ISL 453E- Engineering Design 2

CRN: 12588

Interim Report

Smart Air Humidifier

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1. Introduction

This project focuses on the design of an innovative 2-in-1 device that combines dehumidification and air purification, enhanced with artificial intelligence and UV-LED technology, and establishment of the production facility for our product. The objective is to address increasing consumer demand for health-focused and energy-efficient solutions. As part of this initiative, extensive groundwork has been undertaken, including sector analysis, facility layout plans, time studies, manufacturing process and process design. The factory design process incorporates advanced methodologies such as time study and flow analysis to optimize efficiency and minimize production costs. Additionally, critical choices regarding inventory management such as in-house manufacturing versus outsourcing decisions have been conducted with the assistance of related frameworks. This multi-disciplinary approach aims to ensure a sustainable, competitive, and technologically advanced product launch in both domestic and international markets.

2. Sector Analysis

2.1 Worldwide Market

The market for dehumidifiers and air cleaners is expanding significantly on a global scale because of rising indoor air quality concerns and health consciousness. Especially in the Asia-Pacific Region, since the rapid urbanization and industrial activity, there is growing demand. The global dehumidifier market, for instance, is expected to grow from its 2023 valuation of about USD 3.5 billion to USD 7.1 billion by 2032 (DataIntelo, 2024). Additionally, technological advancements such as in the Internet of Things (IoT) are boosting demand for smart air purifiers and dehumidifiers.(Kings Research, 2023)

2.2 Domestic Market

Urbanization, industry, and climate change have increased interest in indoor air quality solutions in Turkey. High air pollution levels in major cities such as Istanbul are pushing up the demand for air purifiers and dehumidifiers. But since imported goods dominate the market, there are chances for domestic producers to fill this gap.

2.3 Swot Analysis

Strengths:

1. Growing Health Awareness: Especially consumers that are concerned about health prioritizing indoor air quality, driving demand for such devices.
2. Dual Functionality and Efficiency: The combination of air purification and dehumidification in a single device offers cost and space-saving benefits for consumers.
3. Technological Innovations: AI integration enhances product appeal and competitive advantage.

Weaknesses:

1. High Costs: Advanced features such as AI integration may limit affordability for certain customer segments.
2. Energy Consumption: The energy usage of these devices could affect purchasing decisions.
3. Supplier Dependence: Purchasing most of the parts for production increases the dependence of suppliers. Thus, affecting the decision making process poorly.

Opportunities:

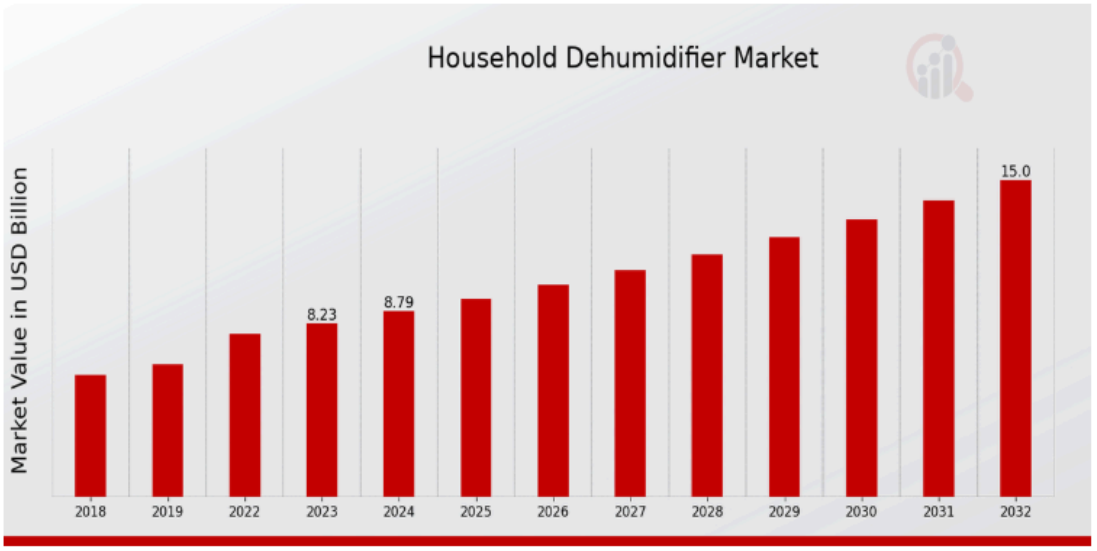
1. Market Growth: Expanding global and local markets offer opportunities for new entrants.
2. Advantage of Local Manufacturing: Boosting local production in Turkey can reduce reliance on imports and improve competitiveness.
3. Diversification of Target Markets: Aside from residential use, rising demand in offices, hotels, and industrial facilities offers significant growth opportunities.

Threats:

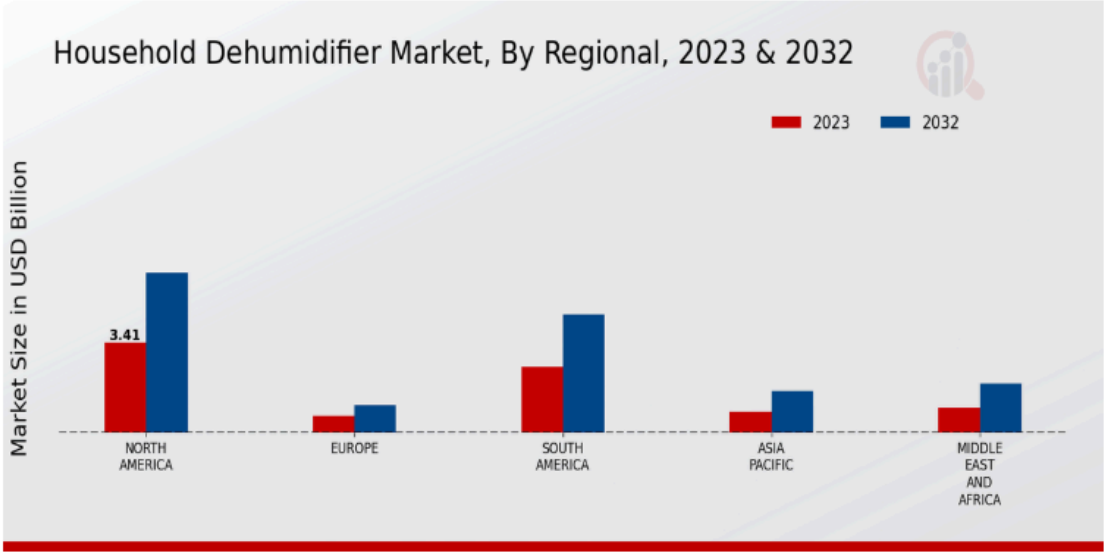
1. Intense Competition: Established global brands dominate the market, posing challenges for newcomers.
2. Economic Fluctuations: Exchange rate volatility and economic uncertainties could impact costs and demand.

2.4 Market Projections

According to Research Reports, the Household Dehumidifier Market Size was estimated at 7.7 Billion $ in 2022 and expected to reach a valuation of 8.23 Billion $ in 2023 to 15.0 Billion $ by 2032. The Household Dehumidifier Market CAGR (growth rate) is expected to be around 6.9% during the forecast period which is 2024 - 2032.



North America is held to dominate the household dehumidifier market throughout the forecast period, owing to the high prevalence of allergies and asthma, as well as favorable climatic conditions. The Residential Dehumidifier Market is experiencing the highest compound annual growth rate (CAGR) in the Asia Pacific region, driven by factors such as escalating urbanization, increasing disposable incomes, and heightened awareness regarding indoor air quality. (Raje, K.)



Middle East and Africa Residential Dehumidifier Compound Annual Growth Rate (CAGR) for 2024 to 2031 is 7.7% and for Turkey CAGR is for 2024 to 2031 is 7.2% according to Residential Dehumidifier Market Report 2024.

2.5 Preliminary Production Decisions

Given the anticipated market growth and existing competition, initiating production with a batch of 5,000 units is a prudent preliminary decision. This volume allows for effective market penetration and brand establishment while also considering production costs and inventory risks. Scaling up production can be considered based on market response and demand trends.

Establishing a pull production system appears to be the most suitable option for the first stage, given that such products are not yet well-known in Turkey. This strategy reduces the dangers of overproduction and excess inventory, two critical issues for a new manufacturer venturing into a new market. Expenses can be cut and better adjustment can be made according to changing customer preferences by producing in response to actual demand. However, possible supply chain delays could be problematic due to the dependence on outside vendors. Thus, a hybrid system might provide the best mix between cost control and operational flexibility, with essential components being pre-stocked (push) and final assembly being pulled based on demand.

3. Company Intro

We are a forward-thinking company specializing in the design and production of innovative dehumidifiers and air purifiers that cater to the growing need for healthier indoor environments. Our products combine cutting-edge technologies, including artificial intelligence and UV-LED systems, to deliver exceptional performance in air purification and humidity control. With a focus on

sustainability, energy efficiency, and customer satisfaction, we aim to lead the industry with high-quality solutions designed to meet the diverse needs of residential, commercial, and industrial sectors.

