# RESEARCH ON THE COMBINATION OF VEGETATIVE STRIPS WITH VERTICAL AGRIVOLTAIC SYSTEMS AS PART OF AGRI-ENVIRONMENTAL-CLIMATE MEASURES SUPPORTING BIODIVERSITY.

Project SS05010243 - **Program** Prostředí pro život 5.

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MINISTERSTVO ZEMĚDĚLSTVÍ

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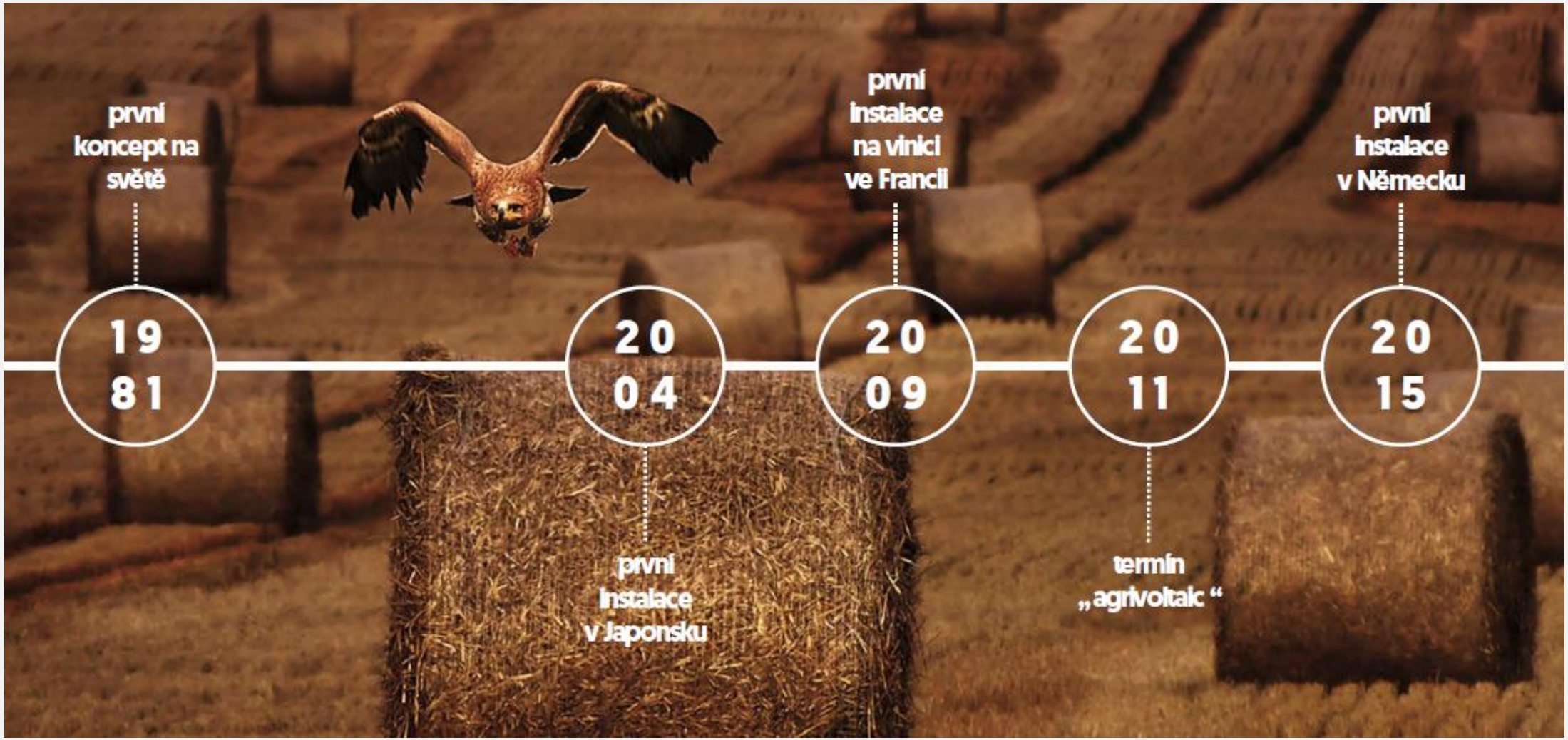
# AIM OF THE PROJECT

