PLANET CHANGE

Green energy
and
green professions

Teachers' manual

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Erasmus+ Programme
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Planet change is the short name of an EU Erasmus+ project aimed at VET teachers and their students. With small activities, the idea is to create awareness about sustainability and acquire 21st century skills. All this is done in a technical context, mostly from space technology.

www.planetchange.eu

Contents:

1. General information

Duration: 150 minutes (can be divided into more than one lesson)

Target group: 16/18 years old

European qualifications framework level: 3-4

Teacher preparation: Before starting the activity, teachers should have contacted all the materials available and experimented using the game suggested. Please, assure your students have access to the internet and the appropriate chosen resources. Conduct a basic review of the content and be prepared to answer questions that the activity might raise. Teachers should also have experimented the NASA Ozone Watch website and be able to guide the students through its main features.

The first part of the activity should introduce the students to the ozone layer through satellites images and make them reflect of what have been happening over the years. Then, they will explore the connection between ozone depletion and greenhouse gases emissions, and, therefore, understand the importance that green transition can have to minimize both problems. Finally, they will learn about the "green collar" professionals, understand what they do, and perhaps be encouraged to pursuing careers related to the topics around energy efficiency. Therefore, teachers should also prepare to orient students who might be interested in continuing their studies or pursuing jobs in space and green fields, providing them with options (in their country but not only) of courses, trainings, job opportunities, etc.

Topic

Themes: Energy Efficiency

Keywords: Ozone layer protection, Fuels, Green energy, green transition, 21st-century skills, Professional Skills, Green Collar Careers

Activity

Goals
The main objective of this activity is to make students aware of the interconnectedness between space observation, stratosphere and atmosphere, and understand how the greenhouse emissions (caused, primarily, by fuels) contribute to ozone layer destruction and vice-versa. They will also gain awareness of how, in this context, the green transition and the adoption of green energy will be crucial, and which green collar professions will make even more sense in the future.

Summary
The main objective of this activity is to make students aware of the interconnectedness between space observation, stratosphere and atmosphere, and understand how the greenhouse emissions (caused, primarily, by fuels) contribute to ozone layer destruction and vice-versa. Therefore, they will gain a better understanding of how minimizing one

problem will be crucial to help with the other. They will also gain awareness of how, in this context, the green transition and the adoption of green energy will be crucial and be introduced to the ones who can make a difference - the green collar professionals. Understanding that these jobs mean, and what are the necessary skills, which can also be inspiring to students, and, thus, the last part of the activity is dedicated to thinking about possible future career paths related to these topics, and how teachers can guide them through the process.

2. Introduction

The depletion of the ozone layer is a critical environmental issue with significant impacts on both the planet and human health. The ozone layer, a protective shield in the Earth's stratosphere, absorbs the majority of the sun's harmful ultraviolet radiation. Without it, life on Earth would be exposed to severe UV radiation, leading to increased skin cancers, cataracts, and other health issues, as well as negatively impacting ecosystems and wildlife. Ozone depletion primarily results from human-made chemicals known as Ozone-Depleting Substances (ODS), such as chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs). These substances were commonly used in refrigeration, air conditioning, aerosol propellants, and other industrial applications. When released into the atmosphere, ODS rise to the stratosphere, where they are broken down by UV radiation, releasing chlorine and bromine atoms that destroy ozone molecules.

Understanding the dynamics of the ozone layer and the factors contributing to its depletion is essential for addressing this global issue. The Montreal Protocol, established in 1987, has been a significant milestone in reducing the production and consumption of ODS. This international treaty, ratified by all UN member states, has led to a substantial decrease in ODS emissions, resulting in gradual recovery of the ozone layer.

However, the problem of ozone depletion is closely linked to broader environmental challenges, particularly climate change. Greenhouse gases, primarily carbon dioxide (CO2) and methane (CH4), trap heat in the atmosphere, leading to global warming. This warming can affect the ozone layer by altering atmospheric conditions, such as temperature and circulation patterns, which in turn can influence the formation of ozone holes. Non-renewable energy sources, especially fossil fuels like coal, oil, and natural gas, are major contributors to greenhouse gas emissions. The extraction, processing, and burning of these fuels release significant amounts of CO2 and other pollutants into the atmosphere. Transitioning to renewable energy sources, such as solar, wind, hydro, and geothermal, is crucial for mitigating climate change and protecting the ozone layer.

