

Appendices

Appendix A: Stakeholder interview setup

1. Introduction

- Introduce yourself and explain the purpose of the thesis project.
- Explain that the project focuses on redesigning the Sunshower infrared therapy device.
- Mention the estimated duration of the interview (approximately 30–60 minutes).
- Ask permission for note-taking or recording.
- Explain confidentiality and how the information will be used.

2. Background Questions

- What is your role or relationship with the Sunshower product or market?
- How familiar are you with infrared therapy or wellness products?
- How often do you interact with this type of product or its users?
- What is your general experience with the current Sunshower product?

3. Background Questions

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- What is your general experience with the current Sunshower product?

4. Needs and Expectations

- What are the most important needs the redesigned product should address?
- What improvements would you prioritize in a redesign?
- Which features or functions would add the most value?
- What would make the product easier or more pleasant to use?
- What expectations do users have regarding comfort, usability, or aesthetics?
- How important are safety, reliability, and maintenance?
- What role does sustainability or energy efficiency play?
- What would make the product stand out from competitors?

5. Stakeholder-Specific Insights

- What concerns or risks do you see regarding the redesign?

- Are there technical, regulatory, manufacturing, or usability constraints that should be considered?
- Which factors are most important for long-term product success?
- What trends or developments are important for the future of infrared wellness products?
- Which user groups should be prioritized during the redesign?
- What would improve the overall customer experience?
- Are there opportunities that you think are currently being overlooked?

6. Collaboration and Communication

- How involved do you think your role should be during the redesign process?
- At which stages of development would your input be most valuable?
- What information would you like to receive during the project?
- Are there other stakeholders who should be involved more closely?

7. Closing Questions

- If you could change one thing about the current product, what would it be?
- What would define a successful redesign for you?

- Is there anything important that has not been discussed yet?
- Do you have additional suggestions or recommendations for the project?

Appendix B: Power-Interest matrix placement explanation

Regulation Authorities (RA)

Regulatory authorities have significant power because the redesigned Sunshower must comply with medical device regulations, electrical safety standards, and consumer health requirements. If the product fails to meet these standards, it cannot be legally marketed or sold. However, regulatory bodies are not directly involved in the design process, which places them in the “keep satisfied” category rather than “manage closely.”

Dermatologists (D)

Dermatologists influence the credibility and acceptance of the Sunshower device because the product relates to skin health and infrared therapy. Their professional opinions can affect consumer trust and recommendations. Although they are important advisors regarding health benefits and safe use, they are not involved in operational or business decisions throughout the redesign process. Therefore, they should be kept satisfied through consultation and validation of health-related claims.

Potential Users (PU)

Potential users are highly interested because the redesign directly affects their user experience, comfort, health benefits, and purchasing decisions. They also hold considerable power because their acceptance ultimately determines the commercial success of the redesigned product. User feedback strongly influences design decisions regarding usability, aesthetics, and functionality, making them key stakeholders to manage closely.

Sunshower BV

Sunshower BV has the highest level of influence over the project because it owns the product, defines strategic goals, controls financial resources, and makes final decisions regarding implementation. The company is also highly interested in the redesign because the project directly impacts market competitiveness, brand image, innovation, and profitability. For this reason, Sunshower BV must be involved closely throughout the entire development process.

Competitors (C)

Competitors have limited direct influence on the redesign process itself, although they indirectly affect market expectations and innovation standards. Their interest in the project is also relatively low because they are focused on their own product development activities. Nevertheless, monitoring competitors is important to remain aware of trends, differentiation opportunities, and emerging technologies within the wellness and infrared therapy market.

Bathroom Retailers (BR)

Bathroom retailers are interested because they are responsible for selling and presenting the product to consumers. Their insights into customer preferences, installation requirements, and market trends can support the redesign process. However, they have limited direct influence over strategic design decisions, which places them in the “keep informed” category.

Marketing Department (M)

The marketing department is highly interested in the redesign because the final product affects branding, communication strategies, and market positioning. Marketing teams provide valuable input regarding target groups and customer perception, but they do not have ultimate authority over technical design decisions. Therefore, they should be kept informed throughout the project.

Users of the Current Product (U)

Existing users have valuable experience with the current Sunshower product and can provide practical feedback on usability, performance, and customer satisfaction. They are highly interested in improvements and potential new features. However, their direct influence on final business decisions is limited, so they are best categorized as stakeholders to keep informed.

Service Technicians (ST)

Service technicians are interested because the redesign may influence installation procedures, maintenance requirements, and repair complexity. Their technical experience can help identify practical issues related to servicing the product. While their operational knowledge is useful, they generally have limited strategic influence on the redesign project.

The Environment (E)

Environmental considerations are increasingly important in product development, particularly regarding sustainability, material use, energy consumption, and product lifespan. Although the environment itself does not directly exert power, environmental concerns influence public perception and future regulations. Therefore, sustainability

factors should remain visible and integrated throughout the redesign process.

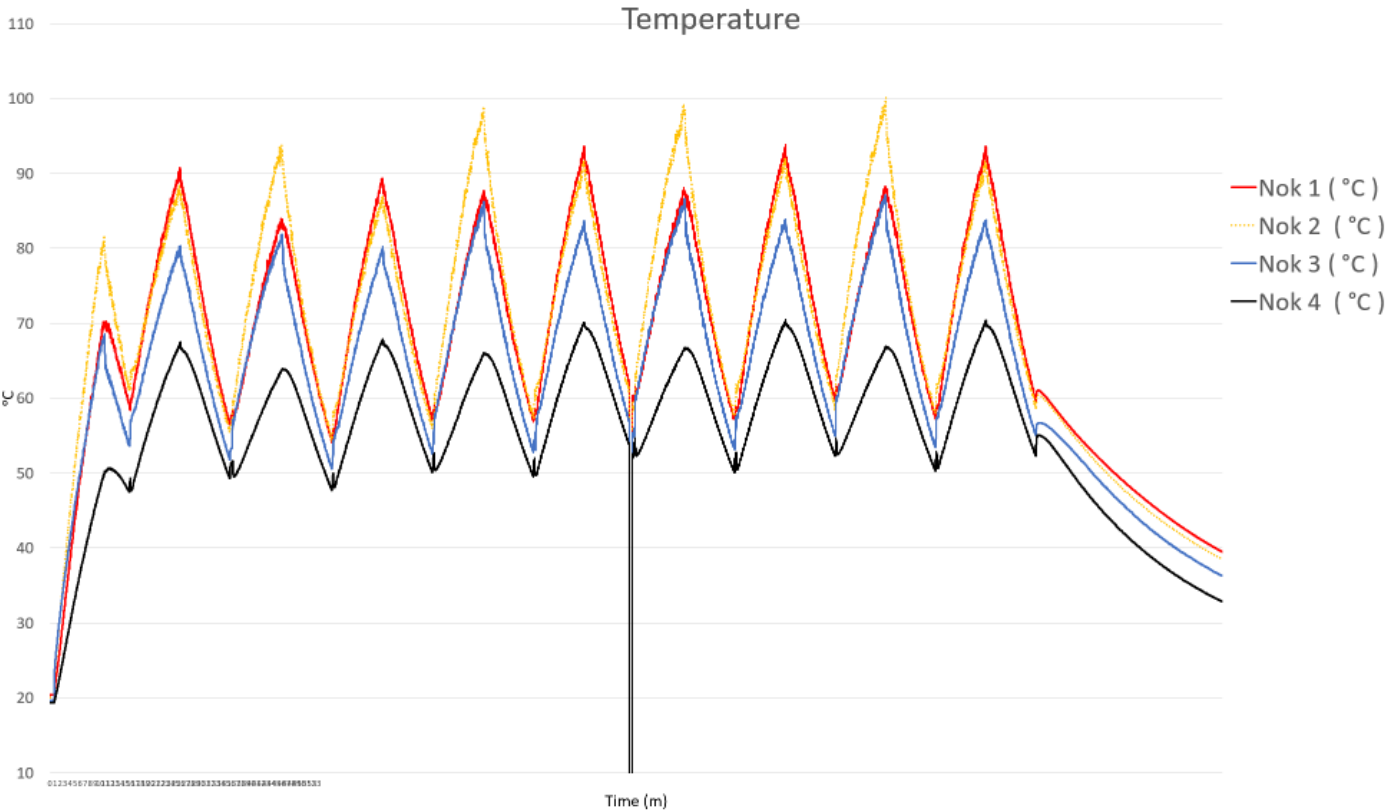
Suppliers (S)

Suppliers are positioned near the center of the matrix because they have moderate influence and interest in the redesign process. They influence component availability, material quality, production costs, and technological possibilities. At the same time, they are interested in maintaining business relationships and adapting to new product requirements. However, they are not the primary decision-makers, which keeps them from belonging to the highest-priority stakeholder groups.