- The aim of the project is to research a combination of vegetative strips with a vertical agrivoltaic system and its contibution to biodiversity in the agricultural landscape while increasing the economic attractiveness of vegetative strips through the generation of renewable electricity. Vegetative strips will be sown by mixtures of grasses and nectar-bearing plants according to the principles of agri-environment-climate measures and vertical photovoltaic panels will be installed in these strips. The changes in the biological diversity of plants and insects, the impact on crops and the performance of the power plant will be monitored. Output will be documents for amendments to legislative regulations and recommendations for agricultural practice.
- -Project participants are– VÚZT, v.v.i., VÚRV, v.v.i., ČZU TF, Stradlova s.r.o.
- Project realisation 2022-2024, implementation period 2025-2027.
- **-Application Guarantor** - Department of Environmental and Organic Agriculture Ministry of Agriculture Czech republic - MZe,

# AGRIVOLTAICS OR AGRIPHOTOVLOTAICS




Source: Agrivoltaika s.r.o. a Solarworks

# STATE OF THE AGRICULTURAL LAND FUND IN THE CZECH REPUBLIC

| Stav ke dni | Orná půda | Chmelnice | Vinice | Zahrada | Ovocný sad | Trvalý travní porost | Celkem zemědělská půda |
|---|---|---|---|---|---|---|---|
| 31.12.2020 | 2 931 912 | 9 548 | 20 179 | 172 059 | 44 022 | 1 022 716 | **4 200 204** |
| 31.12.2019 | 2 940 927 | 9 827 | 20 141 | 169 286 | 44 376 | 1 017 555 | **4 202 112** |
| 31.12.2018 | 2 951 395 | 9 899 | 20 001 | 166 350 | 44 986 | 1 011 095 | **4 203 726** |
| 31.12.2017 | 2 958 603 | 10 066 | 20 008 | 164 815 | 45 245 | 1 006 552 | **4 205 288** |
| 31.12.2016 | 2 965 606 | 10 127 | 19 835 | 164 024 | 45 390 | 1 003 393 | **4 208 374** |
| 31.12.2015 | 2 971 957 | 10 149 | 19 811 | 163 785 | 45 613 | 1 000 620 | **4 211 935** |
| 31.12.2014 | 2 978 989 | 10 276 | 19 611 | 163 601 | 45 920 | 997 225 | **4 215 621** |
| 31.12.2013 | 2 985 792 | 10 312 | 19 652 | 163 476 | 46 172 | 994 461 | **4 219 867** |
| 31.12.2012 | 2 993 236 | 10 355 | 19 562 | 163 320 | 46 393 | 991 523 | **4 224 389** |
| 31.12.2011 | 3 000 390 | 10 454 | 19 489 | 163 152 | 46 390 | 989 293 | **4 229 167** |
| 31.12.2010 | 3 008 090 | 10 552 | 19 434 | 163 010 | 46 556 | 985 859 | **4 233 501** |
| 31.12.2009 | 3 016 858 | 10 661 | 19 292 | 162 877 | 46 511 | 982 776 | **4 238 975** |
| 31.12.2008 | 3 025 597 | 10 762 | 19 131 | 162 642 | 46 231 | 979 718 | **4 244 081** |
| 31.12.2007 | 3 032 448 | 10 766 | 19 116 | 162 322 | 46 537 | 977 988 | **4 249 177** |
| 31.12.2006 | 3 039 669 | 10 844 | 18 906 | 162 033 | 46 725 | 976 226 | **4 254 403** |
| 31.12.2005 | 3 047 249 | 10 967 | 18 670 | 161 811 | 46 994 | 973 789 | **4 259 480** |
| 31.12.2004 | 3 054 654 | 11 045 | 18 278 | 161 548 | 47 300 | 971 748 | **4 264 573** |
| 31.12.2003 | 3 062 009 | 11 063 | 16 740 | 161 186 | 47 593 | 970 627 | **4 269 218** |
| 31.12.2002 | 3 068 239 | 11 105 | 15 902 | 160 910 | 48 373 | 968 272 | **4 272 801** |
| 31.12.2001 | 3 075 178 | 11 236 | 15 626 | 160 710 | 48 803 | 965 882 | **4 277 435** |
| 31.12.2000 | 3 082 383 | 11 232 | 15 574 | 160 609 | 49 008 | 961 070 | **4 279 876** |
| 31.12.1999 | 3 095 960 | 11 268 | 15 494 | 160 329 | 49 196 | 950 199 | **4 282 446** |