Our commitment to local manufacturing in Turkey not only supports the national economy but also ensures cost-effective, competitive production processes. By embracing advanced manufacturing techniques and staying attuned to market demands, we strive to redefine standards in air quality solutions globally and domestically.

3.1 Vision

To be the leading global provider of smart and sustainable indoor air quality solutions, enhancing lives by delivering healthier and more comfortable environments.

3.2 Mission

Our mission is to create innovative, energy-efficient, and reliable products that improve indoor air quality for all. We are dedicated to leveraging advanced technologies, reducing environmental impact, and offering solutions that cater to the evolving needs of our customers in residential, commercial, and industrial spaces.

3.3 Core Values

- **Innovation:** Continuously advancing our products through cutting-edge technologies like AI and UV-LED systems.
- **Sustainability:** Minimizing environmental impact through energy-efficient designs and eco-conscious manufacturing.
- **Customer Focus:** Prioritizing customer health, satisfaction, and convenience in every product we create.
- **Quality Excellence:** Delivering durable, reliable, and high-performance products that exceed industry standards.
- **Integrity:** Building trust through ethical practices and transparent operations.
- **Local Empowerment:** Supporting local economies by fostering Turkish manufacturing and workforce development.

3.4 Organizational Structure

Our organizational structure reflects a balance between innovation, efficiency, and customer-centric operations:

- **Executive Management:** Oversees strategic direction, innovation, and global market positioning.
- **Research & Development (R&D):** Focused on product innovation, technological advancements, and design optimization.
- **Production & Supply Chain:** Manages manufacturing processes, supplier relationships, and logistics to ensure efficient operations.
- **Sales & Marketing:** Develops brand presence and engages with target markets through effective communication and campaigns.
- **Customer Service:** Dedicated to providing exceptional support, addressing customer inquiries, and ensuring satisfaction.
- **Sustainability & Compliance:** Ensures adherence to environmental regulations and promotes sustainable practices throughout operations.

Our streamlined structure allows us to adapt to market changes swiftly, maintain high-quality standards, and deliver innovative solutions that align with our vision and mission.

4. Product Information

4.1 History

In the early 1950s, people living in hot and humid areas began to show interest in dehumidifiers to make their living spaces more comfortable. Portable home dehumidifiers were introduced during this period. In the 70s and 80s, concerns about energy efficiency led to the development of dehumidifiers with lower energy consumption and more compact designs. Today, dehumidifiers are equipped with advanced sensors and digital control systems. These devices, which are quieter, more efficient and more environmentally friendly, are widely used in homes, offices and industrial areas.

4.2 Product Definition

This high-performance dehumidifier combines cutting-edge technology with a modern design to create an optimal solution for controlling humidity and improving air quality. Equipped with integrated UV LED technology, the device purifies air by eliminating bacteria, allergens, and other airborne pollutants, making it ideal for homes, offices, and other spaces prone to dampness. The

device features smart humidity control that automatically adjusts settings based on the environment, ensuring comfort and energy efficiency. Since the device is mostly designed as a home appliance, it uses thermoelectric Peltier Module to condensate the humidity which is a more compact, silent and suitable technology for limited spaces. Its intuitive control panel allows for easy operation, while the energy-efficient system minimizes power consumption without compromising performance.

4.3 Product Features

UV Air Purification: Built-in UV LEDs eliminate airborne bacteria and allergens.

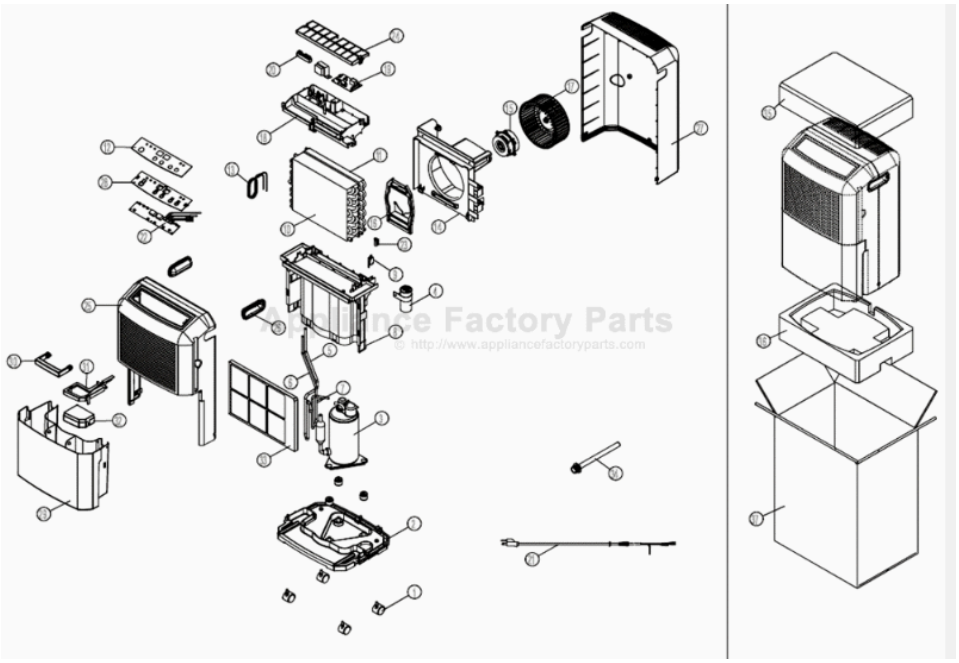
Smart Humidity Control: Automatically maintains desired humidity levels based on environmental conditions.

Energy Efficiency: Optimized operation for minimal energy consumption.

User-Friendly Interface: Intuitive control panel with easy-to-use settings.

4.4 Product Image

4.5 Exploded View of the Product



5. Make or Buy Decisions

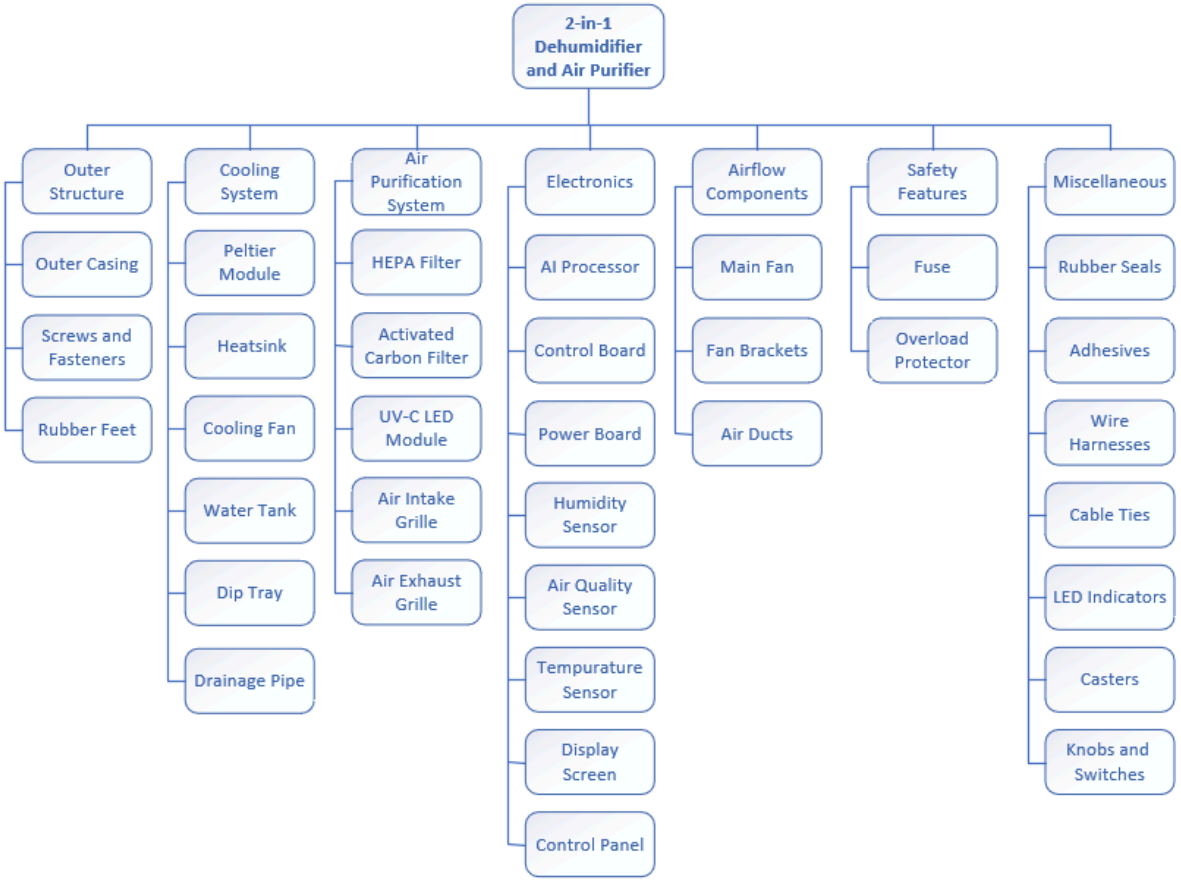
When making or purchasing decisions about raw materials; market availability, manufacturing and procurement costs, production convenience, and accessibility are considered.