Production Facility (P)

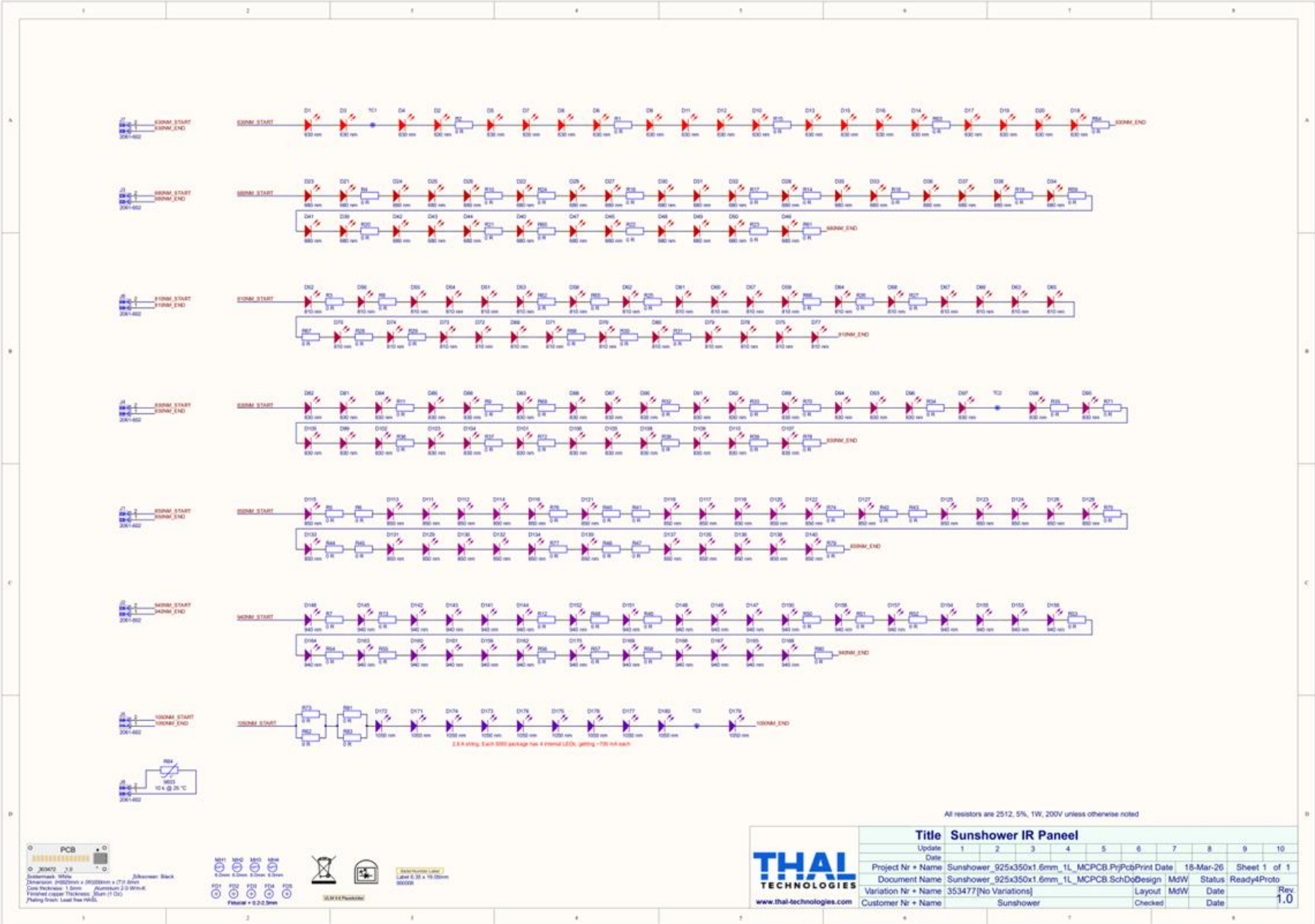
The production facility is positioned between “monitor” and “keep informed” because it is involved in manufacturing feasibility, assembly processes, and production efficiency. The redesign may require adjustments in tooling, workflows, or manufacturing methods, giving the production facility a practical interest in the project. However, it has limited strategic power over final design decisions, resulting in its intermediate placement within the matrix.


Appendix C: Heat measurements current Sunshower



Appendix E: Technical data chosen LEDs

Appendix F: Bill Of Materials and electrical diagram prototype



Bill of Materials		PCB: 303472	Sunshower IR Panel	Revision: 1,0				
		PCBA: 353477	Default Variant	Sunshower IR Panel				
Release State: Ready4Proto								
Release Date: <Parameter pp_rel es		Generated:	18-Mar-25 13:13:15					
Quantity	Thal Part Number	Value	Designator	Technology	Description	Manufacturer	Manufacturer 1	Manufacturer Part Number 1
1	303472	303472	A PCB1		<ProtecName> BareBoard PCB, Revision see BCM header		Thal Technologies	303472
20	450600	WL-6P3535EP60R-630	D1, D2, D3, D4, D5, D6, D7, D8, D9, D10, D11, D12, D13, D14, D15, D16, D17, D18, D19, D20	SMT	High Power Red 630nm LED, 3535, Lumistar, 1kV ESD protected, 3.45 x 3.45 x 3.2 mm		Lumistar	WL-6P3535EP60R-630
30	450601	WL-3P3535EP60HR-680	D21, D22, D23, D24, D25, D26, D27, D28, D29, D30, D31, D32, D33, D34, D35, D36, D37, D38, D39, D40, D41, D42, D43, D44, D45, D46, D47, D48, D49, D50	SMT	High Power Deep Red 680nm LED, 3535, Lumistar, 1kV ESD protected, 3.45 x 3.45 x 3.2 mm		Lumistar	WL-3P3535EP60HR-680
30	450602	WL-3P3535EP60IR-S810	D51, D52, D53, D54, D55, D56, D57, D58, D59, D60, D61, D62, D63, D64, D65, D66, D67, D68, D69, D70, D71, D72, D73, D74, D75, D76, D77, D78, D79, D80	SMT	High Power NR 810nm LED, 3535, Lumistar, 1kV ESD protected, 3.45 x 3.45 x 3.2 mm		Lumistar	WL-3P3535EP60IR-S810
30	450603	WL-3P3535EP60IR-830	D81, D82, D83, D84, D85, D86, D87, D88, D89, D90, D91, D92, D93, D94, D95, D96, D97, D98, D99, D100, D101, D102, D103, D104, D105, D106, D107, D108, D109, D110	SMT	High Power NR 830nm LED, 3535, Lumistar, 1kV ESD protected, 3.45 x 3.45 x 3.2 mm		Lumistar	WL-3P3535EP60IR-830
30	450604	WL-3P3535EP60IR-S850	D111, D112, D113, D114, D115, D116, D117, D118, D119, D120, D121, D122, D123, D124, D125, D126, D127, D128, D129, D130, D131, D132, D133, D134, D135, D136, D137, D138, D139, D140	SMT	High Power NR 850nm LED, 3535, Lumistar, 1kV ESD protected, 3.45 x 3.45 x 3.2 mm		Lumistar	WL-3P3535EP60IR-S850
30	450606	WL-3P3535EP60IR-S940	D141, D142, D143, D144, D145, D146, D147, D148, D149, D150, D151, D152, D153, D154, D155, D156, D157, D158, D159, D160, D161, D162, D163, D164, D165, D166, D167, D168, D169, D170	SMT	High Power SWIR 940nm LED, 3535, Lumistar, 1kV ESD protected, 3.45 x 3.45 x 3.2 mm		Lumistar	WL-3P3535EP60IR-S940
10	450606	WL-6P5050EP60IR-1050	D171, D172, D173, D174, D175, D176, D177, D178, D179, D180	SMT	High Power SWIR 1050nm LED, 3535, Lumistar, 1kV ESD protected, 3.45 x 3.45 x 3.2 mm		Lumistar	WL-6P5050EP60IR-1050
5		Fiducial + 0.2-2.5mm	FD1, FD2, FD3, FD4, FD5		Fiducial symbol, +			
8	401023	2061-602	J1, J2, J3, J4, J5, J6, J7, J8	SMT	Wire-To-Board Terminal Block, 2 Ways, 16...20 AWG / 0.25...1.5 mm ² , Push In cage clamp, Pitch 6 mm		Wago	2061-602/996-404
83	400162	0 R	R1, R2, R3, R4, R5, R6, R7, R8, R9, R10, R11, R12, R13, R14, R15, R16, R17, R18, R19, R20, R21, R22, R23, R24, R25, R26, R27, R28, R29, R30, R31, R32, R33, R34, R35, R36, R37, R38, R39, R40, R41, R42, R43, R44, R45, R46, R47, R48, R49, R50, R51, R52, R53, R54, R55, R56, R57, R58, R59, R60, R61, R62, R63, R64, R65, R66, R67, R68, R69, R70, R71, R72, R73, R74, R75, R76, R77, R78, R79, R80, R81, R82, R83	SMT	Thick film resistor, 0 R, 2512, 5%, 1 W, 200 V, 2 A, -55-155 °C	Free Choice	Yageo	RC2512JK-070RL
1	401054	10 k @ 25 °C	R84	SMT	Thermistor, NTC, 10 k, 0603, 1%, 0.1 mA, 5 V, 1 mW/°C, -40-125 °C	Free Choice	Murata	NCLU18XH103F60R8
1	900006	Label 6.35 x 19.05mm	SerialNr		Label, 0.25 x 0.75 inch, 6.35 x 19.05 mm, Thermal Transfer, polyester, white, THT-1-423-10		Brady	THT-1-423-10

Appendix G: LCA of the current Sunshower

Delft University of Technology
HUMAN RESEARCH ETHICS
CHECKLIST FOR HUMAN RESEARCH
(Version January 2022)

IMPORTANT NOTES ON PREPARING THIS CHECKLIST

1. An HREC application should be submitted for every research study that involves human participants (as Research Subjects) carried out by TU Delft researchers
2. Your HREC application should be submitted and approved **before** potential participants are approached to take part in your study
3. All submissions from Master's Students for their research thesis need approval from the relevant Responsible Researcher
4. The Responsible Researcher must indicate their approval of the completeness and quality of the submission by signing and dating this form OR by providing approval to the corresponding researcher via email (included as a PDF with the full HREC submission)
5. There are various aspects of human research compliance which fall outside of the remit of the HREC, but which must be in place to obtain HREC approval. These often require input from internal or external experts such as [Faculty Data Stewards](#), [Faculty HSE advisors](#), the [TU Delft Privacy Team](#) or external [Medical research partners](#).
6. You can find detailed guidance on completing your HREC application [here](#)
7. Please note that incomplete submissions (whether in terms of documentation or the information provided therein) will be returned for completion **prior to any assessment**
8. If you have any feedback on any aspect of the HREC approval tools and/or process you can leave your comments [here](#)

I. Applicant Information

PROJECT TITLE:	Redesigning the Sunshower to increase accessibility for potential customers
Research period: <i>Over what period of time will this specific part of the research take place</i>	Phase 1: 8-15 Jan 2025 Phase 2: 23 Feb - 5 Mar 2026
Faculty:	Industrial Design Engineering
Department:	Human Centered Design
Type of the research project: <i>(Bachelor's, Master's, DreamTeam, PhD, PostDoc, Senior Researcher, Organisational etc.)</i>	Master's Thesis
Funder of research: <i>(EU, NWO, TUD, other – in which case please elaborate)</i>	Sunshower BV
Name of Corresponding Researcher: <i>(If different from the Responsible Researcher)</i>	Koen van der Park
E-mail Corresponding Researcher: <i>(If different from the Responsible Researcher)</i>	_____
Position of Corresponding Researcher: <i>(Masters, DreamTeam, PhD, PostDoc, Assistant/ Associate/ Full Professor)</i>	Masters
Name of Responsible Researcher: <i>Note: all student work must have a named Responsible Researcher to approve, sign and submit this application</i>	Sonja Paus-Buzink
E-mail of Responsible Researcher: <i>Please ensure that an institutional email address (no Gmail, Yahoo, etc.) is used for all project documentation/ communications including Informed Consent materials</i>	_____
Position of Responsible Researcher : <i>(PhD, PostDoc, Associate/ Assistant/ Full Professor)</i>	Assistant Professor

II. Research Overview

NOTE: You can find more guidance on completing this checklist [here](#)

a) Please summarise your research very briefly (100-200 words)

What are you looking into, who is involved, how many participants there will be, how they will be recruited and what are they expected to do?