*Zdroj: ČÚZK, zpracoval: VÚMOP*

Source: Kolektiv autorů; Situační a výhledová zpráva půda 2021, Ministerstvo zemědělství, Těšnov 65/17, 110 00 Praha 1, 2022, ISBN 978-80-7434-598-2, ISSN 1211-7692, MK ČR E 11003

# LOSS OF AGRICULTURAL LAND 1999–2020

| Stav ke dni | Výměra ZPF celkem [ha] | Meziroční úbytek [ha] | Denní úbytek [ha] |
|---|---|---|---|
| 31.12.2020 | 4 200 204 | 1 909 | 5,2 |
| 31.12.2019 | 4 202 112 | 1 613 | 4,4 |
| 31.12.2018 | 4 203 726 | 1 562 | 4,3 |
| 31.12.2017 | 4 205 288 | 3 086 | 8,5 |
| 31.12.2016 | 4 208 374 | 3 561 | 9,8 |
| 31.12.2015 | 4 211 935 | 3 686 | 10,1 |
| 31.12.2014 | 4 215 621 | 3 291 | 9,0 |
| 31.12.2013 | 4 219 867 | 5 477 | 15,0 |
| 31.12.2012 | 4 224 389 | 4 778 | 13,1 |
| 31.12.2011 | 4 229 167 | 4 334 | 11,9 |
| 31.12.2010 | 4 233 501 | 5 474 | 15,0 |
| 31.12.2009 | 4 238 975 | 5 106 | 14,0 |
| 31.12.2008 | 4 244 081 | 5 096 | 14,0 |
| 31.12.2007 | 4 249 177 | 5 226 | 14,3 |
| 31.12.2006 | 4 254 403 | 5 077 | 13,9 |
| 31.12.2005 | 4 259 480 | 5 093 | 14,0 |
| 31.12.2004 | 4 264 573 | 4 645 | 12,7 |
| 31.12.2003 | 4 269 218 | 3 583 | 9,8 |
| 31.12.2002 | 4 272 801 | 4 634 | 12,7 |
| 31.12.2001 | 4 277 435 | 2 441 | 6,7 |
| 31.12.2000 | 4 279 876 | 2 570 | 7,0 |
| 31.12.1999 | 4 282 446 | | |

*Zdroj: VÚMOP, v.v.i*

Source: Kolektiv autorů; Situační a výhledová zpráva půda 2021, Ministerstvo zemědělství, Těšnov 65/17, 110 00 Praha 1, 2022, ISBN 978-80-7434-598-2, ISSN 1211-7692, MK ČR E 11003