Since they are the primary components of the product and are less complicated and more profitable to make, items like outer case, water tank and drip tray, and plastic covers are chosen to be made, while other parts like rubber slip or screws are chosen to be purchased. Additionally, to be able to set control and power board according to our device those parts also will be adjusted.

5.1 Make or Buy Decision Table

Materials			
Part Number	Name	Quantity	M/B
1	Outer Casing	1	Make
2	Screws and Fasteners	20	Buy
3	Rubber Feet	4	Buy
4	Peltier Module	1	Buy
5	Heatsink	1	Buy
6	Cooling Fan	1	Buy
7	Water Tank	1	Make
8	Drip Tray	1	Make
9	HEPA Filter	1	Buy
10	Activated Carbon Filter	1	Buy
11	UV-C LED Module	1	Buy
12	Air Intake Grille	1	Buy
13	Air Exhaust Grille	1	Buy
14	AI Processor	1	Buy
15	Control Board	1	Make
16	Power Board	1	Make
17	Humidity Sensor	1	Buy
18	Air Quality Sensor	1	Buy
19	Temperature Sensor	1	Buy
20	Display Screen	1	Buy
21	Control Panel	1	Make
22	Main Fan	1	Buy
23	Fan Brackets	2	Make
24	Air Ducts	2	Make
25	Fuse	1	Buy
26	Overload Protector	1	Buy
27	Rubber Seals	2	Buy
28	Adhesives	1(Roll)	Buy
29	Wire Harnesses	5	Buy
30	Cable Ties	12	Buy
31	LED Indicators	3	Buy
32	Casters	4	Buy
33	Knobs and Switches	3	Buy

5.3 Product Tree of 2-in-1 Dehumidifier and Air Purifier



6. Plant Location

6.1 Country Selection

In order to determine the most suitable country for establishing our production facility dedicated to manufacturing air humidifiers, we identified four potential alternatives: Turkey, Georgia, Romania, and Poland. Recognizing that selecting the right country is a critical first step due to its strategic importance in reaching target markets and ensuring an efficient supply chain, we decided to begin the site selection process at the country level.

After a comprehensive review of various multi-criteria decision-making techniques, the Analytical Hierarchy Process (AHP) was chosen as the most appropriate method for this stage. AHP provides a structured framework for comparing alternatives across multiple criteria, translating expert judgments into a set of prioritized factors.

Based on thorough market research and the operational requirements of producing air humidifiers, the following criteria were selected to guide the country evaluation:

- LCSK (Labor Cost & Skilled Workforce): Assessing the availability of skilled labor and the cost-effectiveness of the workforce.
- ECR (Exchange & Country Risk): Evaluating the stability of currency exchange rates and the broader economic environment, including potential volatility and financial risks.
- RME (Raw Materials & Energy): Considering the accessibility and stability of raw materials, as well as the reliability and affordability of energy resources.

- ENV (Environmental Considerations): Examining environmental regulations, sustainability measures, and any ecological constraints that may impact the manufacturing process.
- PM (Proximity to Markets): Measuring geographic closeness to key customer bases, minimizing lead times and transportation costs.
- TR (Tax Rates): Reviewing fiscal conditions such as corporate taxation and incentives, which influence overall operational costs.

Criterion Matrices

Labor Cost & Skills	Turkey	Romania	Poland	Georgia
Turkey	1.00	2.00	3.00	2.00
Romania	0.50	1.00	1.50	2.00
Poland	0.33	0.67	1.00	1.50
Georgia	0.50	0.50	0.67	1.00

Environmental Issues	Turkey	Romania	Poland	Georgia
Turkey	1.00	2.00	2.00	1.50
Romania	0.50	1.00	1.50	2.00
Poland	0.50	0.67	1.00	1.50
Georgia	0.67	0.50	0.67	1.00

Proximity to Markets	Turkey	Romania	Poland	Georgia
Turkey	1.00	3.00	2.00	2.00
Romania	0.33	1.00	0.50	2.00
Poland	0.50	2.00	1.00	2.00
Georgia	0.50	0.50	0.50	1.00

Tax Rates	Turkey	Romania	Poland	Georgia
Turkey	1.00	0.83	1.25	0.67
Romania	1.20	1.00	1.40	0.77
Poland	0.80	0.71	1.00	0.50
Georgia	1.50	1.30	2.00	1.00

Normalized Matrices

Labor Cost & Skills	Turkey	Romania	Poland	Georgia
Turkey	0.43	0.48	0.49	0.31
Romania	0.21	0.24	0.24	0.31
Poland	0.14	0.16	0.16	0.23
Georgia	0.21	0.12	0.11	0.15

Exchange Rates & Economic Risk	Turkey	Romania	Poland	Georgia
Turkey	0.20	0.20	0.20	0.20
Romania	0.26	0.27	0.27	0.27
Poland	0.40	0.40	0.40	0.40
Georgia	0.13	0.13	0.13	0.13

Raw Material & Energy Availability	Turkey	Romania	Poland	Georgia
Turkey	0.43	0.46	0.43	0.38
Romania	0.21	0.23	0.26	0.25
Poland	0.21	0.19	0.21	0.25
Georgia	0.14	0.12	0.11	0.13

Environmental Issues	Turkey	Romania	Poland	Georgia
Turkey	0.38	0.48	0.39	0.25
Romania	0.19	0.24	0.29	0.33
Poland	0.19	0.16	0.19	0.25
Georgia	0.25	0.12	0.13	0.17

Proximity to Markets	Turkey	Romania	Poland	Georgia
Turkey	0.43	0.46	0.50	0.29
Romania	0.14	0.15	0.13	0.29
Poland	0.21	0.31	0.25	0.29
Georgia	0.21	0.08	0.13	0.14

Tax Rates	Turkey	Romania	Poland	Georgia
Turkey	0.22	0.22	0.22	0.23
Romania	0.27	0.26	0.25	0.26
Poland	0.18	0.19	0.18	0.17
Georgia	0.33	0.34	0.35	0.34

Criterion Weights	**Local Priorities**
C1 = 0,217	• C1: Turkey(0,426), Romania(0,251), Poland(0,174), Georgia(0,149)
C2 = 0,090	• C2: Poland(0,400), Romania(0,265), Turkey(0,201), Georgia(0,133)
C3 = 0,216	• C3: Turkey(0,423), Romania(0,238), Poland(0,217), Georgia(0,122)
C4 = 0,030	• C4: Turkey(0,373), Romania(0,263), Poland(0,198), Georgia(0,167)
C5 = 0,381	• C5: Turkey(0,419), Poland(0,265), Romania(0,177), Georgia(0,140)
C6 = 0,066	• C6: Georgia(0,342), Romania(0,259), Turkey(0,222), Poland(0,178)

Final Ranking
1. Turkey ≈ 0,386

Final Ranking
2. Poland ≈ 0,239
3. Romania ≈ 0,222
4. Georgia ≈ 0,152

In conclusion. following the AHP analysis, Turkey was identified as the most favorable country for establishing our air humidifier production facility.

6.2 City Selection

Having identified Turkey as our country of choice, the next step involved narrowing down the optimal city in which to establish our air humidifier production facility. Extensive research was conducted to identify prominent industrial hubs in Turkey that host relevant manufacturing activities and offer advantageous economic conditions. In this regard, four cities emerged as strong candidates: Istanbul, Bursa, Tekirdağ, and Manisa.

Each of these cities differs from one another in terms of industrialization, supplier networks, workforce availability, and cost structures. To make a systematic and transparent choice, the TOPSIS multi-criteria decision-making (MCDM) method was selected. By applying TOPSIS, each city was evaluated against a set of carefully chosen criteria that reflect the operational and strategic requirements of the air humidifier production:

- Raw Material Availability: Ensuring a steady flow of essential inputs and well-developed distribution networks.
- Total Workforce & Costs: Accessing a skilled and educated labor force while maintaining cost efficiency.
- Tax Exemptions & Incentives: Leveraging regional policies and incentives that encourage industrial investment.
- Land Costs: Considering real estate expenses, which have a significant impact due to the large scale of the production facility.
- Industrialized Areas & Suppliers: Benefiting from a well-established network of local suppliers and industrial clusters.
- Logistics Advantage: Examining the city's transportation infrastructure, including highways, ports, and airports, to facilitate efficient delivery to target markets.
- Environmental Policies & Restrictions: Evaluating the regulatory landscape to ensure compliance and minimize ecological impact.

