# AgroBioHeat

Promoting the penetration of agrobiomass heating in European rural areas

# Agrobiomass resources in Europe and the state-of-the-art technologies for heat production

CERTH
CENTRE FOR RESEARCH & TECHNOLOGY HELLAS

BIO COGEN 2030

Webinar

**Biomass CHP solutions to decarbonize agriculture**

*28th April, 11:45 -12:45 (CET)*

Live at

EUBCE 2021
29th European Biomass Conference & Exhibition | 26 - 29 April Online

BLAZE

SmartCHP

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 818369. This document reflects only the author´s view. The Innovation and Networks Executive Agency (INEA) is not responsible for any use that may be made of the information it contains.

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- Agrobiomass overview
  - Definition, European potential, current use, cost-effectiveness
- The AgroBioHeat project
  - Objective, consortium, activities
- State-of-the-art agrobiomass combustion technologies
  - Potential challenges and solutions, technology comparison, first AgroBioHeat boiler test results and conclusions

# Agrobiomass overview

# Agrobiomass – Definition



**Agricultural residues**

- Herbaceous, *e.g.* straw, maize residues, etc.
- Woody, *e.g.* prunings, plantation removal biomass

**Agro-industrial by-products**

- Olive stones / olive cake, nut shells, sunflower husk, rice husk, peach kernels, *etc.*

**Perennial energy crops**

- Herbaceous, *e.g*. miscanthus, switchgrass
- Woody / Short Rotation Coppice, *e.g.* poplar, willow

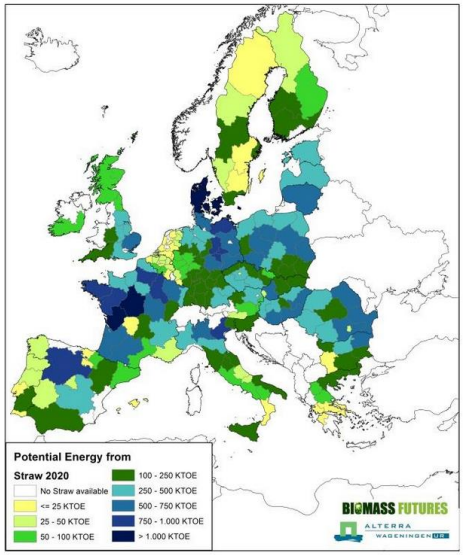
Great range of tradeable forms:

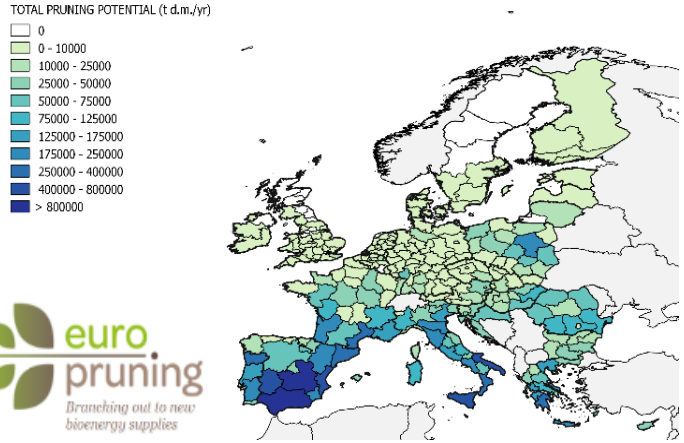
- Whole bales
- Chips or hog fuel
- Pellets or briquettes
- Granular materials

# Agrobiomass – European potential



- **Herbaceous agricultural residues:** 168 Mt dry, technical potential / 123.5 Mt dry sustainable potential
- **Agricultural prunings:** 12.5 Mt dry, technical potential
- **Agro-industrial residues**: not insignificant quantities available on the market, e.g. 1.2 Mt of exhausted olive cake just in Spain
- **Perennial energy crops**: currently 118,480 hectares in EU28 (around 0.07 % of Utilized Agricultural Area), primarily with miscanthus, poplar and willow




euro pruning
*Branching out to new bioenergy supplies*

**References for agrobiomass potential:**

- Herbaceous agricultural residues: Scarlat et al., 2019
- Agricultural prunings: Dyjakon & García-Galindo, 2019
- Agro-industrial residues: Manzanares et al., 2017
- Energy crops: Bioenergy Europe Statistical Report 2020