# PARAMETERS OF (OPEN) AGROVOLTAICS

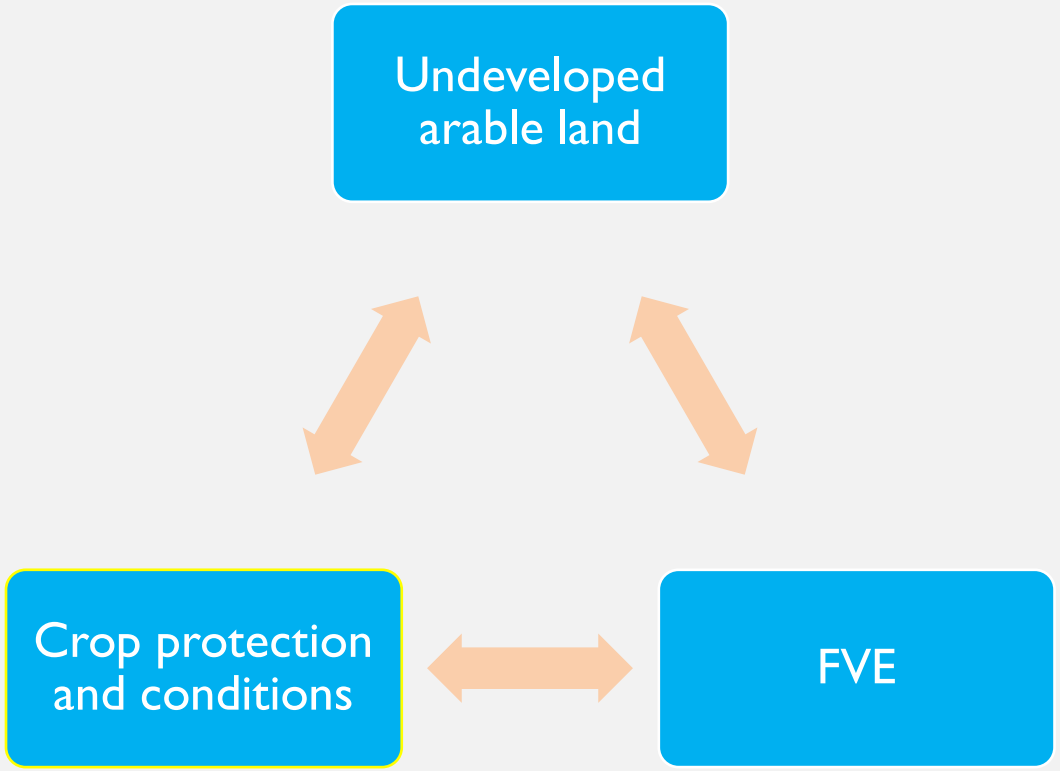
In the Czech Republic, vegetable and fruit yields, for example, for the year 2023 - potatoes without irrigation x with irrigation - approx. 20-25t/ha x 50-60t/ha

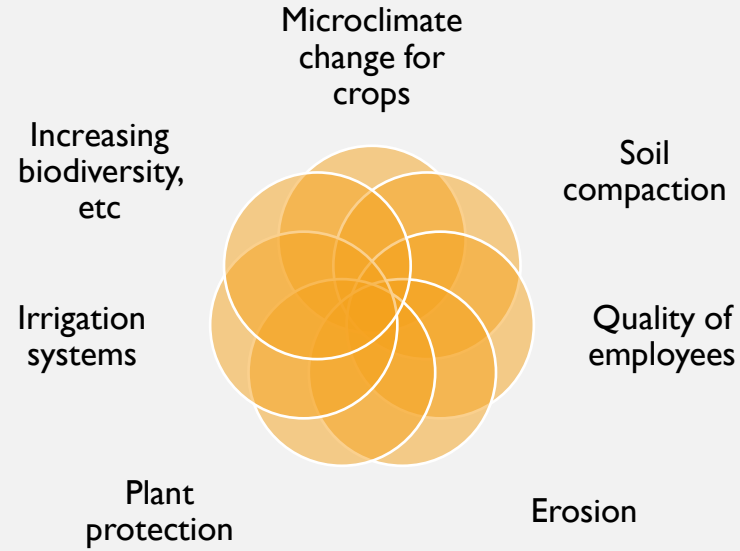
Climatic conditions

Wind erosion, water erosion, soil compaction, fires, soil contamination, etc.

Legislative restrictions - setting aside up to 10% of arable land for natural landscape features by 2030, 25% reduction of pesticides and fertilizers, 25% of agricultural land in ecological mode

