Logical architecture for green technology applications in Roehren-und Pumpenwerk BAUER GmbH (Austria)

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Abstract. The research shows that global climate change and population growth increase the pressure on the planet's natural resources, especially water and land resources. These statistics reveal the state, dynamics and prospects of agricultural development, the use of agricultural land in the EU and Austria. Data on the use of different types of irrigation by Austrian farmers are provided. The use of Austrian irrigation technology in world agriculture with GPS navigation, irrigation programming function based on data obtained using smart controllers, making it easier for the farmer to predict the future crop yield and consumption of water and energy resources. It is shown that the aspiration of modern companies, such as Roehren-und Pumpenwerk BAUER GmbH (Austria), to use green technologies is responsible behaviour before the future generations of the planet Earth.

1. Introduction

"Blue plane in the middle of the blackness of the Universe" - the famous photo taken in 1972 by the Apollo mission (USA) has become a symbol of respect for the Earth and water resources [1]. Green technologies, which combine ecology, economy, social technology, science and technology achievements have become a manifestation of the modern trend of efficiency of an interdisciplinary approach to solving complex problems [2]. In a report at the conference: "Global goals for sustainable development in a mediated world" Directors of the Vienna Institute of Demography Wolfgang Lutz research showed that there is a correlation between education, income growth and state of health, and it leads to an increase in life expectancy and global demand for quality food, which will put unprecedented pressure on the planet's land and water resources in the future [3, 4]. Only an increase in irrigated agricultural land will provide an additional 840 million people with food by 2050. Currently, the consumption of "green water" on arable land in the world is 5406 km³ per year, to achieve crop growth in conditions of "water stress", an additional 2860 km³ of "blue water" will be
required» [5]. The increase in irrigated land over the past two centuries has been fairly uniform. In 1800, there were 8.1 million hectares of irrigated land, in 1950 - 105 million hectares, in the early 1970s more than 170 million hectares, in 2016-331.8 million hectares, in 2030 – 370 million hectares. At the end of the XX century, irrigated land in India and China was especially intensively put into circulation – 1.5-2.0 million hectares/year. In 2016, 8.9 % of the used agricultural areas in the EU were in the status-irrigated (15.5 million ha), actually watered – 10.2 million ha. The largest shares of irrigated land are Spain 15.7 %, Italy 32.6 %. Over the past two decades, water consumption in agriculture in the EU has increased (24% of the total water intake). The current EU Water Directive- WFD (2000/60/EC) regulates the use of river basin waters [6]. The level of environmental impact of agricultural activities depends on natural and environmental conditions and socio-economic factors both within and between EU countries. Based on the results of the IRENA process, the European Commission identified 28 agri-environmental indicators that regulate agricultural production in the field of irrigated agriculture – irrigation areas, fertilizer consumption, pesticide consumption, soil treatment methods, soil cover and manure storage conditions [7]. The total goal of the research is to provide the practice of using water resources and conducting irrigated agriculture to the Republic of Austria; the activities of the Austrian company BAUER GmbH on the application of green technologies.

2. Results and Discussion

Agriculture in Austria is the leading sector of the national economy, and the Government uses various measures to promote it and quotas. In 2017, there were 161,200 agricultural and forestry enterprises in the country, which employed 410,900 people. The main activity is the cultivation of cattle, sheep and goats (58.4 thousand units or 36%). The second largest number of employees is forestry (48.2 thousand units or 30%). This is followed by enterprises that grow cereals, oilseeds and root crops (21.2 thousand units, 13%). 90% of all rural and forest farms in Austria are family-owned enterprises. The average area of agricultural land is 19.7 ha. The total value of products produced in the agricultural sector in Austria in 2017 was 7.3 billion rubles. Euro (+6.8% compared to 2016). 22% of the total agricultural area in Austria was processed in accordance with the requirements for organic agriculture (figure 1) [8, 9].

![Figure 1](image_url)

Figure 1. Number of organizations, number of employees, production volumes in the agricultural sector in Austria in 2017 compared to 1990.
the West and North are suitable for crop production and more intensive forms of animal husbandry (table 1), with farmers using different types of irrigation (table 2).

Table 1. Agricultural and forest lands in the Federal lands of Austria (ha).

| Federal state of Germany | 1990     | 2010     | 2016     |
|-------------------------|----------|----------|----------|
| Burgenland              | 324 919  | 287 532  | 285 460  |
| Carinthia               | 861 523  | 860 375  | 827 680  |
| lower Austria           | 1 681 420| 1 650 661| 1 639 878|
| Upper Austria           | 1 074 614| 1 061 215| 1 048 559|
| Salzburg                | 671 042  | 640 721  | 640 332  |
| Styria                  | 1 502 362| 1 433 357| 1 405 490|
| Tirol                   | 1 195 840| 1 176 094| 1 192 845|
| Vorarlberg              | 215 755  | 215 117  | 202 581  |
| Vienna                  | 27 341   | 22 464   | 18 750   |
| Austria                 | 7 554 815| 7 347 535| 7 261 574|

One of the areas where plant products are cultivated is the semi-arid Pannonian region of Eastern Austria with cold winters and hot dry summers. The average precipitation for the main growing season (May - September) is 250-300 mm.