Decision Matrix							
Alternatives	RMA	TWC	TEI	LC	IAS	LA	EPR
Manisa	8	7	6	3	7	8	3
Bursa	7	8	7	4	7	7	4
Tekirdağ	6	7	5	2	6	8	5
İstanbul	8	9	8	5	9	9	3

Normalized Matrix							
Alternatives	RMA	TWC	TEI	LC	IAS	LA	EPR
M	0.548	0.449	0.455	0.408	0.478	0.498	0.391
B	0.48	0.513	0.531	0.544	0.478	0.436	0.521
T	0.411	0.449	0.379	0.272	0.409	0.498	0.651
I	0.548	0.577	0.606	0.68	0.614	0.56	0.391

Weighted Normalized Matrix							
Alternatives	RMA	TWC	TEI	LC	IAS	LA	EPR
Manisa	0.078	0.064	0.065	0.058	0.068	0.071	0.056
Bursa	0.069	0.073	0.076	0.078	0.068	0.062	0.074
Tekirdağ	0.059	0.064	0.054	0.039	0.058	0.071	0.093
İstanbul	0.078	0.082	0.087	0.097	0.088	0.08	0.056

A*	0.078	0.082	0.087	0.039	0.088	0.08	0.056
A–	0.059	0.064	0.054	0.097	0.058	0.062	0.093

Alternative	D_i*	D_i-
Manisa	0.0406	0.0596
Bursa	0.0534	0.0386
Tekirdağ	0.0642	0.0587
İstanbul	0.058	0.0661

Closeness Coefficient Values	
Alternative	CC_i
Manisa	**0.595**
Bursa	0.419
Tekirdağ	0.478
İstanbul	0.532

Following the TOPSIS analysis, which evaluated Istanbul, Bursa, Tekirdağ, and Manisa against the selected criteria, Manisa emerged as the most suitable city. Its advantageous combination of raw material availability, industrial networks, and overall economic environment makes it the optimal choice for our air humidifier production facility.

6.3 Site Selection

With Manisa established as the ideal city, the next step involved identifying and evaluating specific site alternatives within this region. To ensure a systematic and objective decision-making process at this more granular level, the ELECTRE multi-criteria decision-making method was employed. ELECTRE allows for a comprehensive comparison of alternatives based on multiple criteria, taking into account both concordance and discordance indices to distinguish between close options.

A set of factors was determined to guide the site selection, each reflecting critical operational and strategic priorities for the air humidifier production facility:

• SC (Site Costs): Evaluating the financial implications of establishing operations at each location, including land acquisition and related expenses.

• APAH (Accessibility to Ports, Airports, and Highways): Assessing the efficiency of inbound and outbound logistics, ensuring the site is well-connected to supply chains and distribution networks.

• PS (Proximity to Suppliers): Considering the distance to key raw material and component suppliers, crucial for timely production and cost control.

• OFD (Opportunities for Further Developments): Identifying potential for future expansions, modifications, or strategic investments that may enhance long-term competitiveness.

• IUA (Infrastructure and Utilities Availability): Confirming that essential services—such as reliable electricity, water, and communication networks—are readily accessible to support stable and efficient operations.

Decision Matrix					
Site/Criteria	SC	APAH	PS	OFD	IUA
Turgutlu OSB	3.5	8.5	8.2	3	8
Akhisar OSB	4	7.8	7.9	3.5	7.5
Manisa OSB	4.5	7.5	7.3	4	7.2
Salihli OSB	5	6.2	6.5	4.5	6

Squares of the Matrix Elements					
Site/Criteria	SC(²)	APAH(²)	PS(²)	OFD(²)	IUA(²)
Turgutlu OSB	12.25	72.25	67.24	9	64
Akhisar OSB	16	60.84	62.41	12.25	56.25
Manisa OSB	20.25	56.25	53.29	16	51.84
Salihli OSB	25	38.44	42.25	20.25	36
Sum	73.5	227.78	225.19	57.5	208.09

Normalized Decision Matrix					
Site/Criteria	SC	APAH	PS	OFD	IUA
Turgutlu OSB	0.408	0.564	0.547	0.396	0.555
Akhisar OSB	0.467	0.517	0.527	0.462	0.52
Manisa OSB	0.525	0.498	0.487	0.528	0.499
Salihli OSB	0.583	0.411	0.433	0.594	0.416

Weighted Normalized Decision Matrix					
Site/Criteria	SC	APAH	PS	OFD	IUA
Turgutlu OSB	0.082	0.141	0.109	0.059	0.111
Akhisar OSB	0.093	0.129	0.105	0.069	0.104
Manisa OSB	0.105	0.125	0.097	0.079	0.1
Salihli OSB	0.117	0.103	0.087	0.089	0.083

Concordance Index Matrix				
	Turgutlu	Akhisar	Manisa	Salihli
Turgutlu OSB	-	1	1	1
Akhisar OSB	0	-	1	1
Manisa OSB	0	0	-	1
Salihli OSB	0	0	0	-

Discordance Index Matrix				
	Turgutlu	Akhisar	Manisa	Salihli
Turgutlu OSB	-	0	1	1
Akhisar OSB	0	-	1	1
Manisa OSB	0	0	-	1
Salihli OSB	0	0	0	-

Net Superior/Inferior Values & Ranking				
Alternative	Net Superior Value	Rank	Net Inferior Value	Rank
Turgutlu OSB	1.55	1	-1.7	1
Akhisar OSB	0.8	2	-1.2	2
Manisa OSB	-0.4	3	0.9	3
Salihli OSB	-1.95	4	2	4

After applying the ELECTRE method to evaluate the identified site alternatives within Manisa, Turgutlu OSB emerged as the most advantageous location. This choice ensures optimal balance in cost-effectiveness, accessibility, supplier proximity, potential for future development, and reliable infrastructure. As a result, Turgutlu OSB aligns seamlessly with our operational objectives and provides a solid foundation for the successful production of air humidifiers.

7. Manufacturing Process for High-Performance Dehumidifier

7.1 Research and Development (R&D)

- Concept Design: Develop initial product designs, including the sleek, modern aesthetic and the layout of internal components. Utilize CAD (Computer-Aided Design) software to create 3D models.
- Prototyping: Build prototypes to test the functionality of the UV LED technology, smart humidity control, and energy-efficient systems. Perform rigorous testing to ensure compliance with industry standards and user expectations.

7.2 Material Sourcing

- UV LED Components: Source high-quality UV LEDs designed for air purification, ensuring durability and effectiveness in eliminating airborne bacteria and allergens.
- Humidity Sensors: Procure advanced sensors capable of real-time environmental monitoring for smart humidity control.

- Outer Casing Materials: Choose lightweight yet robust materials (e.g., ABS plastic or metal alloys) for the dehumidifier's exterior, ensuring a sleek design and long-term durability.
- Electronic Components: Secure microcontrollers, PCBs (Printed Circuit Boards), and power-efficient motors for the energy-efficient operation.

7.3 Component Manufacturing

- Injection Molding: Manufacture the outer casing using injection molding techniques to create the modern, streamlined design.
- Circuit Board Assembly: Assemble PCBs for the control panel and other electronic components, integrating microprocessors, humidity sensors, and UV LED modules.
- UV LED Module Assembly: Carefully position UV LEDs within the air purification system to maximize efficiency and safety.

7.4 Assembly Process

- **Sub-Assembly:**
  - Integrate the smart humidity control sensors with the PCB.
  - Connect UV LED modules to the air purification system.
  - Assemble the energy-efficient motor with fan components.
- **Final Assembly:**
  - Install sub-assemblies within the outer casing, ensuring secure placement of each component.
  - Attach the intuitive control panel to the front of the device.
  - Perform wiring and connection of all electronic components to the main PCB.

7.5 Quality Control and Testing

- Electrical Safety Tests: Verify that the dehumidifier meets electrical safety standards.
- Performance Testing: Test the device's dehumidification capacity, UV air purification functionality, and smart humidity control accuracy.
- Energy Efficiency Validation: Measure power consumption under various operating conditions to confirm energy efficiency.
- User Interface Testing: Ensure the control panel is responsive and easy to use.

7.6 Packaging and Distribution

- Packaging: Design protective, eco-friendly packaging that highlights key product features. Include user manuals and warranty information.
- Distribution: Distribute finished units to retailers, warehouses, or directly to customers. Implement tracking systems for inventory management.

7.7 Post-Manufacturing Support

- Provide after-sales services, including customer support, troubleshooting guides, and warranty fulfillment. Collect user feedback to inform future product iterations.

Allocating Takt Time Across Process

Takt Time= Available production Time / Customer Demand

Distribute this takt time across the key manufacturing steps based on complexity and typical durations.

Process Step	Sub-Step	Percentage Of Time	Minutes
Component Manufacturing	*Injection Molding*	20%	0,19
	Circuit Board Assembly	15%	0,14
	UV LED Module Assembly	9%	0,09
	Other Sub-Assembly Tasks	2%	0,02
Assembly Process	*Sub-Assembly*	20%	0,19
	Final Assembly	30%	0,29
Quality Control And Testing	*Electrical Safety Tests*	12%	0,12
	Performance Tests	6%	0,06
	User Interface And Packaging Tests	8%	0,08
Packaging And Distribution	*Final Packaging*	5%	0,05
	Labeling and Shipping Prep	3%	0,03
Total		**100%**	**0,96**

The time percentages for each task are based on the usual difficulty and how workers are assigned to this type of product. The times might change depending on how efficient the process is and how much automation is used. Tasks like circuit board assembly and UV module assembly can be done at the same time to make the work smoother.

Component Manufacturing

Automation can significantly enhance the production rate for high-precision and repetitive tasks in this phase.

Sub-Step	Automation Opportunity	Benefits
Injection Molding	Use fully automated injection molding machines with robotic arms to remove molded parts.	Faster cycle times, reduced labor dependency, consistent quality.
Circuit Board Assembly	Implement Surface-Mount Technology (SMT) machines for PCB assembly and soldering.	High-speed, accurate placement of electronic components, reduced defect rates.
UV LED Module Assembly	Automate LED placement and attachment using pick-and-place robotic systems.	Precise positioning, faster assembly, consistent performance of UV purification components.
Other Sub-Assembly	Use collaborative robots (cobots) for smaller assembly tasks like fastening and wiring.	Flexible deployment, reduced manual workload, and enhanced scalability.