This activity aims to provide students with a comprehensive understanding of the ozone layer, its depletion, and the interconnectedness of environmental issues. By exploring satellite data, historical trends, and the impact of energy sources, students will gain insights into the importance of sustainable practices and the role they can play in preserving our planet's health.

3. Description of the activity

In this activity, students will understand how to use satellite images to understand ozone layer destruction, how it can be monitored over time and help understand the main reasons behind it, comprehend the connection between ozone depletion and greenhouse gas emissions. Additionally, they will gain awareness about careers related to space/green transition exist and understand which are the tasks and skills associated to each one of them. This can open the discussion about possible space or green careers and trace individual plans.

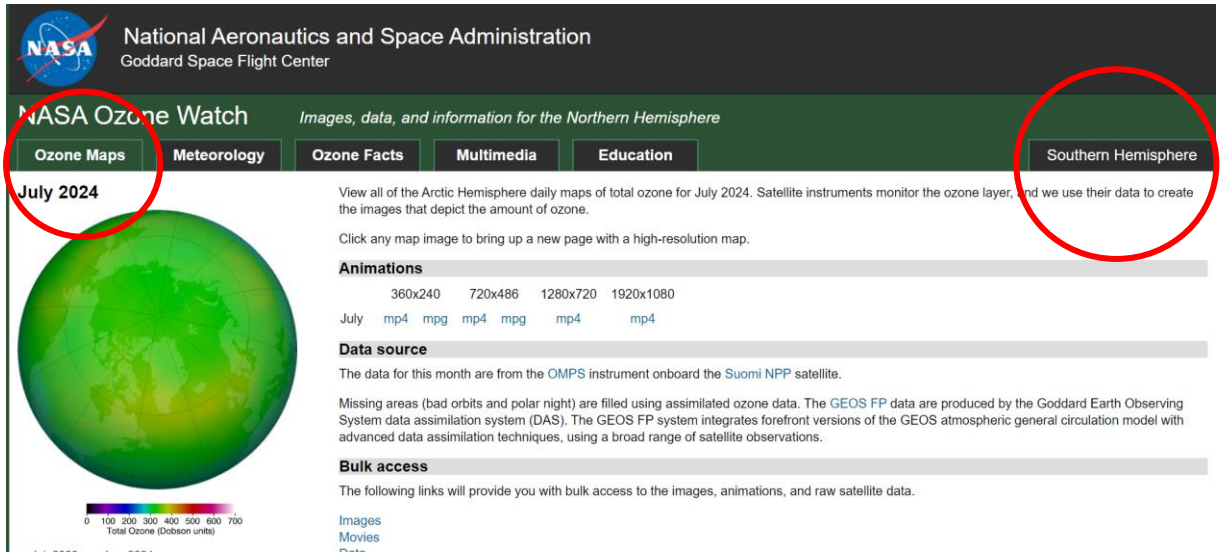
In terms of structure, this activity is divided into four parts:

1. Look up! What can satellites tell us about the ozone layer?
2. Ozone Depletion, Greenhouse gases emissions and Climate Change
3. Green-collar professionals
4. Professional careers related to space or green jobs (optional)

Part 1. Look up! What can satellites tell us about the ozone layer? (150 min)

Step 1: The teacher should briefly introduce the topic and explain the importance of understanding the environmental impact of energy sources, as well as outline the goals of the first part of the activity: understanding the ozone layer, identifying harmful fuels, and discussing their extraction and use.