Table 2. Types of irrigation used by Austrian farms, 2016.

| Federal state of Germany | Sprinkling | Drip irrigation | Surface irrigation |
|-------------------------|------------|-----------------|--------------------|
| Burgenland              | 330        | 273             | 90                 |
| Carinthia               | 38         | 18              | 36                 |
| lower Austria           | 998        | 555             | 137                |
| Upper Austria           | 156        | 195             | 47                 |
| Salzburg                | 42         | 9               | 26                 |
| Styria                  | 365        | 443             | 94                 |
| Tirol                   | 338        | 102             | 137                |
| Vorarlberg              | 101        | 36              | 35                 |
| Vienna                  | 150        | 159             | 31                 |
| Austria                 | 2519       | 1791            | 634                |

Due to large inter-annual differences in precipitation, effective irrigation water use should be based on soil moisture analysis. Research shows that to maintain a high level of crop yield, it is necessary to increase water stress at a depth of 20-40 cm below the soil surface [10]. Farmers can use irrigation standards calculated using (1):

\[ M^\text{op}_t = \frac{R'_t - \bar{R}_0t \times L(M_{Mt} + O_Ct)}{\bar{R}_0t \times L} \times 100, \]

where \( M^\text{op}_t \) - irrigation rate determined based on the conservation and reproduction of soil fertility, m³/ha;

\( R'_t \) - radiation balance of the active surface under anthropogenic influence, t, kj/cm² per year; \( M_{Mt} \) - additional amount of moisture obtained through the use of agrotechnical irrigation, cm/ha; \( \bar{R}_0t \) - "dryness index" in natural conditions.

For agricultural crops in arid zones, taking into account the coefficient of natural moisture, irrigation norms (m³/ha) can be for: perennial grasses (alfalfa) from 1140 to 778 m³/ha; cereals (wheat, barley) from 160 to 4890 m³/ha; vegetables (tomato, cabbage, onion) from 120 to 5210 m³/ha [11, 12]. To assess the soil fertility of irrigated lands (max 20), it is advisable to use the integral indicator "soil index", which reflects the ecological functions of soils, the composition of humus and minerals, as well as acid-base indicators (2):
\[ S = 6.4(G_{\text{гн}} + 0.2G_{\text{фк}})/600 + 8.5\sqrt[3]{NPK} + 5.1 \exp[-|H_H - 1|]/\beta, \]  
\[ (2) \]

where 6.4; 8.5; 5.1 – weighting factor; \( G_{\text{гн}}, G_{\text{фк}} \) – stocks of humane and fulvate humus, respectively, ton/ha; \( N, P, K \) – the presence of mineral nutrition elements (nitrogen, phosphorus, potassium) as a percentage of the optimal value for this culture; \( H_H \) – hydrolytic acidity, mEq-L/100 g of soil; \( \beta \) – coefficient equal to 4 mEq-L/100 g.

The BAUER GmbH group of companies (Austria), realizing that the environment is very sensitive to climate change, aims to take these factors into account when developing new machines and making decisions [13]. The company has been working for more than 80 years in the field of irrigation technologies. Today, 2.5 million hectares around the world are watered by irrigation machines produced by the hands and skills of 675 employees. Consolidated net proceeding for the 2018/2019 year amounted to 135 million euros.

The BAUER Group consists of 17 companies, including: BSA, Eckart and FAN. The main markets are: Germany, France, Russia, China, USA, South America. The line of irrigation equipment consists of well-known models: Centerstar, Centerliner, Linstar. In recent years, irrigation control technologies for sprinklers have been intensively developed in the direction of automation, saving energy and water resources, and increasing the number of tasks performed by the equipment directly during irrigation (application of fertilizers and chemicals with irrigation water). The Smart Rain system installed on irrigation machines makes them quite "smart" (figure 2).

![Figure 2](image-url)

**Figure 2.** Centerstart irrigation management using the Smart Rain program installed on the farmer’s smartphone.

The farmer can get real-time information about the state of the water supply network, irrigation water consumption, soil moisture level, as well as information about the weather and precipitation. The app is available on iOS and Android phones, desktop computers, and works with mobile networks, 4G LTE, and Cat M1 communications. Smart rain controllers placed on the field allow you to take into account evaporation coefficients in order to correctly calculate the irrigation rate (figure 3).
A smart irrigation system combines several elements: a smart controller (sensors for water flow, rain, humidity); computerized planning allows you to store and transmit data, make calculations for evapotranspiration of plants (figure 4).

Water use efficiency is an important agronomic factor, especially in climate zones where there is a limited amount of water that needs to be "stretched over the entire growth period". In 2020, BAUER GmbH is launching a series production of the Rainstar E irrigation machine with a solar panel, which will increase the battery life. The ECOSTAR 6000 irrigation computer, offered as an option, guarantees precise adjustment of the pipe retraction rate and irrigation intensity. The 4.3-inch Full LED screen with touch screen makes maintenance easy and convenient: with just a few last post, you can find functions that allow you to effectively irrigate the field. Among the advantages of the new Rainstar E series: a new design protective cover, optimized power management; a transmission with easier switching; precise adjustment and control using Smart Rain. The Smart CONNEC control Cabinet allows you to start an irrigation machine installed at a distance of 185 km using your smartphone. In the coming years, digital technologies will become a determining factor in the development of national economies, in terms of agriculture [14].

3. Conclusion

Research shows that irrigation technologies are a factor in the development of agriculture in the 21st century. The use of green technologies by BAUER GmbH in the management of irrigation systems makes irrigated agriculture economically balanced and environmentally safe. The introduction of the Rainstar E series on the market is a new step in saving water and energy resources. Research shows
that irrigated agriculture will help to mitigate climate change and provide food for the Earth’s population.

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