Assembly Process

This step includes putting smaller parts together and finishing the product. Using machines can make the work faster and more accurate.

Sub-Step	Automation Opportunity	Benefits
Sub-Assembly	Deploy automated assembly lines with conveyors and robotic arms for integrating components.	Reduces takt time per unit and ensures consistent build quality.
Final Assembly	Use programmable robotic arms for precise placement and screwing of parts.	Faster assembly, fewer errors, and reduced operator fatigue.

Quality Control and Testing

Automation in testing ensures repeatability and faster verification.

Sub-Step	Automation Opportunity	Benefits
Electrical Safety Tests	Implement automated test stations for electrical safety compliance, with sensors and software logging.	Faster and more accurate testing, reduced risk of human error.
Performance Tests	Use automated chambers to simulate environmental conditions and monitor dehumidification and UV purification performance.	Consistent testing conditions, detailed performance data, faster throughput.
User Interface Tests	Deploy vision-based testing systems to check control panel functionality.	Reliable detection of defects, reduced reliance on manual inspection.

Packaging and Distribution

Automation can improve speed and precision in this phase.

Sub-Step	Automation Opportunity	Benefits
Final Packaging	Use automated packing machines to wrap, box, and seal products.	Increases throughput, reduces material waste, and ensures consistent packaging quality.
Labeling and Shipping	Implement automated labeling systems integrated with tracking software.	Reduces errors in labeling, improves inventory management, and ensures faster shipping prep.

Summary of Benefits

- **Faster Takt Times:** Automation accelerates repetitive tasks, reducing the time needed per unit.

- **Consistency and Quality:** Automated systems reduce variation, ensuring every unit meets high standards.
- **Cost Savings Over Time:** While initial investment may be high, automation lowers labor costs and waste.
- **Scalability:** Automated systems make it easier to adjust production rates for fluctuating demand.

8. Process Design

8.1 General Workflow:

1. **Material and Component Procurement:** Sourcing materials and components according to make-or-buy decisions.
2. **Component Processing:** Manufacturing components using methods such as injection molding and PCB assembly.
3. **Assembly Process:** Completing sub-assemblies and final assembly.
4. **Quality Control:** Performing electrical safety, performance, and energy efficiency tests.
5. **Packaging and Distribution:** Protecting and preparing the products for shipment.

8.2 Workflow for Dehumidifier Manufacturing:

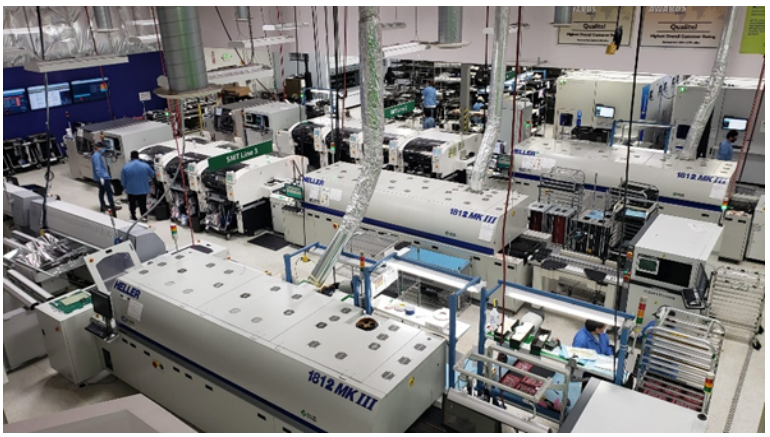
1. Material Procurement and Storage:

- Inputs: ABS plastic, UV LED modules, sensors, and other electronic components.
- Process: Storing materials and transferring them to the production line.
- Equipment Used: Forklift, warehouse shelving systems.

2. Component Manufacturing and Processing:

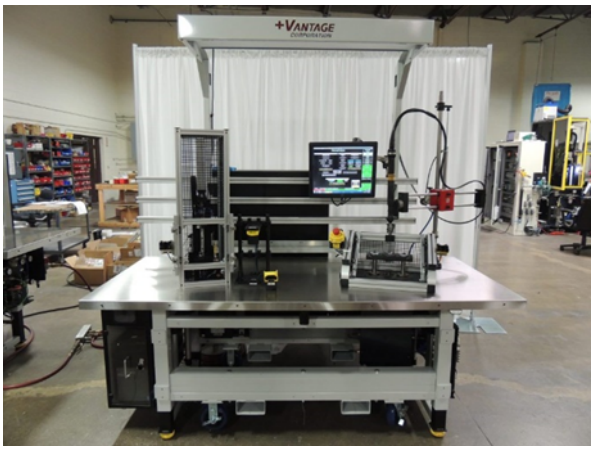
- Process: Producing plastic outer casings and other parts.
- Equipment Used: Injection molding machine.

- Process: Assembling sensors, microprocessors, and other electronic components onto PCBs.
- Equipment Used: Surface Mount Technology (SMT) line, soldering machines.

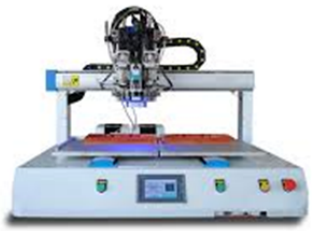


3. Sub-Assembly:

- Process: Assembling UV LED modules.
- Equipment Used: Manual assembly station, testing tools.



- Process: Combining PCBs, UV LED modules, and plastic components.
- Equipment Used: Manual assembly tools, screw-fastening machines.



4. Final Assembly:

- Process: Placing sub-assemblies into the outer casing, completing wiring connections for all components, mounting the control panel.
- Equipment Used: Assembly line conveyor, cable tying tools.
-

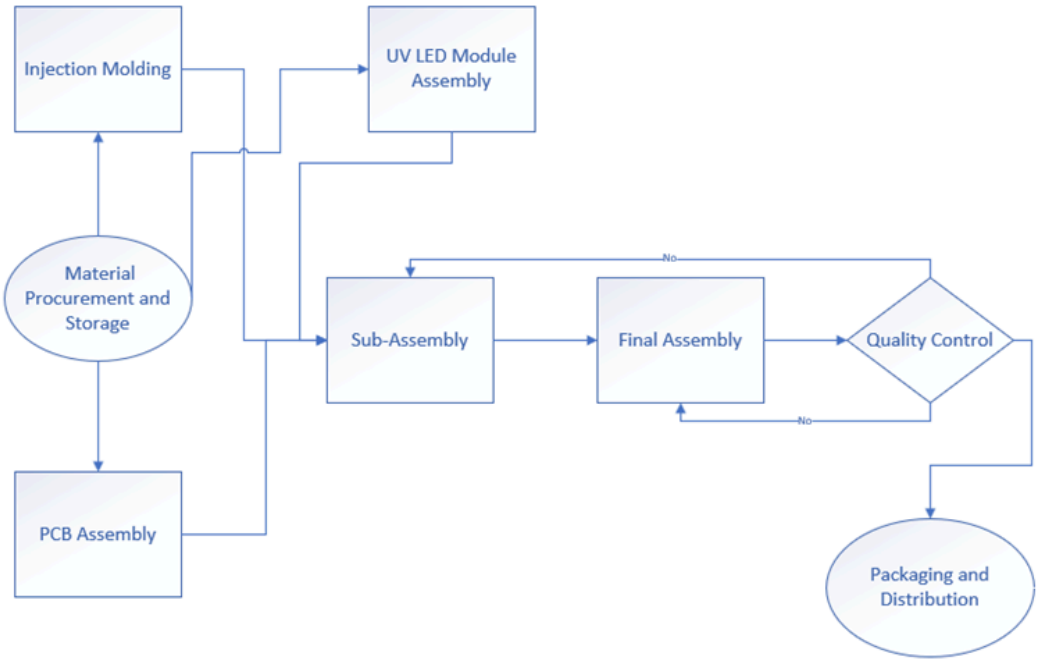
5. Quality Control:

- Process: Electrical tests, performance tests, user interface validation.
- Equipment Used: Electrical safety testing devices, energy measurement tools.

6. Packaging and Distribution:

- Process: Packing the product and preparing it for shipment.
    - Equipment Used: Automated packaging machine, barcode labeling system.