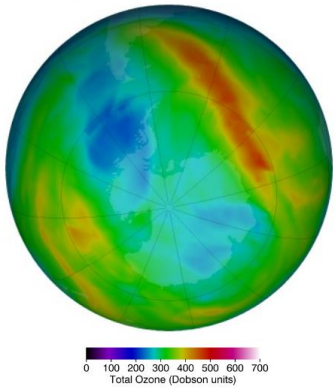
Step 2: Students should be directed to the Ozone Watch site (https://ozonewatch.gsfc.nasa.gov/). They should have some note-taking material (a traditional or online board, a notebook, etc., to take notes on their observations). When they enter the website, this page will appear:



They will focus their attention on the tab “Ozone Maps”. There is a possibility of choosing to observe the Southern and the Northern Hemispheres. So, students can be divided into two groups, each one responsible for looking at one hemisphere.

Step 3: Now, each one of the groups should dedicate themselves to observing some general facts about the current month (in this case, let’s take July 2024 as an example).

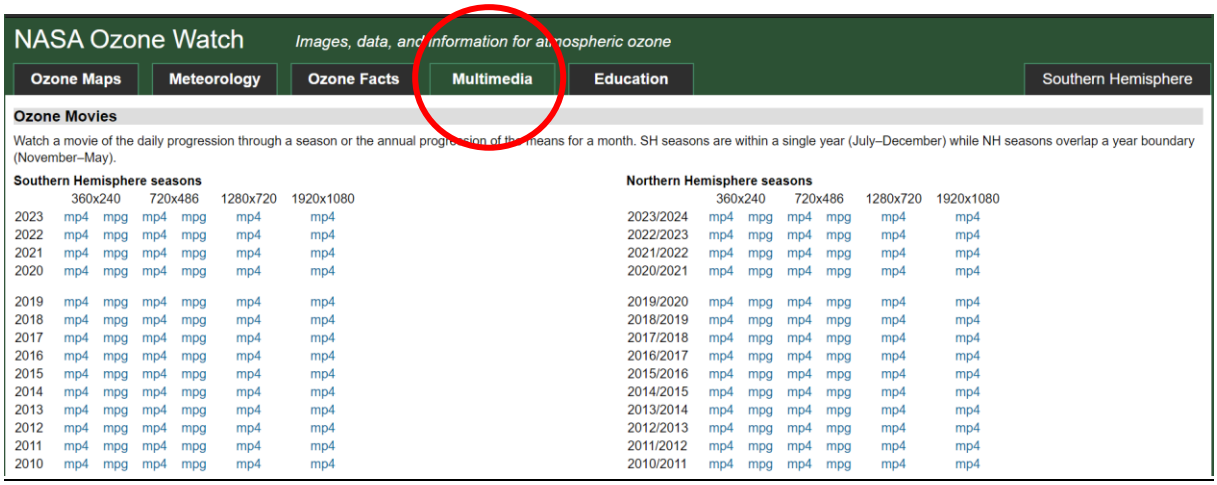
29 July 2024



The latest false-color view of total ozone over the Antarctic pole. The purple and blue colors are where there is the least ozone, and the yellows and reds are where there is more ozone.

- Can you interpret the colors present in the globe? Where are the areas that have more ozone and the ones with less?
- Are there significant changes during the months? Why do think that happens?
- Look at the zones with less ozone. Why do think it looks like that? Which might be the reasons?

Step 4: Next, they should explore the historical evolution. In order to do that, direct them to the “**Multimedia**” tab.



Ozone Movies

Watch a movie of the daily progression through a season or the annual progression of the means for a month. SH seasons are within a single year (July–December) while NH seasons overlap a year boundary (November–May).

Southern Hemisphere seasons

	360x240		720x486		1280x720	1920x1080
2023	mp4	mpg	mp4	mpg	mp4	mp4
2022	mp4	mpg	mp4	mpg	mp4	mp4
2021	mp4	mpg	mp4	mpg	mp4	mp4
2020	mp4	mpg	mp4	mpg	mp4	mp4
2019	mp4	mpg	mp4	mpg	mp4	mp4
2018	mp4	mpg	mp4	mpg	mp4	mp4
2017	mp4	mpg	mp4	mpg	mp4	mp4
2016	mp4	mpg	mp4	mpg	mp4	mp4
2015	mp4	mpg	mp4	mpg	mp4	mp4
2014	mp4	mpg	mp4	mpg	mp4	mp4
2013	mp4	mpg	mp4	mpg	mp4	mp4
2012	mp4	mpg	mp4	mpg	mp4	mp4
2011	mp4	mpg	mp4	mpg	mp4	mp4
2010	mp4	mpg	mp4	mpg	mp4	mp4