Add your text here – (please avoid jargon and abbreviations)

For my MSc thesis project I aim to conduct human-subject research in 2 phases. In phase 1, I aim to interview ±2-5 adults about their shower habits and perceptions of Sunshower use, some will be experienced Sunshower users. In addition, I aim to interview ±3-5 subject-matter experts, such as physicians to gain insight on the biological mechanisms and therapeutic effects and of infrared light-therapy.

In phase 2, the research aims to evaluate usability and user-experience of the Sunshower redesign I will develop within my thesis project. In a simulated-use set-up ±8-12 participants (with and without prior Sunshower experience) are asked to conduct shower-related activities while interacting with a non-functional prototype of the Sunshower redesign (e.g., infrared LEDs will be replaced by regular red LEDs). Participants for research in both phases will be recruited mostly through Sunshower contact channels.

- b) **If your application is an additional project** related to an existing approved HREC submission, please provide a brief explanation including the existing relevant HREC submission number/s.

- c) **If your application is a simple extension of, or amendment to,** an existing approved HREC submission, you can simply submit an [HREC Amendment Form](#) as a submission through LabServant.

III. Risk Assessment and Mitigation Plan

NOTE: You can find more guidance on completing this checklist [here](#)

Please complete the following table in full for all points to which your answer is “yes”. Bear in mind that the vast majority of projects involving human participants as Research Subjects also involve the collection of **Personally Identifiable Information (PII)** and/or **Personally Identifiable Research Data (PIRD)** which may pose potential risks to participants as detailed in Section G: Data Processing and Privacy below.

To ensure alignment between your risk assessment, data management and what you agree with your Research Subjects you can use the last two columns in the table below to refer to specific points in your Data Management Plan (DMP) and Informed Consent Form (ICF) – **but this is not compulsory**.

It’s worth noting that **you’re much more likely to need to resubmit your application if you neglect to identify potential risks**, than if you identify a potential risk and demonstrate how you will mitigate it. If necessary, the HREC will always work with you and colleagues in the Privacy Team and Data Management Services to see how, if at all possible, your research can be conducted.

			<i>If YES please complete the Risk Assessment and Mitigation Plan columns below.</i>		<i>Please provide the relevant reference #</i>	
ISSUE	Yes	No	RISK ASSESSMENT – what risks could arise? <i>Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!</i>	MITIGATION PLAN – what mitigating steps will you take? <i>Please ensure that you summarise what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.</i>	DMP	ICF
A: Partners and collaboration						
1. Will the research be carried out in collaboration with additional organisational partners such as: <ul style="list-style-type: none"> One or more collaborating research and/or commercial organisations Either a research, or a work experience internship provider¹ <i>¹ If yes, please include the graduation agreement in this application</i>	x		This project was offered to me by Sunshower BV. As I am using their facilities, including computer and server, there is a risk that data gathered from participants will end up in Sunshower's database or onedrive environment.	The data at risk are personal experiences and personally identifiable information that is recorded for administrative purposes. To minimize the risk, this information will be collected and stored on my personal laptop and the TU Delft Onedrive. Only anonymized insights and takeaways will be shared with Sunshower.		
2. Is this research dependent on a Data Transfer or Processing Agreement with a collaborating partner or third party supplier? <i>If yes please provide a copy of the signed DTA/DPA</i>		x				
3. Has this research been approved by another (external) research ethics committee (e.g.: HREC and/or MREC/METC)? <i>If yes, please provide a copy of the approval (if possible) and summarise any key points in your Risk Management section below</i>		x				
B: Location						

			<i>If YES please complete the Risk Assessment and Mitigation Plan columns below.</i>	<i>Please provide the relevant reference #</i>		
ISSUE	Yes	No	RISK ASSESSMENT – what risks could arise? <i>Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!</i>	MITIGATION PLAN – what mitigating steps will you take? <i>Please ensure that you summarise what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.</i>	DMP	ICF
4. Will the research take place in a country or countries, other than the Netherlands, within the EU?		x				
5. Will the research take place in a country or countries outside the EU?		x				
6. Will the research take place in a place/region or of higher risk – including known dangerous locations (in any country) or locations with non-democratic regimes?		x				
C: Participants						
7. Will the study involve participants who may be vulnerable and possibly (legally) unable to give informed consent? (e.g., children below the legal age for giving consent, people with learning difficulties, people living in care or nursing homes,).		x				
8. Will the study involve participants who may be vulnerable under specific circumstances and in specific contexts, such as victims and witnesses of violence, including domestic violence; sex workers; members of minority groups, refugees, irregular migrants or dissidents?		x				
9. Are the participants, outside the context of the research, in a dependent or subordinate position to the investigator (such as own children, own students or employees of either TU Delft and/or a collaborating partner organisation)? <i>It is essential that you safeguard against possible adverse consequences of this situation (such as allowing a student's failure to participate to your satisfaction to affect your evaluation of their coursework).</i>		x	in Phase 1, participants recruited from the Sunshower office (my colleagues) are subordinates of my company mentor. Therefore they may feel obligated to participate in the research.	The contact with these participants will not be through my company mentor, who is also not involved in the project in such a detailed way that he knows who would participate or not. Data from these participants will also be anonymised, making it impossible to trace back to anyone specifically. Additionally, as I know these possible participants well personally, they will feel free to decline participation in my project.		
10. Is there a high possibility of re-identification for your participants? (e.g., do they have a very specialist job of which there are only a small number in a given country, are they members of a small community, or employees from a partner company collaborating in the research? Or are they one of only a handful of (expert) participants in the study?		x	As there is a limited number of physicians connected to Sunshower, there might be a risk of these participants being traceable due to their specialistic knowledge in combination with their affiliation with Sunshower being used in my report.	All data and knowledge gained from participants will be processed and analysed anonymously. As there are dozens of physicians with the same specialisms linked to Sunshower, the anonymised information cannot be traced back to a single participant through their affiliation with the company.		
D: Recruiting Participants						

			<i>If YES please complete the Risk Assessment and Mitigation Plan columns below.</i>		<i>Please provide the relevant reference #</i>	
ISSUE	Yes	No	RISK ASSESSMENT – what risks could arise? <i>Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!</i>	MITIGATION PLAN – what mitigating steps will you take? <i>Please ensure that you summarise what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.</i>	DMP	ICF
11. Will your participants be recruited through your own, professional, channels such as conference attendance lists, or through specific network/s such as self-help groups		x				
12. Will the participants be recruited or accessed in the longer term by a (legal or customary) gatekeeper? (e.g., an adult professional working with children; a community leader or family member who has this customary role – within or outside the EU; the data producer of a long-term cohort study)		x				
13. Will you be recruiting your participants through a crowd-sourcing service and/or involve a third party data-gathering service, such as a survey platform?		x				
14. Will you be offering any financial, or other, remuneration to participants, and might this induce or bias participation?		x				
E: Subject Matter <i>Research related to medical questions/health may require special attention. See also the website of the CCMO before contacting the HREC.</i>						
15. Will your research involve any of the following: <ul style="list-style-type: none"> • Medical research and/or clinical trials • Invasive sampling and/or medical imaging • Medical and <i>In Vitro Diagnostic Medical Devices</i> Research 	x		According to the MDR Annex XVI, the Sunshower and the redesign I am working on classify as medical devices.	In both phase 1 and phase 2, the research focuses solely on the device's usability and how the appearance is perceived. Therefore, the participants will be asked to only simulate the usage of the devices and the devices will be non-functional. Also, no data will be collected on the clinical effectiveness of the design or the experience of the therapy.		
16. Will drugs, placebos, or other substances (e.g., drinks, foods, food or drink constituents, dietary supplements) be administered to the study participants? <i>If yes see here to determine whether medical ethical approval is required</i>		x				
17. Will blood or tissue samples be obtained from participants? <i>If yes see here to determine whether medical ethical approval is required</i>		x				
18. Does the study risk causing psychological stress or anxiety beyond that normally encountered by the participants in their life outside research?		x				

			<i>If YES please complete the Risk Assessment and Mitigation Plan columns below.</i>		<i>Please provide the relevant reference #</i>	
ISSUE	Yes	No	RISK ASSESSMENT – what risks could arise? <i>Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!</i>	MITIGATION PLAN – what mitigating steps will you take? <i>Please ensure that you summarise what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.</i>	DMP	ICF
19. Will the study involve discussion of personal sensitive data which could put participants at increased legal, financial, reputational, security or other risk? (e.g., financial data, location data, data relating to children or other vulnerable groups) <i>Definitions of sensitive personal data, and special cases are provided on the TUD Privacy Team website.</i>		x				
20. Will the study involve disclosing commercially or professionally sensitive, or confidential information? (e.g., relating to decision-making processes or business strategies which might, for example, be of interest to competitors)	x		During the research, information about the cost-price of the sunshower and its components will be used. This could hurt Sunshowers competitive position or damage relations with retailers.	As agreed on in the graduation contract, this information that is provided by Sunshower will not be mentioned in the publically available upload of the thesis. Any sensitive information that might be included will be discussed with the company mentor.		
21. Has your study been identified by the TU Delft Privacy Team as requiring a Data Processing Impact Assessment (DPIA)? <i>If yes please attach the advice/ approval from the Privacy Team to this application</i>		x				
22. Does your research investigate causes or areas of conflict? <i>If yes please confirm that your fieldwork has been discussed with the appropriate safety/security advisors and approved by your Department/Faculty.</i>		x				
23. Does your research involve observing illegal activities or data processed or provided by authorities responsible for preventing, investigating, detecting or prosecuting criminal offences <i>If so please confirm that your work has been discussed with the appropriate legal advisors and approved by your Department/Faculty.</i>		x				
F: Research Methods						
24. Will it be necessary for participants to take part in the study without their knowledge and consent at the time? (e.g., covert observation of people in non-public places).		x				
25. Will the study involve actively deceiving the participants? (For example, will participants be deliberately falsely informed, will information be withheld from them or will they be misled in such a way that they are likely to object or show unease when debriefed about the study).		x				
26. Is pain or more than mild discomfort likely to result from the study? And/or could your research activity cause an accident involving (non-) participants?		x				