Labor shortage in agriculture and others

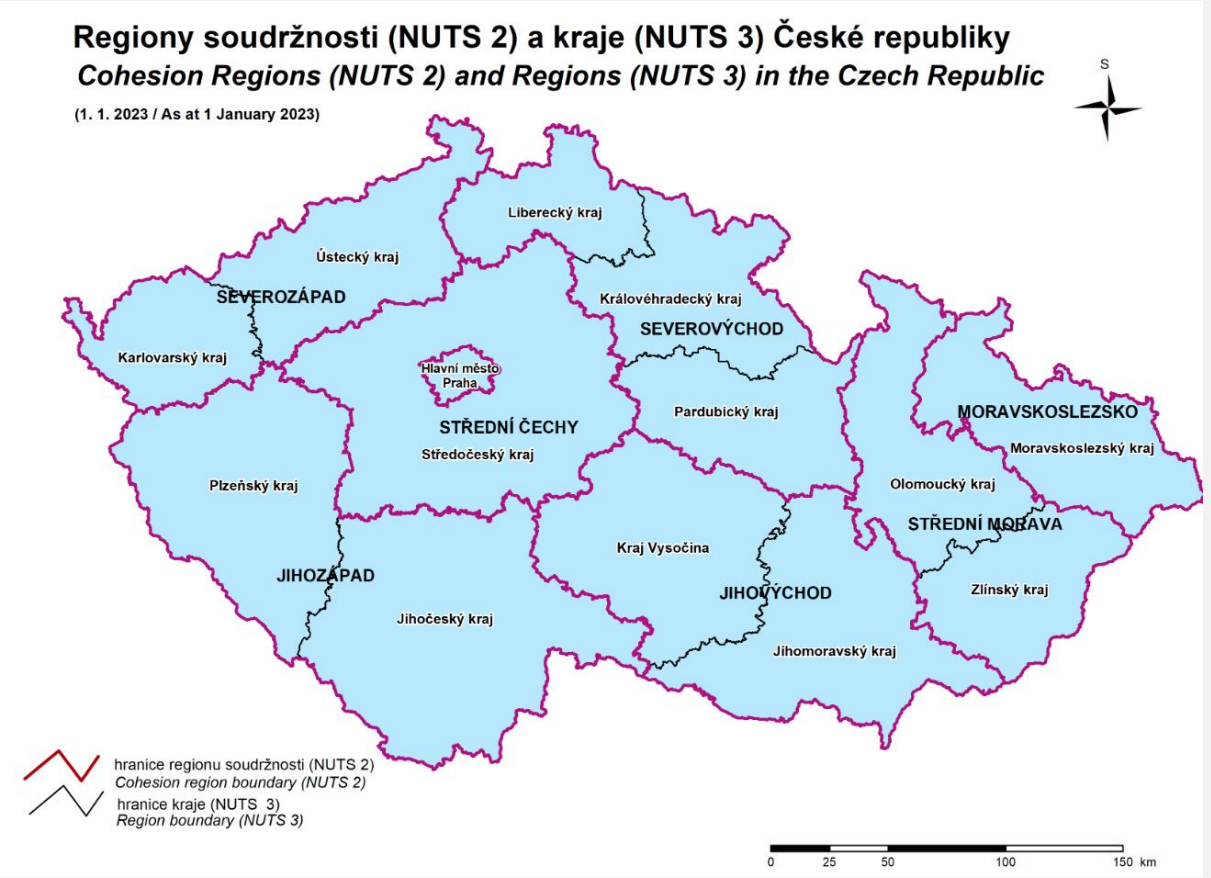



CORRECT SETTING OF THE PARAMETERS IS ESSENTIAL, THE PARAMETERS CANNOT BE SET WITHOUT PILOT PROJECTS.

# POTENTIAL OF AGROVOLTAICS IN THE CZECH REPUBLIC

| Nuts 2 Regions | Country code | Available land (%) | Available land ($km^2$) | Potential capacity (GW) | kWh/kW | Potential energy (TWh) |
|---|---|---|---|---|---|---|
| Severozápad | CZ | 40.2 | 3473 | 104.2 | 971.7 | 101.2 |
| Střední Morava | CZ | 43.6 | 4026 | 120.80 | 967.40 | 116.80 |
| Střední Čechy | CZ | 54.40 | 5947.00 | 178.40 | 979.10 | 174.70 |
| Jihovýchod | CZ | 54.40 | 7609.00 | 228.30 | 1002.30 | 228.80 |
| Jihozápad | CZ | 44.80 | 7934.00 | 238.00 | 960.90 | 228.70 |
| Praha | CZ | 28.70 | 142.00 | 4.30 | 972.80 | 4.20 |
| Moravskoslezsko | CZ | 40.30 | 2185.00 | 65.60 | 955.60 | 62.70 |
| Severovýchod | CZ | 47.70 | 5931.00 | 177.90 | 997.90 | 177.60 |
| Celkem | | 44.2625 | 37247 | 1117.5 | 975.9625 | 1094.7 |




Source: Ali Khan Niazi K, Victoria M. Comparative analysis of photovoltaic configurations for agrivoltaic systems in Europe. Prog Photovolt Res Appl. 2023; 31(11):1101-1113. doi:10.1002/pip.3727 with author export and calculation data in table.