# Agrobiomass – Current uses

- Biomass feedstocks for energy in the EU: 69 % forest, 20 % agriculture, 11 % waste (Bioenergy Europe Statistical Report 2020)
- Straw in Denmark
  - 2.25 % of gross energy consumption and 10.2 % of RES production (2018)
  - Applications include farm heating, DH systems, CHP / large-scale power generation
  - Some examples of replication on local / regional scale in other European countries
- Agro-industrial residues (e.g. exhausted olive cake / olive stones in Mediterranean countries, sunflower husk in Eastern Europe)
  - Self-consumption by producing industries (e.g. olive pomace mills)
  - Leftover quantities are made available to the market for wide range of applications: domestic heating, greenhouses, industrial heat, CHP / power production
- "Local champions"
  - Typically initiated by pioneers with a vision for local agrobiomass utilization
  - May serve as inspirations for similar initiatives
- **Currently unused agrobiomass resources can play a significant role in the cost-effective decarbonization of the European rural heating system**
- **However, it needs support to overcome barriers: lack of knowledge, skepticism, appropriate selection of technologies, lack of policy framework…**

# Agrobiomass – Cost-competitiveness



| Agrobiomass fuels / Spain | Moisture (%) | LHV (kJ/kg) | Fuel Price | |
|---|---|---|---|---|
| | | | (€/t) | (c€/kWh) |
| Straw pellets | 6.3 | 15,940 | 140 | 3.16 |
| Corn stover pellet | 5.5 | 14,400 | 125 | 3.13 |
| Vineyard prunings (hog fuel) | 20.0 | 13,986 | 60 | 1.54 |
| Olive tree prunings (hog fuel) | 27.0 | 12,561 | 50 | 1.43 |
| Up-rooted fruit trees (chips) | 27.9 | 12,427 | 45 | 1.30 |
| Straw (bales) | 11.8 | 14,761 | 50 | 1.21 |
| Exhausted olive cake | 15.0 | 14,985 | 20 | 0.48 |

| Commodity fuels / Spain | Fuel Price – 2018 (c€/kWh) |
|---|---|
| Natural Gas | 7.70 |
| Heating oil | 7.01 |
| Wood pellets (bulk) | 5.06 |
| Fuel oil | 4.84 |
| **Olive stones (bulk)** | **3.47** |
| Wood chips (bulk) | 2.48 |

**Source:** AVEBIOM fuel price index / CIRCE & AVEBIOM – AgroBioHeat project

# AgroBioHeat project and activities

# AgroBioHeat – Summary information

- Overall aim: support European rural decarbonisation through market uptake of agrobiomass heating solutions
- Funding: Horizon 2020, Grant Agreement 818369
- Topic: LC-SC3-RES-28-2018-2019-2020 - Market Uptake support
- Duration: 1st January 2019 – 31st December 2021
- Total budget / EU funding: 2,998,043.75 € / 2,998,043.75 €
- Project Coordinator: Centre for Research and Technology Hellas (Greece)
- Website: http://www.agrobioheat.eu

# AgroBioHeat – Consortium



## Technical partners

CERTH
CENTRE FOR RESEARCH & TECHNOLOGY HELLAS

circe
RESEARCH CENTRE FOR ENERGY RESOURCES AND CONSUMPTION

BIOS
BIOENERGIESYSTEME GmbH

## European Association

Bioenergy EUROPE

## National multipliers

GREEN ENERGY
Romanian Innovative Biomass CLUSTER

LABIO
Bioenergy Association of Ukraine

Aile
initiatives énergie environnement

aveBiom

ΙΝΑΣΟ-ΠΑΣΕΓΕΣ
ΙΝΣΤΙΤΟΥΤΟ ΑΓΡΟΤΙΚΗΣ & ΣΥΝΕΤΑΙΡΙΣΤΙΚΗΣ ΟΙΚΟΝΟΜΙΑΣ

Zelena Energetska Zadruga


## Straw & network expertise

Food & Bio Cluster Denmark

## Operator of biomass heating plants

Agronergy

## Social sciences expertise

WHITE RESEARCH

# Supporting new agrobiomass heating initiatives




https://agrobioheat.eu/agrobioheat-seeks-new-icebreaker-agrobiomass-consumption-initiatives-to-provide-them-with-support/