			<i>If YES please complete the Risk Assessment and Mitigation Plan columns below.</i>	<i>Please provide the relevant reference #</i>		
ISSUE	Yes	No	RISK ASSESSMENT – what risks could arise? <i>Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!</i>	MITIGATION PLAN – what mitigating steps will you take? <i>Please ensure that you summarise what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.</i>	DMP	ICF
27. Will the experiment involve the use of devices that are not ‘CE’ certified? <i>Only, if ‘yes’: continue with the following questions:</i>	x		In phase 1, the participants will only use CE certified products. They will be asked to mimic and tell about their habits using the current sunshower. In phase 2, the participants will be asked to repeat these actions with a non-functional high-fidelity prototype of the LED Sunshower. This prototype will look like the intended design but will not have any therapeutic functionality.	As the research is focused on the usability of the device, the prototypes will therefore be non-functional and participants will only be asked to simulate and mimic normal use of the prototype. The prototype will always be tested by me as well as my supervisor before research. Senior engineers at Sunshower will be consulted during the manufacturing of the prototype to ensure safety. During the use of this prototype, I will always be present to supervise and navigate the participant through the use of the product and stop the test if necessary.		
<ul style="list-style-type: none"> Was the device built in-house? 	x		Most components of the prototype will be ordered through external companies. The connections and final assembly of all the components will be done in the workshop of the sunshower office.	As the largest part of building the device will be fastening screws and bolts, there is little to no risk of misuse and injury. The workshop at the Sunshower office is supervised by senior engineers and the equipment is all CE certified.		
<ul style="list-style-type: none"> Was it inspected by a safety expert at TU Delft? <i>If yes, please provide a signed device report</i> 		x	The prototype has not been inspected by a safety expert as it has not been built yet	When the prototype is built, it will be inspected by engineers at sunshower, my supervisory team and a safety expert at the TU Delft to produce a device report if necessary		
<ul style="list-style-type: none"> If it was not built in-house and not CE-certified, was it inspected by some other, qualified authority in safety and approved? <i>If yes, please provide records of the inspection</i> 		x				
28. Will your research involve face-to-face encounters with your participants and if so how will you assess and address Covid considerations?	x		The research will involve several face-to-face encounters with the participants.	The prototype will be cleaned thoroughly between every participant, to prevent potential transmission of any (contagious) viruses. If I or any participants shows symptoms of disease or any virus, the research session will be canceled and rescheduled for a later moment when the symptoms have disappeared.		

			<i>If YES please complete the Risk Assessment and Mitigation Plan columns below.</i>		<i>Please provide the relevant reference #</i>	
ISSUE	Yes	No	RISK ASSESSMENT – what risks could arise? <i>Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!</i>	MITIGATION PLAN – what mitigating steps will you take? <i>Please ensure that you summarise what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.</i>	DMP	ICF
29. Will your research involve either : a) “big data”, combined datasets, new data-gathering or new data-merging techniques which might lead to re-identification of your participants and/or b) artificial intelligence or algorithm training where, for example biased datasets could lead to biased outcomes?		x				
G: Data Processing and Privacy						
30. Will the research involve collecting, processing and/or storing any directly identifiable PII (Personally Identifiable Information) including name or email address that will be used for administrative purposes only? (eg: obtaining Informed Consent or disbursing remuneration)	x		The research involves collecting informed consent forms from the participants that will contain names, signatures and phone numbers. There is a risk that this information will be seen by employees of Sunshower.	Signed consent forms will be kept in my home, where only I have access to them. The participants names will be linked to a participant ID, so the information can be used without risking the privacy of the participant.		
31. Will the research involve collecting, processing and/or storing any directly or indirectly identifiable PIRD (Personally Identifiable Research Data) including videos, pictures, IP address, gender, age etc and what other Personal Research Data (including personal or professional views) will you be collecting?	x		Photos or video recordings will only be collected during user testing if participants provide separate, explicit consent. These materials may make individuals identifiable to others. Recordings are used to capture how participants interact with the prototype, including body movements, posture, task flow, timing and verbal comments during sessions. Video is used only when less sensitive methods are insufficient. Observation notes cannot capture precise timing or physical interactions, audio recordings lack spatial detail and photos fail to show movement or may disrupt natural behavior by requiring staged moments, making them less suitable for evaluating real-time interaction.	Data will only be collected according to the consent provided by the participant. Recording will be focused on the interaction with the prototype and the faces of participants will be blurred or excluded from the report. Recordings will be made only on a dedicated camera (Canon EOS) that only the researcher has access to and transferred to the TU Delft OneDrive through an SD-card to prevent the footage from being stored in automated personal cloud services. In the informed consent form, the participants can consent to videos or pictures separately and they will be notified that the consent can be revoked at any time. Revoking consent will result in deleting of all data.		
32. Will this research involve collecting data from the internet, social media and/or publicly available datasets which have been originally contributed by human participants		x				
33. Will your research findings be published in one or more forms in the public domain, as e.g., Masters thesis, journal publication, conference presentation or wider public dissemination?	x		As is required to graduate, my thesis will be published on the TU Delft repository and I will present my main findings and design in a final presentation.	Before publication, the thesis and presentation will be checked by me and the supervisory team on any identifiable information of participants to guarantee their privacy.		
34. Will your research data be archived for re-use and/or teaching in an open, private or semi-open archive?		x	As is required to graduate, my thesis will be published on the TU Delft repository and I will present my main findings and design in a final presentation.	Before publication, the thesis and presentation will be checked by me and the supervisory team on any identifiable information of participants to guarantee their privacy.		

H: More on Informed Consent and Data Management

NOTE: You can find guidance and templates for preparing your Informed Consent materials) [here](#)

Your research involves human participants as Research Subjects if you are recruiting them or actively involving or influencing, manipulating or directing them in any way in your research activities. This means you must seek informed consent and agree/ implement appropriate safeguards regardless of whether you are collecting any PIRD.

Where you are also collecting PIRD, and using Informed Consent as the legal basis for your research, you need to also make sure that your IC materials are clear on any related risks and the mitigating measures you will take – including through responsible data management.

Got a comment on this checklist or the HREC process? You can leave your comments [here](#)

IV. Signature/s

Please note that by signing this checklist list as the sole, or Responsible, researcher you are providing approval of the completeness and quality of the submission, as well as confirming alignment between GDPR, Data Management and Informed Consent requirements.

Name of Corresponding Researcher (if different from the Responsible Researcher) (print)

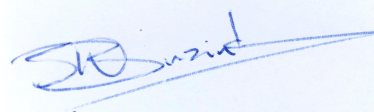
Signature of Corresponding Researcher: Koen van der Park

Date: 3-12-2025

Name of Responsible Researcher (print) Sonja Paus-Buzink

Signature (or upload consent by mail) Responsible Researcher:

Date: 3 December 2025



V. Completing your HREC application

Please use the following list to check that you have provided all relevant documentation

Required:

- **Always:** This completed HREC checklist
- **Always:** A data management plan (reviewed, where necessary, by a data-steward)
- **Usually:** A complete Informed Consent form (including Participant Information) and/or Opening Statement (for online consent)

Please also attach any of the following, if relevant to your research:

Document or approval	Contact/s
Full Research Ethics Application	After the assessment of your initial application HREC will let you know if and when you need to submit additional information
Signed, valid Device Report	Your Faculty HSE advisor
Ethics approval from an external Medical Committee	TU Delft Policy Advisor, Medical (Devices) Research
Ethics approval from an external Research Ethics Committee	Please append, if possible, with your submission
Approved Data Transfer or Data Processing Agreement	Your Faculty Data Steward and/or TU Delft Privacy Team
Approved Graduation Agreement	Your Master's thesis supervisor
Data Processing Impact Assessment (DPIA)	TU Delft Privacy Team
Other specific requirement	Please reference/explain in your checklist and append with your submission

Redesigning the Sunshower

This research is conducted as part of the MSc study Industrial Design Engineering at TU Delft.

Student: Koen van der Park

My graduation project revolves around the redesign of the Sunshower: an infrared therapy device that is used in the shower. The redesign is based on using LEDs as the source of infrared light instead of the halogen lamps in the current design.

The goal of this session is to learn more about how the Sunshower is used. During parts of this session, I will ask you to simulate some steps of your Sunshower routine and narrate what you are doing. You will not be asked to undress or actually shower during this research.

Before, during and after the session, I will ask you some questions about parts of your routine and the interaction with the device. With your consent, I will take photos and videos during the session to record your position and orientation relative to the device.

Informed consent participant

I participate in this research voluntarily.

I acknowledge that I received sufficient information and explanation about the research and that all my questions have been answered satisfactorily. I was given sufficient time to consent my participation. I can ask questions for further clarification at any moment during the research.

I am aware that this research consists of the following activities:

1. Answering some questions regarding your background and your typical Sunshower routine.
2. Simulation of the normal showering routine and use of the Sunshower.
3. Answering questions on the interaction with the product.

I am aware that data will be collected before and after the research, such as notes, pictures and video recordings. I give permission for collecting this data and for making notes, pictures and video recordings before and after the research. Data will be processed and analysed anonymously (without your name or other identifiable information). The data will only be accessible to the research team and their TU Delft supervisors.