8.3 Workflow Diagram



8.4 Time Study

Process	Process Number	Operation Dimensions	Process Definition	Frequency	TMU (Time Measurement Unit)	Normal Time (s)	Allowance (%)	Standard Time (s)	Standard Time (min)	Hour Pieces	Pieces Per Hour
Material Procurement	1	N/A	Transfer materials to production line	1	50	3	10	3.3	0.055	1090.91	1091
Enclosure Manufacturing	2	45x30x20 cm	Injection molding	1	1500	90	10	99	1.65	36.36	36
PCB Assembly	3	N/A	SMT line processing	1	1200	72	10	79.2	1.32	45.45	45
UV LED Module Assembly	4	2x3x1 cm	Manual assembly	1	800	48	10	52.8	0.88	68.18	68
Sub-Assembly	5	N/A	Assemble components into casing	1	900	54	10	59.4	0.99	60.61	61
Wiring and Connections	6	N/A	Complete wiring and connections	1	600	36	10	39.6	0.66	90.91	91
Control Panel Assembly	7	20x10 cm	Attach and configure control panel	1	400	24	10	26.4	0.44	136.36	136
Quality Control: Electrical Tests	8	N/A	Perform electrical safety tests	1	500	30	10	33	0.55	109.09	109
Performance and Energy Tests	9	N/A	Test energy efficiency and functionality	1	1000	60	10	66	1.1	54.54	55
Packaging and Distribution	10	Box: 50x40x30 cm	Package product and prepare for shipment	1	800	48	10	52.8	0.88	68.18	68

Total Estimated Time for One Unit: 6960 TMU (~116 minutes or ~1 hour 56 minutes)

8.5 Route Sheets

1- Route Sheet for Outer Casing

Part Number	Raw Material	Order Quantity	Operations No	Machine Name	Part Name	Operation	Pieces per Hour	Time Standard	Hour per Pieces
1	Plastic Polymer	1	1	Injection Molding Machine	Outer Casing	Molding	60	1.00 min	0.0167
			2	CNC Machine	Outer Casing	Trimming and Finishing	45	1.33 min	0.0222
			3	Inspectio n Bench	Outer Casing	Quality Inspection	30	2.00 min	0.0333

2- Route Sheet for Water Tank

Part Number	Raw Material	Order Quantity	Operations No	Machine Name	Part Name	Operation	Pieces per Hour	Time Standard	Hour per Pieces
7	High-Grade Plastic	1	1	Blow Molding Machine	Water Tank	Molding	50	1.20 min	0.02
			2	CNC Machine	Water Tank	Trimming and Finishing	40	1.50 min	0.025
			3	Inspectio n Bench	Water Tank	Quality Inspection	25	2.40 min	0.04

3- Route Sheet for Drip Tray

Part Number	Raw Material	Order Quantity	Operations No	Machine Name	Part Name	Operation	Pieces per Hour	Time Standard	Hour per Pieces
8	Stainless Steel	1	1	Press Machine	Drip Tray	Stamping	70	0.85 min	0.0142
			2	Polishing Machine	Drip Tray	Surface Polishing	55	1.09 min	0.0182
			3	Inspectio n Bench	Drip Tray	Quality Inspection	35	1.71 min	0.0285

4- Route Sheet for Control Board

Part Number	Raw Material	Order Quantity	Operations No	Machine Name	Part Name	Operation	Pieces per Hour	Time Standard	Hour per Pieces
15	PCB Board	1	1	PCB Assembly Machine	Control Board	Component Placement	40	1.50 min	0.025
			2	Soldering Station	Control Board	Soldering	30	2.00 min	0.0333
			3	Testing Bench	Control Board	Functional Testing	25	2.40 min	0.04
			4	Inspection Bench	Control Board	Quality Inspection	20	3.00 min	0.05

5- Route Sheet for Power Board

Part Number	Raw Material	Order Quantity	Operations No	Machine Name	Part Name	Operation	Pieces per Hour	Time Standard	Hour per Pieces
16	PCB Board Material	1	1	PCB Manufacturing Line	Power Board	Circuit Etching	40	1.50 min	0.025
			2	Soldering Station	Power Board	Component Assembly	35	1.71 min	0.0285
			3	Inspection Bench	Power Board	Quality Inspection	25	2.40 min	0.04

6- Route Sheet for Control Panel

Part Number	Raw Material	Order Quantity	Operations No	Machine Name	Part Name	Operation	Pieces per Hour	Time Standard	Hour per Pieces
21	Composite Plastic	1	1	Injection Molding Machine	Control Panel	Molding	65	0.92 min	0.0153
			2	CNC Machine	Control Panel	Slotting and Drilling	50	1.20 min	0.02
			3	Inspection Bench	Control Panel	Quality Inspection	30	2.00 min	0.0333

7- Route Sheet for Fan Brackets

Part Number	Raw Material	Order Quantity	Operations No	Machine Name	Part Name	Operation	Pieces per Hour	Time Standard	Hour per Pieces
23	Aluminum Alloy	2	1	Die Casting Machine	Fan Brackets	Casting	55	1.09 min	0.0182
			2	CNC Machine	Fan Brackets	Trimming and Drilling	45	1.33 min	0.0222
			3	Inspection Bench	Fan Brackets	Quality Inspection	35	1.71 min	0.0285

8- Route Sheet for Air Ducts

Part Number	Raw Material	Order Quantity	Operations No	Machine Name	Part Name	Operation	Pieces per Hour	Time Standard	Hour per Pieces
24	Aluminum Alloy	2	1	CNC Cutting Machine	Air Ducts	Cutting	50	1.20 min	0.02
			2	Press Brake Machine	Air Ducts	Bending/Forming	40	1.50 min	0.025
			3	Surface Finishing Machine	Air Ducts	Deburring/Polishing	30	2.00 min	0.0333
			4	Inspection Bench	Air Ducts	Quality Inspection	25	2.40 min	0.04

9. Space and Layout Design

In the tables below, a comprehensive area calculation has been made for different sections of the factory, such as production area, office area, warehouse area, auxiliary services area, etc., with their subdivisions.

9.1.1 Production Area Requirements

The production area is designed to ensure efficiency, safety, and ease of operation. The space must accommodate manufacturing equipment and workstations, testing stations, and utility areas.

Production Area	Length	Width	Area	Number Needed	Total Area Needed
Manufacturing Equipments and Work Stations					***227.60 m2***
Injection Molding Machine	*5.00 m*	*2.50 m*	*12.50 m2*	*3*	*37.50 m2*
CNC Machine	*3.00 m*	*1.75 m*	*5.25 m2*	*3*	*15.75 m2*
Inspection Bench	*2.00 m*	*1.25 m*	*2.50 m2*	*2*	*5.00 m2*
Blow Molding Machine	*5.00 m*	*2.50 m*	*12.50 m2*	*2*	*25.00 m2*
Press Machine	*4.00 m*	*2.50 m*	*10.00 m2*	*2*	*20.00 m2*
Polishing Machine	*2.50 m*	*1.25 m*	*3.13 m2*	*2*	*9.39 m2*
PCB Assembly Machine	*2.50 m*	*1.50 m*	*3.75 m2*	*2*	*11.25 m2*
Soldering Station	*1.25 m*	*0.75 m*	*0.94 m2*	*3*	*2.82 m2*
Die Casting Machine	*5.00 m*	*2.50 m*	*12.50 m2*	*2*	*37.50 m2*
CNC Cutting Machine	*4.00 m*	*2.50 m*	*10.00 m2*	*2*	*20.00 m2*
Press Brake Machine	*5.00 m*	*2.50 m*	*12.50 m2*	*2*	*25.00 m2*
Surface Finishing Machine	*3.50 m*	*1.75 m*	*6.13 m2*	*2*	*18.39 m2*
Testing Stations:					***220.00 m2***
Functionality Testing Areas	*8.00 m*	*5.00 m*	*40.00 m2*	*2*	*80.00 m2*
Post-Montage Testing Areas	*6.00 m*	*5.00 m*	*30.00 m2*	*2*	*60.00 m2*
Material Testing Areas	*6.00 m*	*5.00 m*	*30.00 m2*	*1*	*30.00 m2*
Final Product Testing Areas	*10.00 m*	*5.00 m*	*50.00 m2*	*1*	*50.00 m2*
Utility Areas:					***380.00 m2***
Electrical and Power Distribution Area	*8.00 m*	*5.00 m*	*40.00 m2*	*1*	*40.00 m2*
Water and Air Compressors Area	*12.50 m*	*4.00 m*	*50.00 m2*	*1*	*50.00 m2*
Waste Management Area	10.00 m	*5.00 m*	*50.00 m2*	*1*	*50.00 m2*
Chemical Storage Area	*6.00 m*	*5.00 m*	*30.00 m2*	*1*	*30.00 m2*
Cooling and HVAC Systems Area	*10.00 m*	*5.00 m*	*50.00 m2*	*1*	*50.00 m2*
Employee Break Area	*10.00 m*	*6.00 m*	*60.00 m2*	*2*	*120.00 m2*
Cleaning and Hygiene Area	*6.00 m*	*5.00 m*	*30.00 m2*	*1*	*30.00 m2*
Security Area	*4.00 m*	*2.50 m*	*10.00 m2*	*1*	*10.00 m2*
TOTAL AREA NEEDED :					***827.60 m2***

9.1.2. Office Area Requirements

The office area is designed for administrative and managerial operations. Key requirements include offices for all departments, and meeting rooms.