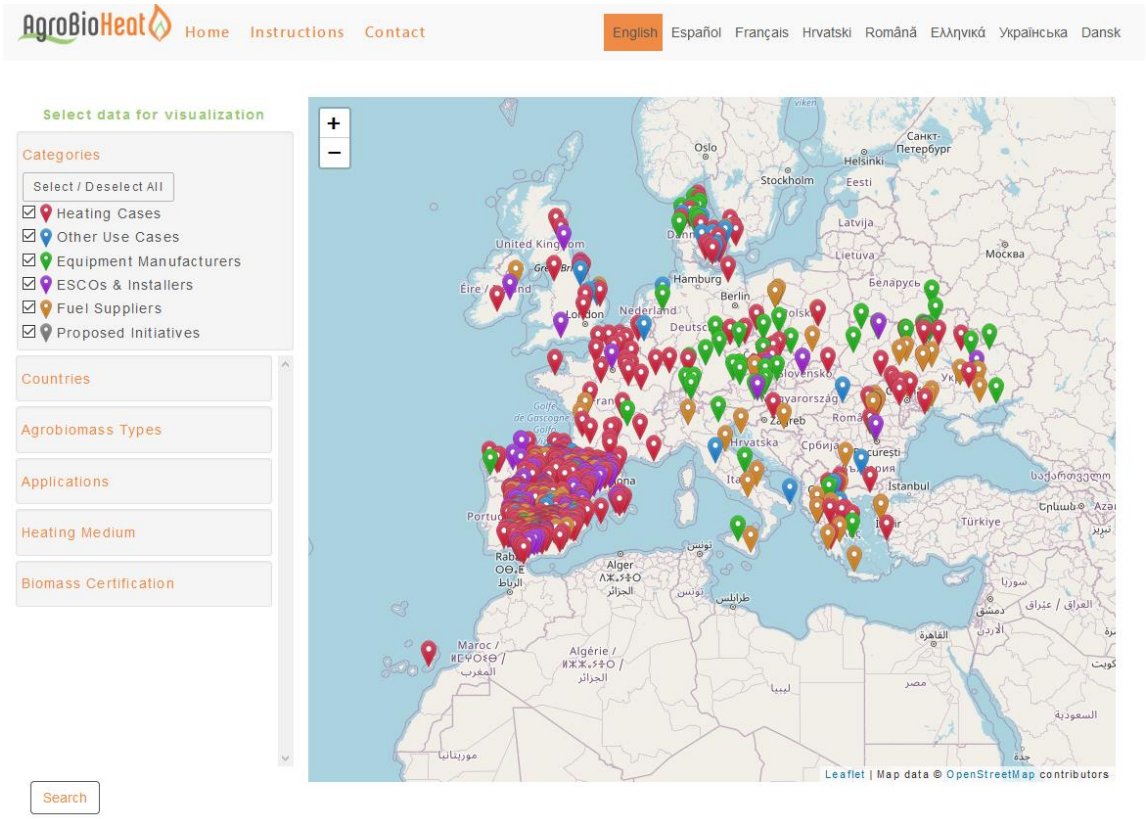
- More than 20 initiatives have been identified in Spain, Ukraine, Romania, Croatia and Greece
  - Various types of agrobiomass and end-users considered
- 7 initiatives selected for further project support
- 1 facility of Agronergy in France to investigate transition from wood chips to agrobiomass

## Vilafranca del Penedès (ES) – 27th February 2020


- Workshop on using vineyard prunings for heat / energy production
- Site-visit to “La Girada” district heating of local municipality, fueled exclusively with vineyard prunings / 500 kW Heizomat boiler
- Site-visit to Familia Torres / 2.6 MW biomass boiler coupled with adsorption chiller for cooling / fueled by forest wood chips and vineyard prunings
- Further information: https://agrobioheat.eu/vilafranca-del-penedes-visit/