Northern Hemisphere seasons

	360x240		720x486		1280x720	1920x1080
2023/2024	mp4	mpg	mp4	mpg	mp4	mp4
2022/2023	mp4	mpg	mp4	mpg	mp4	mp4
2021/2022	mp4	mpg	mp4	mpg	mp4	mp4
2020/2021	mp4	mpg	mp4	mpg	mp4	mp4
2019/2020	mp4	mpg	mp4	mpg	mp4	mp4
2018/2019	mp4	mpg	mp4	mpg	mp4	mp4
2017/2018	mp4	mpg	mp4	mpg	mp4	mp4
2016/2017	mp4	mpg	mp4	mpg	mp4	mp4
2015/2016	mp4	mpg	mp4	mpg	mp4	mp4
2014/2015	mp4	mpg	mp4	mpg	mp4	mp4
2013/2014	mp4	mpg	mp4	mpg	mp4	mp4
2012/2013	mp4	mpg	mp4	mpg	mp4	mp4
2011/2012	mp4	mpg	mp4	mpg	mp4	mp4
2010/2011	mp4	mpg	mp4	mpg	mp4	mp4

Southern Hemisphere annual progression

	360x240		720x486		1280x720	1920x1080
January	mp4	mpg	mp4	mpg	mp4	mp4
February	mp4	mpg	mp4	mpg	mp4	mp4
March	mp4	mpg	mp4	mpg	mp4	mp4
April	mp4	mpg	mp4	mpg	mp4	mp4
May	mp4	mpg	mp4	mpg	mp4	mp4
June	mp4	mpg	mp4	mpg	mp4	mp4
July	mp4	mpg	mp4	mpg	mp4	mp4
August	mp4	mpg	mp4	mpg	mp4	mp4
September	mp4	mpg	mp4	mpg	mp4	mp4
October	mp4	mpg	mp4	mpg	mp4	mp4
November	mp4	mpg	mp4	mpg	mp4	mp4
December	mp4	mpg	mp4	mpg	mp4	mp4

Northern Hemisphere annual progression

	360x240		720x486		1280x720	1920x1080
January	mp4	mpg	mp4	mpg	mp4	mp4
February	mp4	mpg	mp4	mpg	mp4	mp4
March	mp4	mpg	mp4	mpg	mp4	mp4
April	mp4	mpg	mp4	mpg	mp4	mp4
May	mp4	mpg	mp4	mpg	mp4	mp4
June	mp4	mpg	mp4	mpg	mp4	mp4
July	mp4	mpg	mp4	mpg	mp4	mp4
August	mp4	mpg	mp4	mpg	mp4	mp4
September	mp4	mpg	mp4	mpg	mp4	mp4
October	mp4	mpg	mp4	mpg	mp4	mp4
November	mp4	mpg	mp4	mpg	mp4	mp4
December	mp4	mpg	mp4	mpg	mp4	mp4

As seen, there are a set of records of the ozone progression over seasons and through the year.

Students will focus on the **annual** progression. For that, they should choose the following months:

- For the Southern Hemisphere, tell them to choose **September,** as this when the ozone hole over Antarctica typically reaches its maximum size, making it the most critical month for observation.
- For the Northern Hemisphere, choose March**,** as the ozone depletion in this hemisphere is usually most noticeable in late winter to early spring, around March. This period is when the conditions for ozone-depleting reactions are most favorable (http://atmosphere.copernicus.eu/monitoring-ozone-layer)

Step 5: For each month they chose, they should see the correspondent video and stop on the following times:

1. September 1979/ September 1989/ September 1999/ September 2009/September 2019/September 2023
2. March 1979/ March 1989/ March 1999/ March 2009/March 2019/March 2023

Ask them to write down their thoughts and the changes they have observed. They should present the findings to the class and compare results. Provide them the following questions as a guide. They can use the Internet or other resources to find the answers to the questions they don't know.