The notes and recordings will be used to support analysis of the collected data.

I give permission for using photos and/or video recordings of my participation:

(select what applies for you)

- in which I am recognisable in publications and presentations about the project.
- in which I am not recognisable in publications and presentations about the project.
- for data analysis only and not for publications and presentations about the project.

I give permission to store the data for a maximum of 5 years after completion of this research and using it for educational and research purposes.

I acknowledge that no financial compensation will be provided for my participation in this research.

With my signature I acknowledge that I have read the provided information about the research and understand the nature of my participation. I understand that I am free to withdraw and stop participation in the research at any given time. I understand that I am not obliged to answer questions which I prefer not to answer and I can indicate this to the research team.

I will receive a copy of this consent form.

Last name

First name

Participant ID:

___ / ___ / 2026
Date (dd/mm/yyyy)

Signature

Redesigning the Sunshower

This research is conducted as part of the MSc study Industrial Design Engineering at TU Delft.

Student: Koen van der Park

Contact information: 06 57959822 – k.vanderpark@student.tudelft.nl

Mijn afstudeerproject draait om het herontwerp van de Sunshower: een infraroodtherapie-apparaat dat onder de douche wordt gebruikt. Het herontwerp is gebaseerd op het gebruik van LED's als bron van infrarood licht in plaats van de halogeenlampen in het huidige ontwerp.

Het doel van deze sessie is om meer inzicht te krijgen in hoe de Sunshower wordt gebruikt. Tijdens delen van deze sessie zal ik je vragen enkele stappen van je Sunshower-routine te simuleren en te vertellen wat je doet. Je wordt niet gevraagd om je uit te kleden of daadwerkelijk te douchen tijdens dit onderzoek.

Voorafgaand aan, tijdens en na de sessie zal ik je enkele vragen stellen over onderdelen van je routine en de interactie met het apparaat. Met jouw toestemming zal ik tijdens de sessie foto's en video's maken om je positie en oriëntatie ten opzichte van het apparaat vast te leggen.

Informed consent participant

Ik neem vrijwillig deel aan dit onderzoek.

Ik erken dat ik voldoende informatie en uitleg heb ontvangen over het onderzoek en dat al mijn vragen naar tevredenheid zijn beantwoord. Ik heb voldoende tijd gekregen om in te stemmen met mijn deelname. Ik kan op ieder moment tijdens het onderzoek vragen stellen voor verdere toelichting.

Ik ben me ervan bewust dat dit onderzoek uit de volgende activiteiten bestaat:

1. Het beantwoorden van enkele vragen over uw achtergrond en uw typische Sunshower-routine.
2. Het simuleren van de normale douche-routine en het gebruik van de Sunshower.
3. Het beantwoorden van vragen over de interactie met het product.

Ik ben me ervan bewust dat er voor en na het onderzoek gegevens worden verzameld, zoals notities, foto's en video-opnamen. Ik geef toestemming voor het verzamelen van deze gegevens en voor het maken van notities, foto's en video-opnamen voor en na het onderzoek. De gegevens worden anoniem (zonder uw naam of andere identificeerbare informatie) verwerkt en geanalyseerd. De gegevens zijn alleen toegankelijk voor het onderzoeksteam en hun begeleiders van de TU Delft.

De notities en opnamen zullen worden gebruikt ter ondersteuning van de analyse van de verzamelde gegevens.

Ik geef toestemming voor het gebruik van foto's en/of video-opnamen van mijn deelname: (kruis aan wat voor u van toepassing is)

- waarin ik herkenbaar ben in publicaties en presentaties over het project.
- waarin ik niet herkenbaar ben in publicaties en presentaties over het project.
- alleen voor data-analyse en niet voor publicaties en presentaties over het project..

Ik geef toestemming om de gegevens maximaal 5 jaar na afronding van dit onderzoek op te slaan en te gebruiken voor educatieve en onderzoeksdoeleinden.

Ik erken dat er geen financiële vergoeding wordt verstrekt voor mijn deelname aan dit onderzoek.

Met mijn handtekening erken ik dat ik de verstrekte informatie over het onderzoek heb gelezen en de aard van mijn deelname begrijp. Ik begrijp dat ik vrij ben om op elk moment mijn deelname aan het onderzoek te stoppen. Ik begrijp dat ik niet verplicht ben vragen te beantwoorden die ik liever niet beantwoord en dat ik dit kan aangeven aan het onderzoeksteam.

Ik ontvang een kopie van dit toestemmingsformulier

Participant ID:

Achternaam

Voornaam

___ / ___ / 2026
Datum (dd/mm/yyyy)

Handtekening

User experience of an infrared therapy device

This research is conducted as part of the MSc study Industrial Design Engineering at TU Delft.

Student: Koen van der Park

Contact information: 06 57959822 – k.vanderpark@student.tudelft.nl

My graduation project revolves around the redesign of the Sunshower: an infrared and UV therapy device that is used in the shower. The redesign is based on using LEDs as the source of infrared light instead of the halogen lamps in the current design.

To validate the cognitive experience of the user, the use of the prototype will be simulated in the normal use context. This model will look, feel and sound like the intended design. This means that the size and materials of the outside of the device will be as the design details. However, due to ethical implications, the prototype will not actually emit any infrared radiation. The red glow that is normally emitted by the low wavelength infrared will be imitated by normal red LEDs.

To research how the new design is perceived, the participant will mimic their normal shower routine with the Sunshower. During **no** moment in this research, the participant will be asked to undress or actually shower. These actions are to be simply imitated while the participant narrates their habits. These habits include turning on the shower and Sunshower, undressing, having a shower and drying off.

Informed consent participant

I participate in this research voluntarily.

I acknowledge that I received sufficient information and explanation about the research and that all my questions have been answered satisfactorily. I was given sufficient time to consent my participation. I can ask questions for further clarification at any moment during the research.

I am aware that this research consists of the following activities:

1. Filling out a questionnaire on my mental and physical state before the session
2. Simulation of the normal showering routine and use of the redesigned LED Sunshower.
3. Filling out a questionnaire on my general experience with the product and my mental and physical state after the sessions

I am aware that data will be collected before and after the research, such as notes, pictures and video recordings. I give permission for collecting this data and for making notes, pictures and video recordings before and after the research. Data will be processed and analysed anonymously (without your name or other identifiable information). The data will only be accessible to the research team and their TU Delft supervisors.

The notes and recordings will be used to support analysis of the collected data.

I give permission for using photos and/or video recordings of my participation:

(select what applies for you)

- in which I am recognisable in publications and presentations about the project.
- in which I am not recognisable in publications and presentations about the project.
- for data analysis only and not for publications and presentations about the project.

I give permission to store the data for a maximum of 5 years after completion of this research and using it for educational and research purposes.

I acknowledge that no financial compensation will be provided for my participation in this research.

With my signature I acknowledge that I have read the provided information about the research and understand the nature of my participation. I understand that I am free to withdraw and stop participation in the research at any given time. I understand that I am not obliged to answer questions which I prefer not to answer and I can indicate this to the research team.

I will receive a copy of this consent form.

Participant ID:

Last name

First name

___ / ___ / 2026
Date (dd/mm/yyyy)

Signature

An LED-based redesign of an infrared therapy device

This research is conducted as part of the MSc study Industrial Design Engineering at TU Delft.

Student: Koen van der Park

Contact information: 06 57959822 – k.vanderpark@student.tudelft.nl

My graduation project revolves around the redesign of the Sunshower: an infrared therapy device that is used in the shower. The redesign is based on using LEDs as the source of infrared light instead of the halogen lamps in the current design.

The goal of this session is to test the redesign and compare it to the current Sunshower. During parts of this session, I might ask you to simulate some steps of your Sunshower routine and narrate what you are doing. You will not be asked to undress or actually turn on the shower during this research. The light shining from the prototype is not invasive and is not capable of causing any harm.

Before, during and after the session, I will ask you some questions about parts of your routine and the interaction with the device. With your consent, I will take photos and videos during the session to record your position and orientation relative to the device.

Informed consent participant

I participate in this research voluntarily.

I acknowledge that I received sufficient information and explanation about the research and that all my questions have been answered satisfactorily. I was given sufficient time to consent my participation. I can ask questions for further clarification at any moment during the research.

I am aware that this research consists of the following activities:

1. Answering some questions regarding your background and your typical Sunshower routine.
2. Simulating the normal showering routine and use of the redesigned LED Sunshower.
3. Answering questions on the interaction with the product.

I am aware that data will be collected before and after the research, such as notes, pictures and video recordings. I give permission for collecting this data and for making notes, pictures and video recordings before and after the research. Data will be processed and analysed anonymously (without your name or other identifiable information). The data will only be accessible to the research team and their TU Delft supervisors.

The notes and recordings will be used to support analysis of the collected data.

I give permission for using photos and/or video recordings of my participation:

(select what applies for you)

- in which I am recognisable in publications and presentations about the project.
- in which I am not recognisable in publications and presentations about the project.
- for data analysis only and not for publications and presentations about the project.

I give permission to store the data for a maximum of 5 years after completion of this research and using it for educational and research purposes.

I acknowledge that no financial compensation will be provided for my participation in this research.

With my signature I acknowledge that I have read the provided information about the research and understand the nature of my participation. I understand that I am free to withdraw and stop participation in the research at any given time. I understand that I am not obliged to answer questions which I prefer not to answer and I can indicate this to the research team.

I will receive a copy of this consent form.

Participant ID:

Last name

First name

___ / ___ / 2026
Date (dd/mm/yyyy)

Signature

Een herontwerp van een infrarood therapie apparaat op basis van LED

This research is conducted as part of the MSc study Industrial Design Engineering at TU Delft.

Student: Koen van der Park

Contact information: 06 57959822 – k.vanderpark@student.tudelft.nl

Mijn afstudeerproject draait om het herontwerp van de Sunshower: een infraroodtherapie-apparaat dat onder de douche wordt gebruikt. Het herontwerp is gebaseerd op het gebruik van LED's als bron van infrarood licht in plaats van de halogeenlampen in het huidige ontwerp.