Office Area	Area	Number Needed	Total Area Needed
Management Offices	45.00 m2	**2**	45.00 m2
CEO/General Management Office	30.00 m2	1	30.00 m2
Executive Assistant Office	15.00 m2	1	15.00 m2
Human Resources Offices	40.00 m2	**2**	40.00 m2
HR Office	20.00 m2	1	20.00 m2
Training and Development Office	20.00 m2	1	20.00 m2
Finance and Accounting Department	40.00 m2	**2**	40.00 m2
Finance Office	25.00 m2	1	25.00 m2
Accounting Office	15.00 m2	1	15.00 m2
Sales and Marketing Department	75.00 m2	**3**	75.00 m2
Sales Office	30.00 m2	1	30.00 m2
Marketing Office	25.00 m2	1	25.00 m2
Customer Service Office	20.00 m2	1	20.00 m2
Production Department	95.00 m2	**4**	95.00 m2
Product Manager Office	20.00 m2	1	20.00 m2
Product Planning Office	25.00 m2	1	25.00 m2
Quality Control Office	20.00 m2	1	20.00 m2
R&D Office (Research and Development)	30.00 m2	1	30.00 m2
Supply Chain and Logistics Department	40.00 m2	**2**	40.00 m2
Supply Chain Office	20.00 m2	1	20.00 m2
Logistics Office	20.00 m2	1	20.00 m2
IT and Technical Support Department	45.00 m2	**2**	45.00 m2
IT Office	25.00 m2	1	25.00 m2
Technical Support Office	20.00 m2	1	20.00 m2
Legal Department	20.00 m2	**1**	20.00 m2
Legal Office	20.00 m2	1	20.00 m2
Warehouse and Inventory Management Department	15.00 m2	**1**	15.00 m2
Warehouse Office	15.00 m2	1	15.00 m2
Product and Project Management Department	20.00 m2	**1**	20.00 m2
Project Manager Office	20.00 m2	1	20.00 m2
Security and Maintenance Department	30.00 m2	**2**	30.00 m2
Security Office	10.00 m2	1	10.00 m2
Maintenance Office	20.00 m2	1	20.00 m2
TOTAL AREA NEEDED :			**445.00 M2**

9.1.3. Warehouse Requirements

The warehouse must efficiently handle raw materials, work-in-progress (WIP) components, and finished goods.

Warehouse Area	Length	Width	Area	Number Needed	Total Area Needed
Raw Material Storage Area	20.00 m2	10.00 m2	200.00 m2	1	200.00 m2
Finished Goods Storage Area	30.00 m2	10.00 m2	300.00 m2	1	300.00 m2
Packaging Material Storage Area	10.00 m2	5.00 m2	50.00 m2	1	50.00 m2
Loading and Unloading Area (Docking Area)	16.00 m2	5.00 m2	80.00 m2	2	160.00 m2
Work-In-Progress (WIP) Storage Area	20.00 m2	5.00 m2	100.00 m2	1	100.00 m2
Spare Parts and Maintenance Supplies Area	6.00 m2	5.00 m2	30.00 m2	1	30.00 m2
Staging Area	12.50 m2	8.00 m2	100.00 m2	1	100.00 m2
Office Area for Warehouse Staff	6.00 m2	5.00 m2	30.00 m2	1	30.00 m2
TOTAL AREA NEEDED :					**970.00 m2**

9.1.4. Auxiliary Services Area Requirements

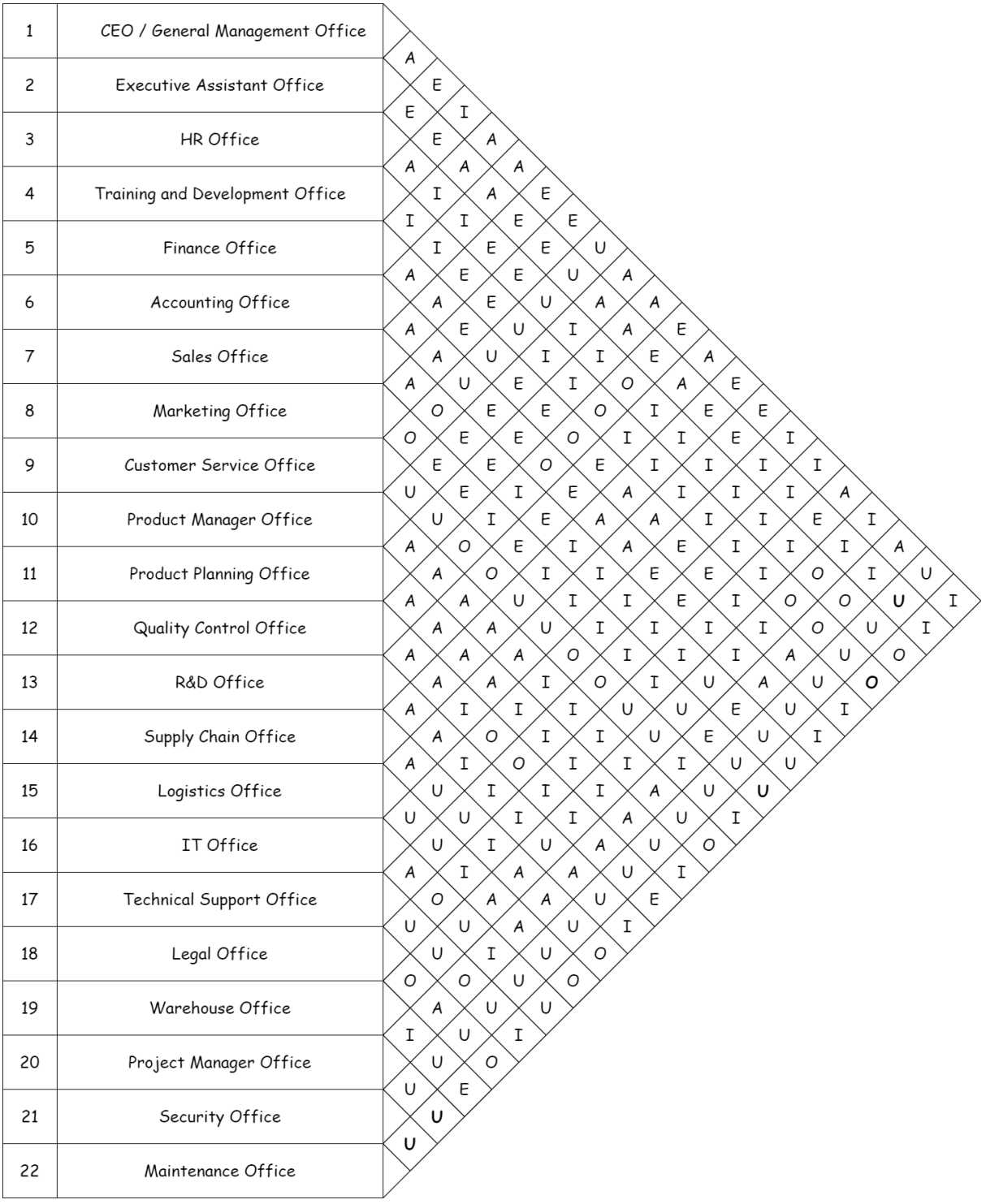
The auxiliary services are designed to support production. The area must include a maintenance workshop, utility rooms, and sanitation facilities.

Auxiliary Services Area	Length	Width	Area	Number Needed	Total Area Needed
Maintenance Workshop	12.50 m	8.00 m	100.00 m2	1	100.00 m2
Tool Room	8.00 m	5.00 m	40.00 m2	1	40.00 m2
Centralized Utility Room	10.00 m	7.00 m	70.00 m2	1	70.00 m2
Employee Locker and Changing Rooms	10.00 m	8.00 m	80.00 m2	1	80.00 m2
Canteen or Cafeteria	15.00 m	10.00 m	150.00 m2	1	150.00 m2
First Aid Room or Medical Center	6.00 m	5.00 m	30.00 m2	1	30.00 m2
Fire Safety Equipment Storage	7.50 m	2.00 m	15.00 m2	1	15.00 m2
IT and Server Room	6.00 m	5.00 m	30.00 m2	1	30.00 m2
Wastewater Treatment Area	10.00 m	8.00 m	80.00 m2	1	80.00 m2
Cleaning Equipment Storage	5.00 m	3.00 m	15.00 m2	1	15.00 m2
Restrooms and Sanitation Facilities	12.50 m	4.00 m	50.00 m2	1	50.00 m2
Smoking Area	5.00 m	3.00 m	15.00 m2	1	15.00 m2
Storage for Office Supplies	5.00 m	3.00 m	15.00 m2	1	15.00 m2
Kitchen	6.25 m	4.00 m	25.00 m2	1	25.00 m2
TOTAL AREA NEEDED :					**715.00 m2**

9.2. Layout Design

The layout should prioritize lean principles to minimize muda (waste) and optimize workflow.

