

# F-Gas-Compliant Low-GWP Freeze Dryer Powered by Renewable Energy

Cluster 4: Industrial Technologies

Cluster 6: Food, Bioeconomy, Natural Resources, Agriculture and Environment



# Project Definition

«F-Gas-Compliant Low-GWP Freeze Dryer  
Powered by Renewable Energy»

- ▶ This project aims to develop a **next-generation freeze dryer** that is **compliant with the EU F-Gas Regulation**, featuring **low-GWP refrigeration technology** and **high energy efficiency**. The system will be designed with a **renewable-ready energy infrastructure** and an **AI-enabled control system**; thereby enabling the simultaneous optimization of **energy consumption, process performance, and product/service quality**.
- ▶ The existing freeze dryer systems are not compliant with the F-Gas Regulation. Moreover, **freeze drying is an inherently high energy consuming process**. This project seeks to deliver a **sustainable and future-ready industrial freeze dryer solution** by jointly addressing **regulatory compliance, energy efficiency, and digitalization**.

## Expected Outcomes and Impacts

Full compliance with the EU F-Gas Regulation and continued product availability in the EU market

Reduced carbon footprint through low-GWP refrigeration

More efficient and stable freeze-drying processes AI-driven optimization

Lower energy consumption with a renewable-ready energy infrastructure

A sustainable and future-ready new freeze dryer product

# Technical Methodology

## Refrigeration System and F-Gas Compliance

- **New design** of an **F-Gas Regulation-compliant refrigeration cycle** using **low-GWP refrigerants** (down to  $-50^{\circ}\text{C}$ )
- **Full integration** with the freeze dryer **process**
- Conducting **system safety, leak-tightness, and risk analyses**

## Renewable-Ready Energy Architecture

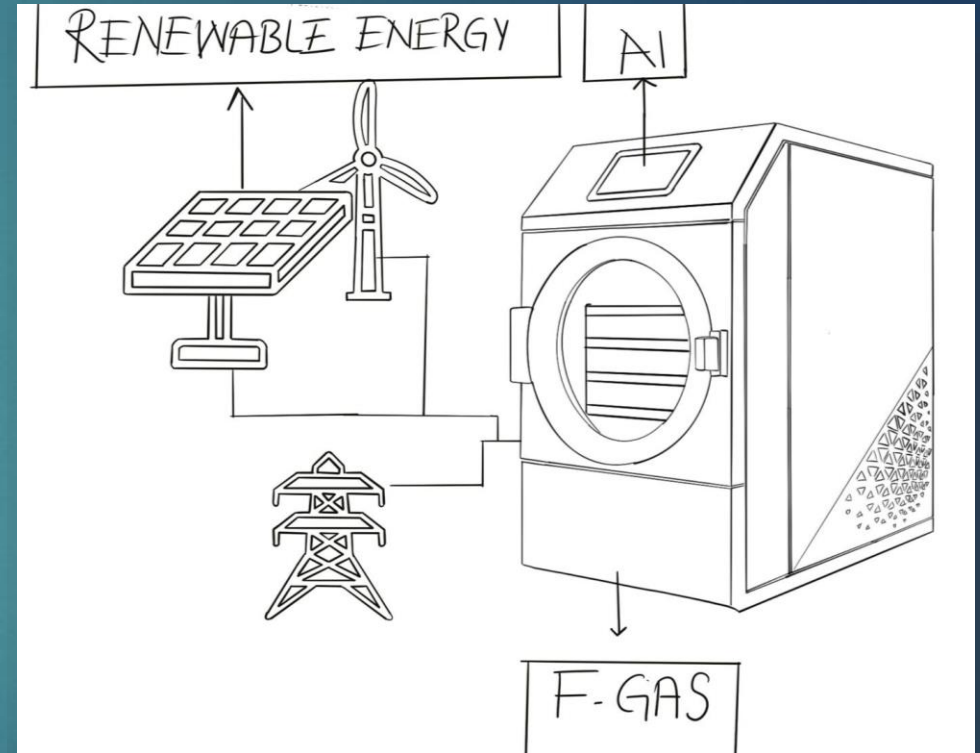
- **New design** that is **ready for integration** with **renewable energy sources** (solar/wind and other green sources)

## AI-Enabled Control and Optimization

- **Real-time** acquisition of sensor and process data
- **Machine learning** algorithms for process control and optimization
- Energy consumption monitoring and **intelligent energy management**

## System Integration and Validation

- Modular and scalable system architecture
- Digital monitoring and data logging infrastructure
- Verification of energy, performance, and safety requirements
- Prototype validation at real industrial conditions / customers



# Partners and Consortium Structure

## Project Lead

- Coordination, Standardization, EU Regulation Compliance and Production.

## Partner 1 – ‘F-Gas Free’ Cooling System Development

- University / research center with expertise in refrigeration and low-GWP technologies.

## Partner 2 – AI Based Drying Optimization

- University / research center with AI & data analytics expertise.

## Partner 3 – Renewable- Ready Energy Infrastructure

- Organizations with expertise in energy systems and the integration of renewable energy sources.

## Partner 4 – Pilot Application & Validation and LCA

- Pilot users (primary food sectors, secondary pharma/bio technologies)
- Research organizations with expertise in Life Cycle Assessment (LCA)

# Draft Timeline



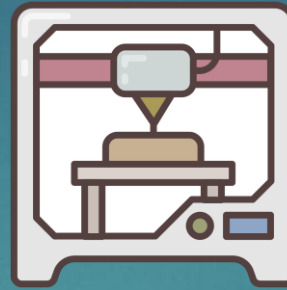
NRW.Europa

## Partner Search & Literature Review

- Form consortium
- Analyze literature & regulations

## System Design

- Cooling
- Energy
- Control
- Mechanical



## Prototype Development

- Integrated freeze dryer prototype
- Production process design

## Validation and Testing

- Conduct performance, energy & safety tests
- Ensure regulatory compliance



## Pilot Product and Commercialization

- Implement pilot applications
- Prepare for commercialization

# NÜVE Experience (Technology & Capabilities )

Since 1968 in TURKEY

Laboratory & Sterilization Systems

Design, Production & Sales

Certified R&D Center

EU Medical Device Directive

ISO 9001,13485,45001

68 Models over 110 countries

## Incentive Projects

TUBITAK 1998: Laboratory Centrifuge Device

TUBITAK 2001: Vacuum Dried Vapor Sterilizer

TUBITAK 2007: Class B Autoclave

TUBITAK 2009: CO2 Incubator

TUBITAK 2013: High Capacity Centrifuge

TUBITAK 2024: Green Gas Cooled Centrifuge