Het doel van deze sessie is om het herontwerp te testen en te vergelijken met de huidige Sunshower. Tijdens delen van deze sessie kan ik je vragen om enkele stappen van je Sunshower-routine te simuleren en te vertellen wat je doet. Je wordt niet gevraagd om je uit te kleden of daadwerkelijk de douche aan te zetten tijdens dit onderzoek. Het licht dat van het prototype komt is niet invasief en kan geen schade veroorzaken.

Voorafgaand aan, tijdens en na de sessie zal ik je enkele vragen stellen over onderdelen van je routine en de interactie met het apparaat. Met jouw toestemming zal ik tijdens de sessie foto's en video's maken om je positie en oriëntatie ten opzichte van het apparaat vast te leggen.

Informed consent deelnemer

Ik neem vrijwillig deel aan dit onderzoek.

Ik erken dat ik voldoende informatie en uitleg heb ontvangen over het onderzoek en dat al mijn vragen naar tevredenheid zijn beantwoord. Ik heb voldoende tijd gekregen om in te stemmen met mijn deelname. Ik kan op ieder moment tijdens het onderzoek vragen stellen voor verdere toelichting.

Ik ben mij ervan bewust dat dit onderzoek uit de volgende activiteiten bestaat:

1. Het beantwoorden van enkele vragen over uw achtergrond en uw typische Sunshower-routine.
2. Het simuleren van de normale douche-routine en het gebruik van de herontworpen LED-Sunshower.
3. Het beantwoorden van vragen over de interactie met het product.

Ik ben mij ervan bewust dat er voor en na het onderzoek gegevens worden verzameld, zoals notities, foto's en video-opnamen. Ik geef toestemming voor het verzamelen van deze gegevens en voor het maken van notities, foto's en video-opnamen voor en na het onderzoek. De gegevens worden anoniem (zonder uw naam of andere identificeerbare informatie) verwerkt en geanalyseerd. De gegevens zijn alleen toegankelijk voor het onderzoeksteam en hun begeleiders van de TU Delft.

De notities en opnamen zullen worden gebruikt ter ondersteuning van de analyse van de verzamelde gegevens.

I give permission for using photos and/or video recordings of my participation:

(select what applies for you)

- in which I am recognisable in publications and presentations about the project.
- in which I am not recognisable in publications and presentations about the project.
- for data analysis only and not for publications and presentations about the project.

Ik geef toestemming om de gegevens maximaal 5 jaar na afronding van dit onderzoek op te slaan en te gebruiken voor educatieve en onderzoeksdoeleinden.

Ik erken dat er geen financiële vergoeding wordt verstrekt voor mijn deelname aan dit onderzoek.

Met mijn handtekening erken ik dat ik de verstrekte informatie over het onderzoek heb gelezen en de aard van mijn deelname begrijp. Ik begrijp dat ik vrij ben om op elk moment mijn deelname aan het onderzoek te stoppen. Ik begrijp dat ik niet verplicht ben vragen te beantwoorden die ik liever niet beantwoord en dat ik dit kan aangeven aan het onderzoeksteam.

Ik ontvang een kopie van dit toestemmingsformulier

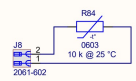
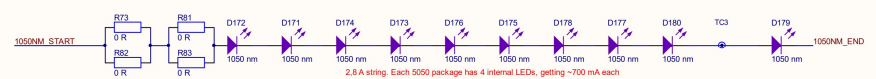
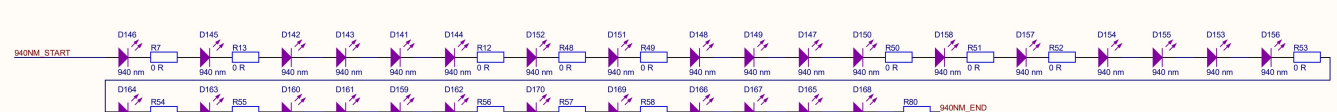
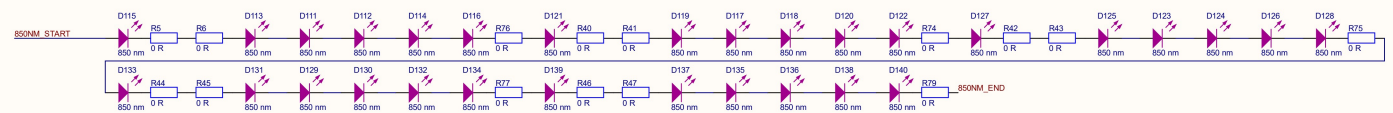
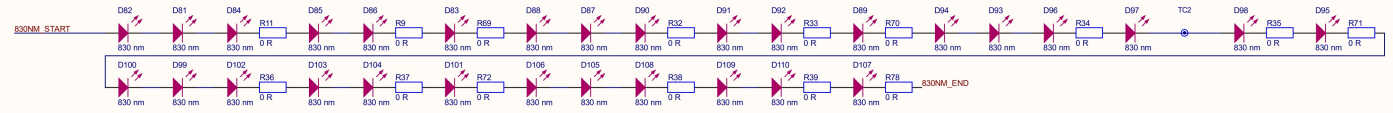
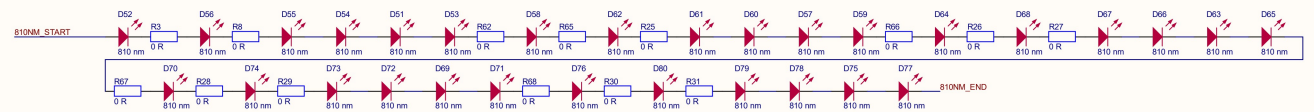
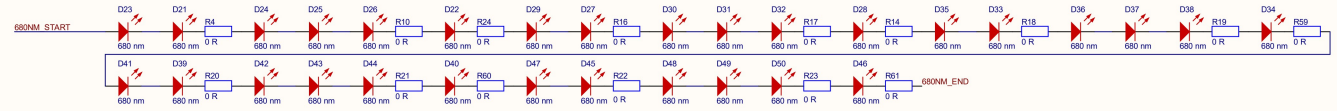
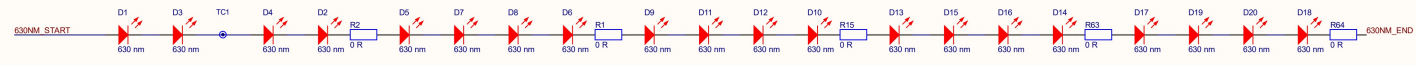
Participant ID:

Achternaam

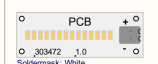
Voornaam

___ / ___ / 2026
Datum (dd/mm/yyyy)

Handtekening



All resistors are 2512, 5%, 1W, 200V unless otherwise noted



PCB
 303472 1.0
 Soldermask: White
 Dimension: (H925mm x W350mm x T1) 6mm
 Core thickness: 1.5mm Aluminium 2.0 W/m-k
 Finished copper thickness: 35um (1 Oz)
 Plating finish: Lead free HASL



Serial Number Label
 Label 6.35 x 19.05mm
 900008



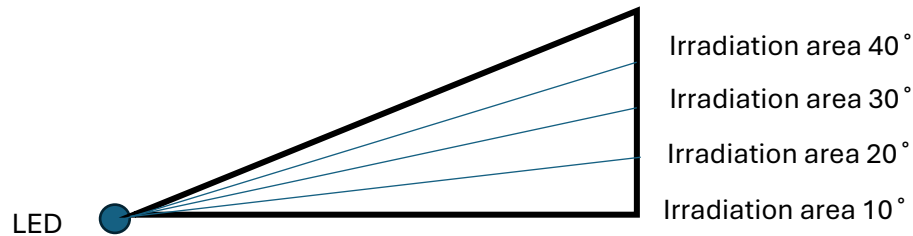
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Update	1	2	3	4	5	6	7	8	9	10
Date										
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Document Name	Sunshower_925x350x1.6mm_1L_MCPbC.SchDoc						MdW	Status	Ready4Proto	
Variation Nr + Name	353477[No Variations]						Layout	MdW	Date	Rev. 1.0
Customer Nr + Name	Sunshower						Checked	Date		

Appendix H: Calculation irradiation

To calculate the irradiation that would come out of an LED array, a calculator model can be set up. Excel was used as a tool to model this calculation and make a visual representation of it. The first step is to take the total optical output of the LED and see how it is divided over the angle of its output.

From the datasheet of this 850 nm SMD LED from LUMIXTAR, it can be derived that the total radiant power is 600 mW. In the viewing angle curve, we can find how this radiant power is divided over the angles.

In this calculation, the distance to calculate the irradiation at is 30 cm. In the figure below, a schematic visual is shown of the side profile of this situation. Using the Pythagorean theory, the surface that each angle ray would reach over 30 cm can be determined. Dividing the total power in that angle by the surface area leads to an approximation of the irradiance that the LED has in that area.