- What significant changes in ozone levels did you observe over your selected time range in September and March?
- What is different from the observation of the Northern and Southern hemispheres?
- Can you connect any major events or trends correlating with the changes you saw in specific years?
- Do you know where the so-called "ozone hole" is? Why was it formed there?
- And regarding other zones with high ozone depletion - what could be the major factors?

Teacher's Input: *It is important that, at this point, teachers introduce how ozone depletion is linked to human activity, what are the main causes, and make the connection between energy production and ozone depletion, which will be explored in the next part.*

Part 2. Ozone Depletion, Greenhouse gases emissions and Climate Change (30 min)

The main contributors to the ozone depletion

Although some natural phenomena contribute to harming the ozone layer (ex. volcanic eruptions), the major factors are human caused. Mostly, the ozone layer destruction is aggravated by the release of chemicals present in industrial gases which have been used for many years in a range of products and applications including aerosol sprays, refrigerators, air conditioners, fire extinguishers and crop fumigation. These substances, called Ozone-Depleting Substances (ODS) are, particularly, hydrochlorofluorocarbons (HCFCs) and chlorofluorocarbons (CFCs).

Note: *Teachers should also mention the Montreal Protocol (1987), conducted to address the destruction of the ozone layer. It was the first international treaty to be signed by all countries of the world and is considered the greatest environmental success story in the history of the United Nations. The Montreal Protocol's objective is to cut down the production and consumption of ozone-depleting substances, in order to reduce their presence in the atmosphere and thus protect the Earth's ozone layer, and has led to significant positive changes over the years (read more here).*

The connection between ozone depletion, energy usage and greenhouse emissions

It is important to start by explaining that, while non-renewable energy is not the main driver of the ozone layer destruction, it was significant negative impacts on climate change, and, therefore, also on the ozone level.

Global warming is mainly caused by the build-up of human-produced greenhouses gases, mostly carbon dioxide and methane, which trap heat in the lower levels of the atmosphere. One of the major sources of greenhouse emissions are the production of non-renewable energy, particularly, the extraction of fossil fuels - coal, oil and gas - which account for "75 percent of global greenhouse gas emissions and nearly 90 percent of all carbon dioxide" (United Nations - Climate Action).

And how does climate change, powered by greenhouse gases emissions, impact the ozone layer?

In several ways:

- Climate change, driven by GHGs, contributes to warming in the troposphere and cooling in the stratosphere, which creates a more favorable environment for the formation of polar stratospheric clouds (PSCs), which are a key factor in the development of polar ozone holes.
- Also, the enhancement of the greenhouse effect may also be causing changes in circulation patterns in the troposphere that are, in turn, altering the circulation in the stratosphere, which, in turn, leads to an increase of cooling forces on the stratosphere over the poles and are thus making the formation of ozone holes more likely.
- Finally, increased levels of UV radiation (influenced by greenhouse emissions as well) affect sun-driven chemical reactions in the atmosphere, changing its composition, which is believe to lead to intensifying both climate change and ozone depletion, and, moreover, a delay of the ozone layer (see more).

Fossil Fuels and Green Transition

Step 1: The teacher should now, after this introduction, turn into, specifically, the extraction of fossil fuels (coal, oil and gas) as one of the major issues to climate change, and, subsequently, ozone layer destruction.

Step 2: First, students can be divided into three groups: Coal, Oil and Natural Gas. They will be responsible for explaining:

- What is fossil fuel under analysis and what is mostly used for?
- How is it extracted?
- **How does** the use of fossil fuels contribute to greenhouse emissions and, potentially, ozone depletion?

Step 3: After they gather the results, they should discuss them in class and share their major conclusions. Afterwards, as a transition, ask them: "And how can green transition contribute to minimize this problem?"

Let them search for answers and list the benefits, which can be, but are not limited to:

- **Green Energy Sources:** Use of solar, wind, hydro, and geothermal energy reduces greenhouse gas emissions and mitigates global warming.
- **Reduced ODS Emissions:** Renewable energy technologies minimize the reliance on processes that produce ozone-depleting substances.
- **Improved Air Quality:** Less pollution from green energy sources improves air quality and public health.
- **Energy Efficiency:** Promotes sustainable practices and reduces overall energy consumption.

