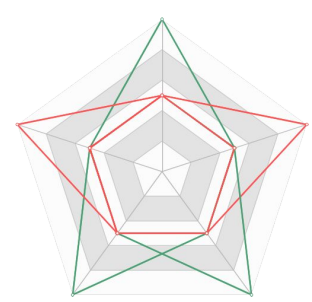
Optimal substrate size



Suboptimal substrate size

When choosing a suboptimal substrate size, the risk of realizing a negative NPV is increased substantially. We see that:

1. **Optimal substrate size:** the average NPV is around **-\$250 million** with **56%** of the cases yielding a negative NPV.
2. **Suboptimal substrate size:** the average NPV is around **-\$500 million** with **87%** of the cases yielding a negative NPV.



# Production percentages

For option 2 and option 3, profitable products are produced with at least a certain percentage of the total production capacity. This means that at least a certain percentage of the total substrates are devoted to a product.

Since televisions have larger dimensions than notebooks and monitors, the number of substrates reserved for televisions must be higher than for notebooks and monitors to obtain a more reasonable number of products. To incorporate this difference, the percentages per product market have been scaled to how many products fit on a substrate size of 1.85m x 1.55m for option 2.

The corresponding percentages for both option 2 and 3 are shown below:

	Option 2	Option 3
<b>Notebooks</b>	1.0% for the whole market	0.5% for every product in the market
<b>Monitors</b>	1.8% for the whole market	0.5% for every product in the market
<b>Televisions</b>	2.8% for the whole market	0.5% for every product in the market