# The AgroBioHeat Observatory

## www.agrobiomass-observatory.eu

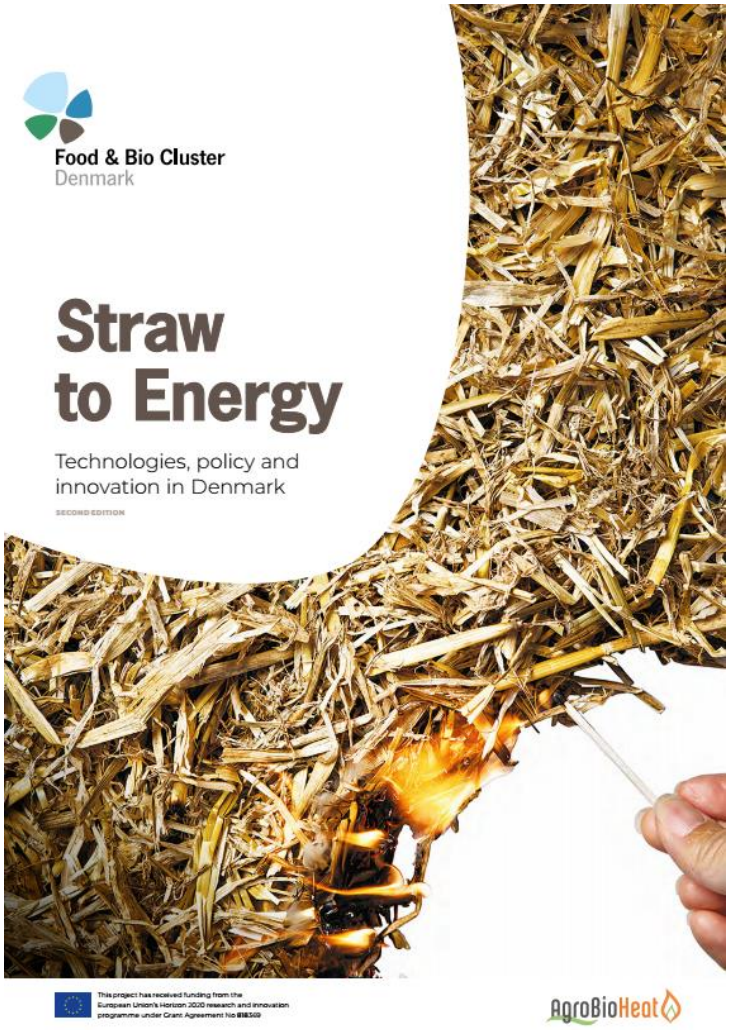



- 680 agrobiomass heating cases (thermal output < 50 MW)
- 51 other cases of agrobiomass use (power, CHP, large-scale heat, *etc.*)
- 67 equipment manufacturers (boilers, flue gas cleaning systems, others)
- 113 ESCOs & Installers
- 114 agrobiomass fuel suppliers

**Continuously updated!**

# Guides and factsheets






AgroBioHeat

## State of the art combustion systems factsheet

In order to achieve high combustion efficiency and low emissions when using agrobiomass, the selection of appropriate, modern combustion systems is very important and each boiler subsystem – feeding system, combustion chamber, heat exchanger, ash removal system, control system and flue gas cleaning system – has to be compatible with the specific biomass's properties.
Usually such systems are automatically controlled and have a moving grate that allows for an effective and complete combustion and automated heat exchanger cleaning in order to prevent ash deposit formation and corrosion.

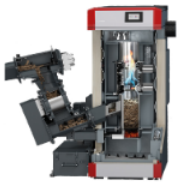
*Modern biomass boiler with moving grate and automated mechanical heat exchanger cleaning*

**Feeding systems**: The majority of modern boilers includes an automatic fuel feeding system. Depending on the form the agrobiomass is available in the market and how it is stored, different feeding systems may be required. The most common fuel feeding systems for granular fuels and chips/hog fuel are **feeding screws**, coupled with **agitators** if needed.

**Ash removal systems**: Ash removal is often considered to be a main drawback with regard to the ease of use in biomass boilers. This is why the de-ashing system is of great importance. Grate ash and ash resulting from the heat exchanger cleaning process are collected in the ash box. De-ashing is typically carried out automatically by a de-ashing screw that conveys the ash into a sufficiently large-sized container.