Part 3. Green-collar professionals (45 min)

What are the green-collar professionals?

Step 1: Start by asking the students: "Do you know what green collar professionals are?". Let them have a brainstorming session, and afterward, provide them with an explanation. Also, mention that later they will play a game about what these people actually do.

This theoretical part can be based on the information provided below:

Green-collar professionals are workers in the growing green economy engaged in jobs that help reduce carbon emissions and promote sustainable and renewable energy sources. These professionals work across various sectors, including renewable energy, energy efficiency, clean transportation, sustainable agriculture, and conservation.

Green-collar jobs often require skilled labor, specialized training, and education. They are vital to the green economy, which will likely expand significantly due to the rising demand for clean and sustainable energy; therefore, they are expected to play a crucial role in driving economic growth, reducing greenhouse gas emissions, and addressing climate change.

Learn more here.

Examples of green-collar professions include:

- **Renewable energy technicians**, who install, maintain, and repair solar panels, wind turbines, and other renewable energy systems.
- **Energy efficiency auditors**, who analyze energy usage in buildings and recommend energy-saving measures to reduce energy consumption.
- **Sustainable agriculture specialists**, who work on farms and ranches to promote sustainable and eco-friendly farming practices.
- **Conservation biologists**, who work to protect and conserve natural resources and habitats.
- **Clean transportation engineers**, who design and develop cleaner transportation systems such as electric vehicles and public transit.

Gamer or professional? Learn what green-collar professionals do!

Step 1: Start by highlighting to the students the need and crucial importance of green-collar jobs, now but especially in the future. Then, distribute the "*Green Collar Professional and professional skills"* game cards and ask them to match the **profession** with the **description** and **skills needed**. They can work alone or in groups. The **solution sheet** for the game is in the annexes of this activity.

Step 2: After the game is finalized and the responses are checked, open the discussion:

- What did you think about these professions? Did you like any of them?
- Do you see yourself doing any or some of them?
- What skills do you think are still missing that you need to develop in order to achieve it?

Part 4. Professional careers related to space or green jobs (optional) (30 min)

The activity of watching the ozone layer through satellites can be related to future opportunities in the space sector as it highlights the importance of space technology and its applications in monitoring and protecting the Earth's environment. This activity can inspire students to consider careers in the space sector, particularly in the field of Earth observation and environmental monitoring.

In addition, the focus on sustainability and renewable energy sources in the activity is also relevant to the space sector, as there is a growing demand for sustainable and environmentally friendly practices in space exploration and satellite technology. For example, space agencies such as NASA and ESA are exploring the use of solar power and other renewable energy sources in their missions.

Moreover, the concept of green-collar jobs introduced in the activity can also be applied to the space sector, as there is a need for skilled workers who can contribute to the development and implementation of sustainable and eco-

friendly practices in space technology and exploration. This could include roles such as renewable energy technicians, sustainable agriculture specialists, and conservation biologists, among others.

By linking the activity to future opportunities in the space sector, VET schools can encourage students to consider careers in this exciting and rapidly growing field, while also promoting the importance of sustainability and environmental protection in the context of space exploration. Taking the game as a starting point, and the discussion held in the previous step, teachers can help the interested students trace individual career or training plans, helping them find the ways to pursue a career that caught their attention - to get the training needed, to develop necessary skills and enter the job market.

4. Annex I: Materials

- Computer or tablet with internet connection
- Physical or digital board
- Printed game cards

5. Annex II: Background information and tutorials

Further information / background:

Monitoring of the ozone layer | Copernicus

The Montreal Protocol on Substances that Deplete the Ozone Layer

Ozone Depletion and Climate Change

Green Collar Workers: An Emerging Workforce in the Environmental Sector - PMC

Skills development and inclusivity for clean energy transitions

Skills development for renewable energy and energy efficient jobs

The cards for the *Green Collar Professional and professional skills game* are included in this activity (in a separate document), so you can download and use them. Also, edit them if needed: editable cards.