Angle (*)	Radiant percentage	Total radiant power (mW)	Irradiation (mW/cm ²)
0	100	136,9863014	
10	99	135,6164384	1,550494737
20	88	120,5479452	0,446818026
30	60	82,19178082	0,178494639
40	18	24,65753425	0,050963884
50	0	0	0,006088355
60	0	0	0
70	0	0	0
80	0	0	0
90	0	0	0

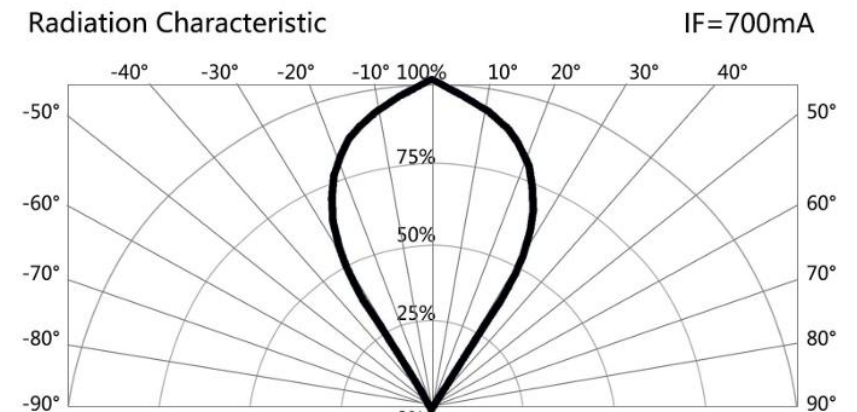
3. Absolute Maximum Rating @ Ta=25° C

Parameter	Symbol	Maximum Rating	Unit
Continuous Forward Current	IF	700	mA
Peak Forward Current (1/10 Duty Cycle, 0.1ms Pulse Width)	IFp	1000	mA
Reverse Voltage	VR	5	V
Power Dissipation	PD	3	W
Electrostatic Discharge	ESD	1000	V
Operating Temperature Range	TOPR	-25°C to +60°C	
Storage Temperature Range	TSTG	-35°C to +80°C	
Lead Soldering Temperature	TSOL	260°C	

4. Optical Character @ Ta=25° C

Parameter	Symbol	Color	Min.	Typ.	Max.	Unit	Test Condition
Forward Voltage	VF	IR	3.0	3.2	3.4	V	IF=700mA
Radiant Power	PO	IR	500	600	700	mW	IF=700mA
Peak Wavelength	WIP	IR	845	847	850	nm	IF=700mA
Reverse Current	IR		0		10	µA	VR=5V
Viewing Angle	2θ1/2				60	deg	IF=700mA
Recommend Forward Current	IF(rec)	IR			700	mA	

7. Viewing Angle Curves



Appendix I: User test results

Participant ID	Age group	Gender	Sunshower Experience	First impressions	Power button experience	Light experience	Feeling	Distance feedback	Movement	Overige
1	20-25									
2	25-30									
3	20-25									
4	25-30			Strak ontwerp, mooi plat tegen de muur, mooie plaatsing door hoogte en in het midden te hangen, mooi op ooghoogte. Is een mooi geheel hoe de onderdelen op elkaar aansluiten. neemt niet te veel ruimte in. Verwacht infrarood en dat je eventueel met een app kan verbinden of je gegevens/data kan checken.	Knop aan de zijkant of recht op de voorkant. Bovenkant zou onhandig zijn met water en voor kleine mensen die het niet kunnen zien.	"Zo, ohja, wat een licht" vind het licht niet zo fel, de sunshower is feller. lichtbeeld is bijzonder, puntjes in het licht storen niet. het licht voelt high-tech en het voelt alsof het werkt, niet oogverblindend. het licht geeft een beetje een sauna vibe, rode kleur geeft sowieso een ontspannen uitstraling	Voelt niks, geen warmte. Voelt niet vervelend om dichtbij te staan. je ziet dat het werkt	Piepje geeft het idee alsof er een error is in het apparaat. Feedback is wel fijn, hierdoor weet je dat het echt nut heeft omdat de afstand uitmaakt. handleiding zou wel fijn zijn zodat je weet wat het betekent als het knippert. Observatie: doet wel haar best om op de juiste afstand te staan, is geïnteresseerd.	Geen verschil in beweging, misschien verander ik wel hoe ik beweeg omdat ik graag goed het licht op me krijg, zodat ik er goed voor sta	Doet ogen veel dicht en draait rond. Check om de zoveel tijd of afstand nog juist is
5	20-25			Lekker plat, neemt weinig ruimte in beslag. Wel ophangen. Het heeft een beetje een ipad vibe door het zwarte scherm.	Vind aanknop snel, zou de knop eventueel aan de zijkant willen zien. Het figuur is duidelijk	"Oeh dat is fel" observatie: schrikt een klein beetje als het aangaat. Kleur van het licht wel mooi en het hult de douche in een hele experience, hierdoor weet je dat het werkt. Doet wel een klein beetje aan bordeel vibe denken, maar is ook wel weer leuk	"vind het jammer dat ik niks voel"	De afstand voelt automatisch in het midden van de douche, het spreekt redelijk voor zichzelf, observatie: besteed weinig aandacht aan de feedback terwijl het knippert, vind de piepjes overbodig en onhandig voor slechthorenden	Het apparaat hangt niet in de weg, is erg plat en dun, kan gewoon alle handelingen uitvoeren zonder last te hebben van het model.	
6	30-35			Heel sleek, een strak en sleek ontwerp. Ziet er erg dun uit, heel erg plat. het doet een beetje aan een tv denken. Het is net een soort ipad waar ik straks spelletjes op kan gaan spelen. Het apparaat is stiller dan ze had verwacht	Knop verwacht ze op ooghoogte midden op het scherm, Het figuurtje is duidelijk "iedereen snapt dit plaatje toch"	Ze had geen puntjes in het licht verwacht maar meer een groot vlak rood, maar dit stoort niet. het licht is wel fel, maar niet te fel. door de puntjes voelt het nice en hightech	Voelt geen warmte en heeft daardoor wel het gevoel dat het minder doet	Let erg op of ze de goede afstand heeft. Piepjes geven het idee dat ze iets fout doet, het knippen voelt als een subtiele hint. Ze houdt wel graag haar ogen dicht maar vind het niet erg om af en toe te kijken of ze nog goed staat	Hangt wel af van hoe groot douche is of je er iets van merkt. Heeft zelf een kleine douche en verwacht dat het daar wel krap wordt. In deze douche stoort het niet.	
7	25-30			Hij is niet dik, breed genoeg dat je best wat speling hebt	Vind aanknop direct, weet hem goed in te drukken. Locatie en vorm van knop zijn erg duidelijk	Ik vind het licht niet onaangenaam, wel feller dan verwacht, niet naar om in te kijken of gewoon lekker je ogen dichtdoen, de stipjes zijn niet heel gek, weet niet of ik het heel mooi vind, het stoort me niet, fijn dat je op andere muren ook ziet dat het werkt	Voelt niks, maar het licht draagt wel bij aan dat je denkt dat het iets doet, je merkt nu wel dat hij niet aanstaat maar als je onder een warme douche staat mis je dat niet(warmte)	Gaat zelf automatisch redelijk dichtbij staan. Feedback is erg fijn, zo weet je dat het niet gevaarlijk is en dat het nuttig is wat het apparaat doet. Het knippen is duidelijk	Kan lekker haartjes wassen en rondbewegen zonder het apparaat te raken.	
8	30-35			Breed apparaat, door kleuren en rondingen doet denken aan big hero 6 (film karakter cartoon rond zacht en wit), hierdoor lijkt het een vriendelijk apparaat. vind het zwarte vlak wel erg opvallend en niet per se mooi, meer kleuren om uit te kiezen zou beter zijn.	Vind knop in een keer en zou ook geen andere plek verwachten dan dezelfde als bij de Sunshower. Het logo is duidelijk en geeft direct het idee waar je hem aan moet zetten	Het licht voelt niet in evenwicht, ze zijn niet helemaal symmetrisch (zijn ze in principe wel), het licht is erg fel en voelt misschien zelfs schadelijk. de kleur van het licht is wel gezellig, oogt warm. de bolletjes storen niet, maar staan wel te ver uit elkaar	Voelt niet echt wat. Later in de sessie begint ze toch wat te voelen qua warmte	Feedback door knippen is duidelijk en genoeg. Heeft voornamelijk ogen dicht en checkt om de 30 seconden of ze nog goed staat, is wel duidelijk bezig met de goede afstand en houding voor het apparaat, Piepjes vind ze ook duidelijk, dan hoor je het ook als je je ogen dicht hebt.	Heeft genoeg ruimte, doet alsof ze haren wast met handen in haar en draait rondjes, raakt het model neit	Is duidelijk constant bezig met goede houding en afstand en vind het prima om hier mee bezig te zijn
9	35-40			Iphone achtig -> straalt luxe en modern uit. Verwacht infrarood en UV de donkere glasplaat geeft een luxe gevoel, en het is fijn dat je er weinig doorheen ziet, dat maakt het mooi afgewerkt en	Vind aanknop direct -> associeert het met een sunshower knop, duurt wel lang voordat hij uiteindelijk aangaat (duurt wat langer door technisch niveau prototype)	Puntjes in het licht niet zo mooi, kleur van het licht wel mooi, en effect in douche is mooi. Licht op muur en in reflectie van metalen doucheonderdelen maakt het een hele experience. Wellness gevoel door het complete licht. Voelt zich omgeven en 'geknuffeld' door het licht.	Voelt geen warmte van het licht, Krijgt wel een wellness gevoel alsof hij is omgeven een omarmd wordt door het licht	Lijkt op de goede afstand te blijven staan uit intuïtie en merkt op dat gewoon normaal onder de douchekelep staan een goede maatstaf is die automatisch voelt. Het knippen is opvallend genoeg "na 2-3 keer kijken weet je ook wel wat de goede afstand ongeveer is, dit hoeft je niet continu te checken". Door piepjes voel je je een beetje gecorrigeerd	Wordt in de beweging niet beperkt-> draait rondjes met ellebogen uitgestoken en raakt niks. het apparaat is niet obstructief. Bijzondere opmerking: de warmte helpt afstand houden.	Zou graag het licht meer als een egaler geheel zien. Dit zou namelijk zorgen voor een professioneler en meer chique gevoel en minder prototype achtig.