**Moving grates**: Moving grate burners can achieve a high combustion velocity and efficiency, because the solid fuel moves across the grate from the inlet section to the ash discharge section and this allows a better mixing between air and fuel and facilitates the distribution of char, which then burns more quickly. Moving grates have a different configuration according to the different mechanical principle that moves the grate. The main types of moving grates are: **travelling grates, reciprocating grates, vibrating grates, cigar burners** and **through-screw systems**.

**Control systems**: A state of the art automated process control system of a modern biomass combustion plant usually consists of load control, combustion control, furnace temperature control, furnace pressure control and control loops needed for operation safety aspects.



A revolutionary example of state of the art combustion systems with high fuel flexibility are **biomass gasification boilers** that include an updraft gasifier, a gas burner and a hot water boiler. Such systems can achieve almost zero CO and OGC emissions, significantly reduced NOx emissions (compared to conventional fixed-bed combustion technologies) and very low particulate matter emissions.

**Heat exchanger cleaning**: Usually, in small and medium-scale biomass boilers, gas tube heat exchangers are applied (hot flue gas flows inside the tubes while the water flows outside the tubes).A clean heat exchanger is crucial for the lifespan and efficiency of an agrobiomass boiler. There are two main technologies for heat exchanger cleaning, one is based on mechanical means and the other on pressurized air. A pneumatic heat exchanger pipe cleaning system regularly removes the deposited ashes from the heat exchanger with **short bursts of compressed air**, while a mechanical heat exchanger cleaning system moves them by the automatic periodic **reciprocating movement of turbulators**.

*Image sources:modern biomass boiler with moving grate and automated mechanical heat exchanger cleaning - CAMINO DESIGN (www.caminodesig.gr), biomass gasification boiler - PuroWIN Windhager (www.windhager.com)*

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Find out more about agrobiomass systems equipment manufacturers in AgroBioHeat's Agrobiomass Heating Observatory

SCAN ME

# Matchmaking events and sector promotion


https://bringing-value-to-agrobiomass.b2match.io/

- 259 participants
- > 280 bilateral meetings
- 2nd edition planned for Autumn 2021




# State-of-the-art agrobiomass combustion technologies

# Challenges & solutions in agrobiomass combustion



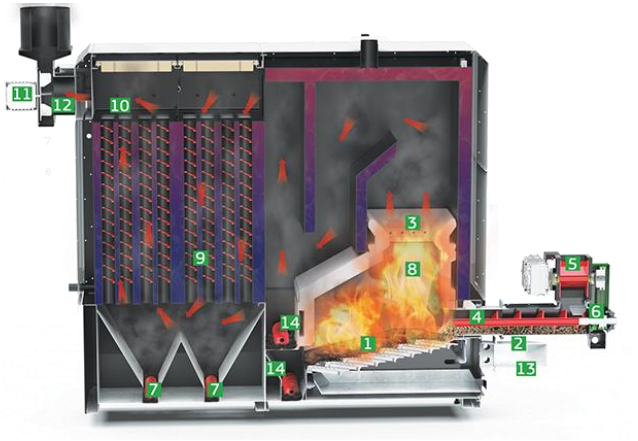
- Different agrobiomass assortments may present different challenges during combustion
- Solutions available, but always a question of techno-economic feasibility
- For large applications (typically above 1 MW), possibilities for tailored solutions
- Good boiler design is key to many potential issues

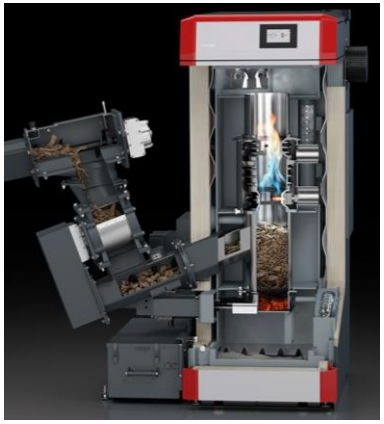
| Characteristic | Potential challenges | Solutions |
|---|---|---|
| **Ash** | High ash content → Large volumes to handle | Adequately designed ash handling system |
| **Sulphur** | High fuel-S → SOx emissions & corrosion | Secondary measures (lime injection)<br>High water-side temperatures and high grade steel |
| **Nitrogen** | High fuel-N → NOx emissions | Primary measures (air staging)<br>Secondary measures (SNCR / SCR) |
| **Chlorine** | High fuel-Cl → HCl and dioxin emissions & corrosion | Proper boiler design<br>Sufficiently high return temperatures |
| **Potassium** | High fuel-K → Fouling & high PM emissions | Large combustion volume to lower flue gas temperatures before first boiler tube pass<br>Use of inorganic fuel additives<br>Secondary measures for PM control |
| **Ash melting temperature** | Low ash shrinkage starting temperature → Slagging / clinker formation & fouling | Water cooled grate<br>Flue gas recirculation below the grate |
| **Physical properties** | Debaling, inhomogeneity, stickiness, low bulk density, etc. | Good design of fuel handling / pre-treatment system |