Tutorial of the game

Gameplay

1. First, shuffle the profession titles and the profession descriptions cards and place them face down on the game board.
2. The students will take turns flipping over a profession title card and a profession description card. They must then identify if they match. Then place the cards either together, if they match or separately if they don´t. The following student does the same, until every profession has their accordingly description card.
3. The second part is to link which skills and competences are linked to each profession.

Solutions

Profession	Description	Skills and competences
Renewable Energy Engineer	Designs and implements systems that harness renewable energy sources. They develop sustainable solutions such as solar, wind, or hydroelectric power systems, maximizing energy efficiency and reducing reliance on fossil fuels.	• Strong foundation in electrical, mechanical, or civil engineering principles • Knowledge of renewable energy technologies (solar, wind, hydro, geothermal) • Problem-solving skills • Data analysis proficiency • Project management skills • Practical knowledge of installing and maintaining renewable energy equipment and systems
Urban planner	Develops plans and programs for land use in urban areas, balancing social, economic, and environmental factors to create sustainable communities. They work on projects such as transportation systems, public spaces, and zoning regulations.	• Ability to assess urban data and trends • Knowledge of regulations and policies affecting land use • Proficiency in presenting plans to stakeholders and the public • Skills in coordinating and managing urban development projects
Space Systems Analyst	Analyzes and evaluates space systems and technologies. They assess the feasibility, performance, and effectiveness	• Strong foundation in aerospace engineering and space technology • Ability to analyze complex data and system performance

	of various space missions, satellite systems, and spacecraft designs.	• Proficiency in simulation and modeling tools • Skills in troubleshooting and optimizing space systems
Environmental Scientist	Studies the natural world and its interactions with human activities to assess and mitigate environmental issues. They conduct research, collect and analyze data, and evaluate the impact of human actions on ecosystems, biodiversity, and the overall environment.	• Ability to design and conduct scientific studies • Proficiency in analyzing environmental data • Skills in preparing reports and scientific papers • Experience in conducting environmental assessments and sampling
Solar Panel Technician	They are responsible for installing, maintaining, and repairing solar energy systems. Their expertise lies in handling electrical components, ensuring safety protocols, and optimizing the efficiency of solar power systems. iance on fossil fuels.	• Knowledge of electrical systems and solar technology • Ability to perform physically demanding tasks • Skills in diagnosing and fixing system issues • Understanding of safety protocols and practices
Energy Auditor	Conducts energy audits for residential, commercial, and industrial buildings to assess energy consumption patterns and identify opportunities for energy efficiency improvements. Performs on-site inspections, evaluates energy usage data, and provides recommendations..	• Ability to analyze energy consumption data • Understanding of heating, cooling, and electrical systems • Proficiency in explaining findings and recommendations to clients • Skills in conducting thorough inspections and assessments
Conservation Scientist	Manages the overall land quality of forests, parks, rangelands, and other natural resources. They work to	• Ability to conduct studies on natural resource management • Proficiency in analyzing ecological data • Experience in monitoring and

	conserve soil, water, and biodiversity.	assessing natural resources ● Skills in developing conservation strategies and solutions
Space Environmental Scientist	They focus on understanding how space activities, such as satellite launches, space debris, and radiation, impact the Earth's atmosphere and ecosystems. Their work involves analyzing data from space missions, developing sustainable practices for space exploration, and ensuring that space activities do not adversely affect the planet.	● Strong foundation in environmental science and space technology ● Ability to analyze complex datasets from satellites and other space instruments ● Proficiency in designing and conducting scientific studies related to space and environmental interactions ● Skills in developing sustainable solutions for minimizing the environmental impact of space activities ● Understanding of both space science and environmental regulation
Environmental Educator	Educates and raises awareness about environmental issues, sustainability, and conservation. Focuses on promoting environmentally responsible behaviors, fostering a sense of environmental stewardship, and inspiring positive change.	● Ability to present information to diverse audiences ● Proficiency in developing and delivering educational programs ● Understanding of environmental science and sustainability ● Skills in conveying complex information in an accessible manner