9.2.1. Activity Relationship Diagram



9.2.2. Activity Relationship Table

Activity	Degree of Closeness					
	A	E	I	O	U	X
CEO / General Management Office	2,5,6,10,11,13,18,20	3,7,8,12,14,15	4,16,17,19,22	-	9,21	-
Executive Assistant Office	1,5,6,10,11,13	3,4,7,8,12,14,15,18	16,17,19,20,22	-	9,21	-
HR Office	4	1,2,7,8	5,6,10,11,13,14,15,16,17,18	12,19,20	9,21	-
Training and Development Office	3	2,7,8	1,5,6,10,11,13,14,15,16,17,18	12,19,20	9,21	-
Finance Office	1,2,6,7,14,15,20	8,10,11,13,16,17	3,4	3,4,18,19,22	9,21	-
Accounting Office	1,2,5,7,8,14,15,20	10,11,13,16,17	3,4,18,19,22	13	9,21	-
Sales Office	5,6,8	1,2,3,4,10,11,13,20	12,14,15,16,17,18	9	19,1,22	-
Marketing Office	5,6,8	1,2,3,4,10,11,13,20	12,14,15,16,17,18	9	19,1,22	-
Customer Service Office	-	-	20,22	7,8,12,13,16,17	1,2,3,4,5,6,10,11,14,15,18,19,21	-
Product Manager Office	1,2,11,12,13,14,15,20	5,6,7,8	3,4,16,17,18,19	22	9,21	-
Product Planning Office	1,2,10,12,13,14,15,20	5,6,7,8	3,4,16,17,18,19,22	-	9,21	-
Quality Control Office	10,11,13,14,20	1,2,22	7,8,15,18,19	3,4,5,6,9,16,17	21	-
R&D Office	1,2,10,11,12,14,15,20	5,6,7,8	3,4,16,17,18,22	9	19,21	-
Supply Chain Office	5,6,10,11,12,13,15,19,20	1,2	3,4,7,8,18	22	9,16,17,21	-
Logistics Office	5,6,10,11,13,15,19,20	1,2	3,4,7,8,12,18	22	9,16,17,21	-
IT Office	17	5,6	1,2,3,4,7,8,10,11,13,20,21	9,12,18	14,15,19,21,22	-
Technical Support Office	17	5,6	1,2,3,4,7,8,10,11,13,21,22	9,12,20	14,15,18,19,21	-
Legal Office	1,2	2	3,4,5,6,7,8,10,11,12,13,14,15	16,19,22	9,17,21	-
Warehouse Office	14,15	22	1,2,5,6,10,11,12	3,4,18	7,8,9,13,16,17,21	-
Project Manager Office	1,5,6,10,11,12,13,14,15,18	7,8	2,9,16,19	3,4,17	21	-
Security Office	-	-	-	-	All	-
Maintenance Office	-	12,18	1,2,5,6,9,11,13,17	3,4,10,14,15,18	7,8,16,21,22	-

10. Inventory Management

10.1 Annual Material Requirements

To classify materials into ABC groups, the list of raw and procured materials was prepared by referring to the make-or-buy decision table. The annual material requirements were calculated based on the first year's forecasted production demand. Material prices were determined using wholesale market rates, ensuring accuracy and consistency.

Part Number	Name	Unit	Quantity per Product	Annual Requirements	Price per Unit ($)	Annual Cost ($)
1	Outer Casing	Piece	1	32150	15	482250
2	Screws and Fasteners	Piece	20	643000	0,05	32150
3	Rubber Feet	Piece	4	128600	0,2	25720
4	Peltier Module	Piece	1	32150	10	321500
5	Heatsink	Piece	1	32150	6	192900
6	Cooling Fan	Piece	1	32150	5	160750
7	Water Tank	Piece	1	32150	3	96450
8	Drip Tray	Piece	1	32150	2	64300
9	HEPA	Piece	1	32150	15	482250

	Filter					
10	Activated Carbon Filter	Piece	1	32150	10	321500
11	UV-C LED Module	Piece	1	32150	6	192900
12	Air Intake Grille	Piece	1	32150	1	32150
13	Air Exhaust Grille	Piece	1	32150	1	32150
14	AI Processor	Piece	1	32150	40	1286000
15	Control Board	Piece	1	32150	20	643000
16	Power Board	Piece	1	32150	15	482250
17	Humidity Sensor	Piece	1	32150	3	96450
18	Air Quality Sensor	Piece	1	32150	3	96450
19	Temperatu re Sensor	Piece	1	32150	2	64300
20	Display Screen	Piece	1	32150	10	321500
21	Control Panel	Piece	1	32150	12	385800
22	Main Fan	Piece	1	32150	5	160750
23	Fan Brackets	Piece	2	64300	1	64300
24	Air Ducts	Piece	2	64300	2	128600
25	Fuse	Piece	1	32150	0,1	3215
26	Overload Protector	Piece	1	32150	0,5	16075
27	Rubber Seals	Piece	2	64300	0,2	12860
28	Adhesives	Piece	10	321500	0,05	16075
29	Wire Harnesses	Piece	5	160750	0,3	48225
30	Cable Ties	Piece	12	385800	0,05	19290
31	LED Indicators	Piece	3	96450	0,5	48225
32	Casters	Piece	4	128600	1	128600
33	Knobs and Switches	Piece	3	96450	0,5	48225

	Total Cost					6507160
	Cost per Production					202,4

10.2 ABC Analysis

ABC analysis categorizes inventory based on its contribution to the total cost, with a focus on optimizing inventory management. In this case, inventory items have been classified into three groups: A, B, and C, based on their annual costs and cumulative contribution to the total value. Group A items account for approximately 80% of the total value but only a small percentage of the items, warranting more frequent monitoring and strict inventory control. These high-value items will be counted monthly to ensure accuracy and minimize stockouts. Group B items, which contribute around 15% of the value, will be counted quarterly, while Group C items, with the lowest value contribution (approximately 5%), will be counted biannually. This approach ensures resource prioritization for critical components while maintaining adequate oversight of lower-value inventory, enhancing stock management efficiency and minimizing operational risks.

Part Number	Name	Quantity	M/B	Cost Per Unit	Total Cost	Cumulative Cost	Cumulative %	Category
14	AI Processor	1	Buy	40	40	40	19,71	A
15	Control Board	1	Make	20	20	60	29,57	A
1	Outer Casing	1	Make	15	15	75	36,96	A
9	HEPA Filter	1	Buy	15	15	90	44,36	A
16	Power Board	1	Make	15	15	105	51,75	A
21	Control Panel	1	Make	12	12	117	57,66	A
4	Peltier Module	1	Buy	10	10	127	62,59	A
10	Activated Carbon Filter	1	Buy	10	10	137	67,52	A
20	Display Screen	1	Buy	10	10	147	72,45	A
5	Heatsink	1	Buy	6	6	153	75,41	A
11	UV-C	1	Buy	6	6	159	78,36	A

	LED Module							
6	Cooling Fan	1	Buy	5	5	164	80,83	B
22	Main Fan	1	Buy	5	5	169	83,29	B
32	Casters	4	Buy	1	4	173	85,26	B
24	Air Ducts	2	Make	2	4	177	87,24	B
18	Air Quality Sensor	1	Buy	3	3	180	88,71	B
17	Humidity Sensor	1	Buy	3	3	183	90,19	B
7	Water Tank	1	Make	3	3	186	91,67	B
19	Temperature Sensor	1	Buy	2	2	188	92,66	B
8	Drip Tray	1	Make	2	2	190	93,64	B
23	Fan Brackets	2	Make	1	2	192	94,63	B
29	Wire Harnesses	5	Buy	0,3	1,5	193,5	95,37	C
31	LED Indicators	3	Buy	0,5	1,5	195	96,11	C
33	Knobs and Switches	3	Buy	0,5	1,5	196,5	96,85	C
2	Screws and Fasteners	20	Buy	0,05	1	197,5	97,34	C
13	Air Exhaust Grille	1	Buy	1	1	198,5	97,83	C
12	Air Intake Grille	1	Buy	1	1	199,5	98,32	C
28	Adhesives	10	Buy	0,1	1	200,5	98,82	C
3	Rubber	4	Buy	0,2	0,8	201,3	99,21	C

	Feet							
30	Cable Ties	12	Buy	0,05	0,6	201,9	99,51	C
26	Overload Protector	1	Buy	0,5	0,5	202,4	99,75	C
27	Rubber Seals	2	Buy	0,2	0,4	202,8	99,95	C
25	Fuse	1	Buy	0,1	0,1	202,9	100	C

10.3 Holding and Setup(Order Cost)

After conducting the ABC analysis, the EOQ model was utilized to optimize the supply chain by determining the ordering costs for each inventory class (A, B, and C). To calculate these costs, several factors were considered:

1.Border and Documentary Costs: Border fees remain at $65.00, and documentary fees are $49.00 per shipment. These are fixed costs incurred for all imports.

2.Shipment Costs: The updated shipment cost for a 40ft container from China to Izmir is $12,800. This was divided based on the class weights from the ABC analysis (A: 80%, B: 15%, C: 5%).

3.Transportation Costs (Izmir to Manisa): Products are transported by train from Izmir port to Manisa, with a cost of $14.74 per load.

4.Holding Costs: A holding cost margin of 34% was applied to account for inventory risk, capital costs, and storage requirements.

Class	Border Cost ($)	Documentary Cost ($)	Izmir to Manisa Transport Cost ($)	Shipment Fee ($)	Ordering Cost ($)
A	65	49	14,74	10240	10368,74
B	65	49	14,74	1920	2048,74
C	65	49	14,74	640	768,74

11. Ergonomics and Workstation Design Space Requirement

The design of the air purifier prioritizes easy accessibility and practical ergonomics reminiscent of our layout design. Space requirements while increasing usability were targeted for the compact and systematic layout. In order to achieve a productive work environment, spaces between each workstation, flow of the product, and each worker's requirements were examined and designed accordingly.

11.1 …..Area

11.2 Plastic Injection Area

Outer Casing, Water Tank, Drip Tray

11.3

11.4

11.5

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