10	55-60			<p>Super strak, gave uitstraling, erg leuk. Het apparaat ziet er slank en strak uit, niet te groot en mooi dun,</p>	<p>Zoekt de aanknop eerder op de zijkant op ooghoogte. Observatie: voelt rond de zijkant en bovenkant aan de rand van het prototype</p>	<p>Vind licht erg fel, vooral het contrast tussen aan en uit, schrikt van het aanspringen van het licht en zou graag meer waarschuwing hiervoor zien. Het licht blijft vervelend fel, stelt voor dat het licht</p>	<p>Zegt een beetje warmte te voelen -> voelt aan voorkant apparaat : " hij wordt wel een beetje warm he?" . Vind het een bijzonder gevoel, je voelt niks, maar er is toch iets</p>	<p>Afstand voelt intuïtief door afstand tot de waterstraal. Vind de feedback van de knipperende display wel wat verwarrend maar met een handleiding wordt het wel duidelijk. Raakt van piepjes feedback meteen in de war en</p>	<p>Voelt zich niet beperkt door het apparaat. Observatie: stoot tijdens rondraaien wel even tegen prototype aan</p>	
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Appendix J: List of requirements

No.	Category	Requirement / Wish	Type	Related Standard / Regulation	No.
1	Performance	The product shall emit infrared radiation at the correct wavelengths and irradiance levels to achieve the intended physiological benefits.	Requirement	IEC 62471, ICNIRP, MDR	1
2	Performance	The emitted radiation field shall cover the user from approximately knee height to chin height of an average adult user.	Requirement	MDR	2
3	Performance	The product shall deliver the intended therapeutic dose within a single shower session.	Requirement	ICNIRP, MDR	3
4	Performance	The product shall provide intuitive and user-friendly operation.	Requirement	IEC 60335	4
5	Environmental Resistance	The enclosure shall achieve a minimum protection rating of IPX5.	Requirement	IEC 60529	5
6	Environmental Resistance	The product shall withstand prolonged exposure to high	Requirement	IEC 60335, IEC 60529	6

		humidity levels in bathroom environments.			
7	Environmental Resistance	The product materials and surfaces shall resist limescale accumulation.	Wish	Product quality	7
8	Environmental Resistance	The product shall withstand incidental impacts and accidental knocks during normal use.	Requirement	IEC 60335	8
9	Environmental Resistance	The product surfaces shall resist soap residue accumulation and degradation.	Wish	Product quality	9
10	Product Lifetime	The product shall remain functional for a minimum service life of five years under daily usage conditions.	Requirement	IEC 60335	10
11	Maintenance	Defective light sources shall be replaceable without replacing the entire product.	Requirement	Sustainability	11
12	Maintenance	Defective light sources shall be diagnosable during servicing.	Requirement	Maintainability	12
13	Cost	The target production cost shall not exceed €400 per unit.	Requirement	Business target	13

14	Cost	The target retail price shall be approximately €1600.	Wish	Business target	14
15	Cost	The product shall support a target profit margin of approximately 60%.	Wish	Business target	15
16	Logistics	Multiple packaged products shall fit efficiently on standard Europallets.	Requirement	Logistics	16
17	Packaging	Packaging shall protect the product and components during transportation.	Requirement	Logistics	17
18	Packaging	Packaging shall protect the enclosure, electronics, and window surfaces against dents and transport damage.	Requirement	Logistics	18
19	Manufacturing	The product shall be suitable for serial production.	Requirement	Manufacturing	19
20	Manufacturing	Components should preferably be manufactured within Europe.	Wish	Sustainability	20
21	Manufacturing	Product assembly shall remain compatible with production at social enterprise	Wish	Manufacturing strategy	21

		facilities such as Confed.			
22	Dimensions and Weight	The product dimensions shall fit within standard residential shower environments.	Requirement	User environment	22
23	Dimensions and Weight	The total product weight shall not exceed 23 kg.	Requirement	Installation safety	23
24	Dimensions and Weight	The product dimensions shall not exceed those of the current Sunshower Medium model.	Requirement	Product strategy	24
25	Dimensions and Weight	The product depth shall not exceed 6 cm.	Requirement	Product integration	25
26	Dimensions and Weight	Product packaging dimensions shall remain compatible with Europallet transport.	Requirement	Logistics	26
27	Aesthetics	The product shall visually appeal to the intended target group.	Wish	Industrial design	27
28	Aesthetics	The product design language shall align with the Sunshower brand identity.	Requirement	Branding	28
29	Aesthetics	The product shall integrate aesthetically into a wide range of bathroom interiors.	Wish	Industrial design	29

30	Materials	All applied materials shall be non-toxic and compliant with RoHS requirements.	Requirement	RoHS, MDR	30
31	Materials	Materials with antibacterial properties should be preferred where feasible.	Wish	Hygiene	31
32	Materials	Sustainable and recyclable materials should be prioritized where feasible.	Wish	Sustainability	32
33	Materials	Materials shall withstand prolonged exposure to humidity.	Requirement	IEC 60335	33
34	Materials	Materials shall withstand temperatures generated by the electronic and thermal components.	Requirement	IEC 60335	34
35	Product Strategy	The product platform should remain commercially viable until at least 2040.	Wish	Business strategy	35
36	Compliance	The product shall comply with all applicable NEN, IEC, MDR, ICNIRP, and RoHS requirements.	Requirement	All listed standards	36
37	Electrical Safety	Accessible conductive parts shall not create hazardous touch	Requirement	NEN 1010, IEC 60335	37

		voltages in fault conditions.			
38	Electrical Safety	The product shall be permanently installed and connected to the mains supply.	Requirement	NEN 1010	38
39	Electrical Safety	The product shall be certified for installation and use within bathroom Zone 1 environments.	Requirement	NEN 1010	39
40	Electrical Safety	User controls located within Zone 1 shall use SELV circuits or be internally isolated.	Requirement	NEN 1010, IEC 60335	40
41	Electrical Safety	Power cables shall be protected using cable ducts or grounded metal enclosures.	Requirement	NEN 1010	41
42	Electrical Safety	The installation shall be protected by a residual-current device (RCD) with a maximum tripping current of 30 mA.	Requirement	NEN 1010	42
43	Thermal Safety	User interface surfaces shall not exceed a temperature rise of 45 K above ambient temperature.	Requirement	IEC 60335	43
44	Ergonomics	Users shall receive clear indication when the product is active.	Requirement	IEC 60335	44

45	Ergonomics	The user interface shall provide feedback regarding session progress and remaining exposure time.	Requirement	MDR	45
46	Ergonomics	Product controls shall be intuitive and easy to understand.	Requirement	Usability	46
47	Ergonomics	Users with reduced mobility or strength shall be capable of operating the product.	Requirement	Inclusive design	47
48	Ergonomics	The product shall provide users with a perception of safety and comfort during use.	Wish	User experience	48
49	Ergonomics	Visible light emitted by the product shall not cause discomfort or glare.	Requirement	IEC 62471	49
50	Ergonomics	User-accessible surfaces shall remain safe to touch during operation.	Requirement	IEC 60335	50
51	Ergonomics	Product noise levels shall remain within comfortable limits for bathroom use.	Wish	User experience	51
52	Ergonomics	Product operation shall require minimal physical effort.	Requirement	Inclusive design	52

53	Reliability	Electrical components shall be protected against water ingress during normal operation and fault conditions.	Requirement	IEC 60529, IEC 60335	53
54	Reliability	Thermal protection systems shall automatically deactivate the product during overheating conditions.	Requirement	IEC 60335	54
55	Reliability	The product shall continue operating safely in the event of partial LED failure.	Requirement	Functional safety	55
56	Storage	Components shall withstand at least 12 months of storage in non-climate-controlled warehouse conditions.	Requirement	Logistics	56
57	Verification and Validation	Irradiance output shall be tested before shipment from the production facility.	Requirement	IEC 62471, MDR	57
58	Verification and Validation	Compliance with relevant international standards shall be verified by an accredited inspection or certification body.	Requirement	MDR, CE	58
59	Verification and Validation	IP protection ratings shall be validated	Requirement	IEC 60529	59

		through standardized testing procedures.			
60	Verification and Validation	Electromagnetic emissions and immunity shall be tested according to EMC standards.	Requirement	IEC 61000	60
61	Verification and Validation	Thermal cycling tests shall be conducted on mechanical parts and electrical connections.	Requirement	Reliability	61
62	Verification and Validation	LED lifespan testing shall be conducted on the lighting modules.	Requirement	Reliability	62
63	Verification and Validation	Life cycle testing shall be performed on control electronics and interfaces.	Requirement	Reliability	63
64	Verification and Validation	Installation procedures shall be tested and validated.	Requirement	Product liability	64
65	Safety	User-accessible surface temperatures shall not exceed safe contact limits.	Requirement	IEC 60335	65
66	Safety	Infrared exposure to the eyes shall remain below ICNIRP exposure limits.	Requirement	ICNIRP, IEC 62471	66
67	Safety	Infrared exposure to the skin shall remain below ICNIRP exposure limits.	Requirement	ICNIRP, IEC 62471	67

68	Safety	Electrical components shall remain below their maximum rated operating temperatures.	Requirement	IEC 60335	68
69	Safety	Electrical components shall not come into contact with water during operation.	Requirement	IEC 60529	69
70	Safety	The product shall not contain sharp edges or geometries that could cause injury.	Requirement	IEC 60335	70
71	Product Policy	The product positioning shall not directly compete with the Sunshower Round product line.	Wish	Business strategy	71
72	Product Policy	The product shall remain serviceable throughout its operational life.	Requirement	Sustainability	72
73	Sustainability	The product shall consume significantly less energy than the Sunshower Round model.	Requirement	Sustainability	73
74	Medical and Ethical Claims	Only scientifically substantiated medical claims shall be communicated regarding product effects.	Requirement	MDR	74

75	Medical and Ethical Claims	Claimed health benefits shall be supported by validated scientific evidence.	Requirement	MDR	75
76	Product Liability	The product shall include clear instructions, warnings, and documentation regarding safe exposure duration and usage conditions.	Requirement	MDR, IEC 60335	76
77	Product Liability	Burns and electrical shocks shall be prevented through fail-safe mechanisms.	Requirement	IEC 60335	77
78	Product Liability	Installation documentation shall minimize the risk of incorrect mounting or product detachment.	Requirement	Product liability	78
79	Installation	The product should be installable by consumers without specialized tools.	Wish	Usability	79
80	Installation	Installation shall not require major modifications to existing bathrooms.	Requirement	Product integration	80
81	Installation	Installation time should not exceed 30 minutes.	Wish	Usability	81
82	Installation	Components shall be designed to prevent	Requirement	IEC 60335	82

		incorrect assembly or installation.			
83	Installation	Total power consumption shall not exceed 800 W.	Requirement	Energy and installation constraints	83
84	Installation	Installation shall be possible by a single person.	Wish	Usability	84
85	Installation	The product shall be compatible with conventional bathroom wall constructions.	Requirement	Product integration	85
86	Circularity	Permanent inseparable connections should be minimized to facilitate recycling and repair.	Wish	Sustainability	86
87	Circularity	Individual LEDs shall be testable and replaceable.	Requirement	Repairability	87