Table adapted from L. Justsen / Justsen Energiteknik A/S, WBA Webinar: Agricultural residues to energy / Latest technological developments

# Main agrobiomass combustion technologies





| | Moving grate | Gasification concept |
|---|---|---|
| **Market maturity** | Widely deployed / numerous manufactures and models | Innovative concept / currently offered by limited manufacturers |
| **Capacity ranges** | ~ 30 kW - 150 MW | ~ 30 kW – 20 MW |
| **Unburnt pollutants** | Conventional air staging | Extreme air staging |
| **Particle emissions** | Further reduction through secondary measures (e.g. ESPs, bag-filters) | Low emissions achieved without the need for secondary measures |
| **NOx emissions** | Primary measures<br>Secondary measures may apply above the 1 MW scale | Primary measures (some potential for further reduction compared to grate-fired systems) |

Images sources: Camino Design (left), Windhager (right)

# AgroBioHeat boiler tests – first results



| | CO [mg/Nm³] | OGC [mg/Nm³] | $NO_x$ as $NO_2$ [mg/Nm³] | TSP ds boiler [mg/Nm³] | TSP ds ESP [mg/Nm³] |
|---|---|---|---|---|---|
| Ecodesign emission limit* | 500 | 20 | 200 | 40 | 40 |
| Boiler 1 / SH pellets | 4.5 | < 1.0 | 369.4 | 16.6 | n.a. |
| Boiler 1 / Poplar | 52.9 | < 1.0 | 299.9 | 15.4 | n.a. |
| Boiler 1 / Agropellets | 7.0 | < 1.0 | 480.8 | 12.8 | n.a. |
| Boiler 2 / Miscanthus | 169.4 | < 1.0 | 238.7 | 91.7 | 28.0 |
| Boiler 2 / Olive stones | 267.8 | < 5.5 | 177.6 | 68.7 | 21.0 |

* According to the Ecodesign Regulation for woody biomass fuels

Boiler 1: 45 kW nominal capacity (with wood chips), based on innovative extreme air staging concept

Boiler 2: 49 kW nominal capacity (with wood chips) / 40 kW (with miscanthus, agropellets and energy corn) based on moving grate technology and conventional air staging, coupled with ESP

All data relate to seasonal emissions = 0.15*emission FL + 0.85*emission PL (FL: Full Load; PL: Partial Load) and dry flue gas @10 vol% $O_2$

- Boiler efficiencies ranging from 87% to 94% (on fuel NCV basis)
- Dioxin measurements for miscanthus well below the limits of German regulations (1. BImSchV)

→ For further details, see EUBCE 2021 presentation / paper: T. Brunner, P. Nowak, C. Mandl, I. Obernberger, Assessment of Agrobiomass Combustion in State-of-The-Art Residential Boilers, Session reference: 2AO.5.1

# AgroBioHeat boiler tests – first conclusions



- Compliance with Ecodesign Regulation emission limits for CO, OGC and TSP has been demonstrated for a wide range of agrobiomass fuels using state-of-the-art residential biomass boilers implementing appropriate technologies
- Elevated fuel-N content of agrobiomass generally leads to NOx emissions higher than the Ecodesign limit
  - However, NOx emission limit value of the MCP Directive (480 mg/Nm$^3$ at 10 vol% $O_2$) seems feasible
- Use of inorganic additives in the production of agropellets can help control TSP emissions from high-K agrobiomass assortments
- Additional tests with other small-scale biomass boilers and agrobiomass fuel assortments are planned and will lead to the consolidated project proposal about the applicable agrobiomass emission limits for the review of the Ecodesign Regulation

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# Thank you for your attention!

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