# BASIC TYPES OF CONSTRUCTIONS AGROVOLTAICS

Photovoltaic panels are oriented to the south (mono) or east/west (bi). Fixed or tracking (single-axis or dual-axis) photovoltaic systems are also used, which follow the movement of the sun and thus maximize energy yield during the day. .

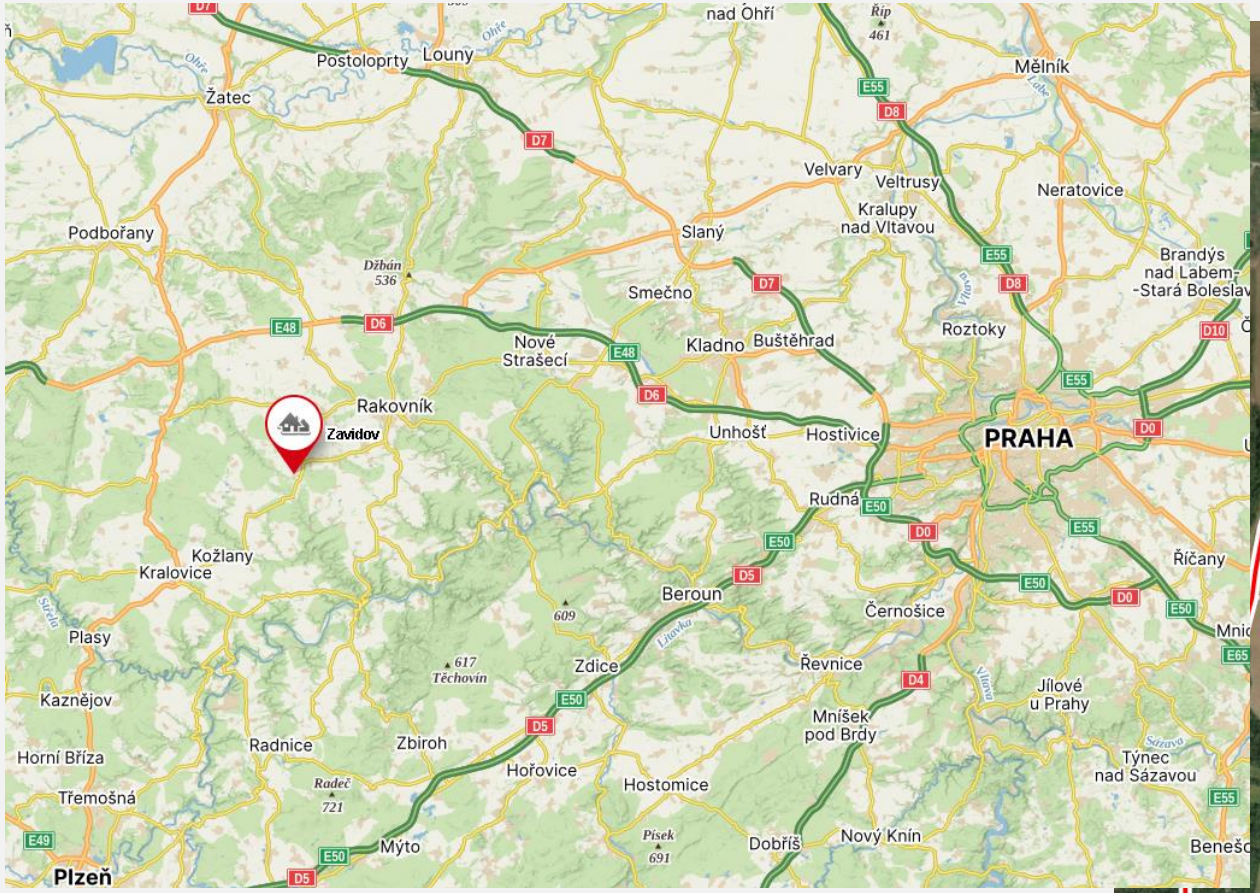
DIN SPEC 91434 standard – was created in 2021 in Germany, where it specifies the definition of agrivoltaics and the basic types of construction and agricultural use.

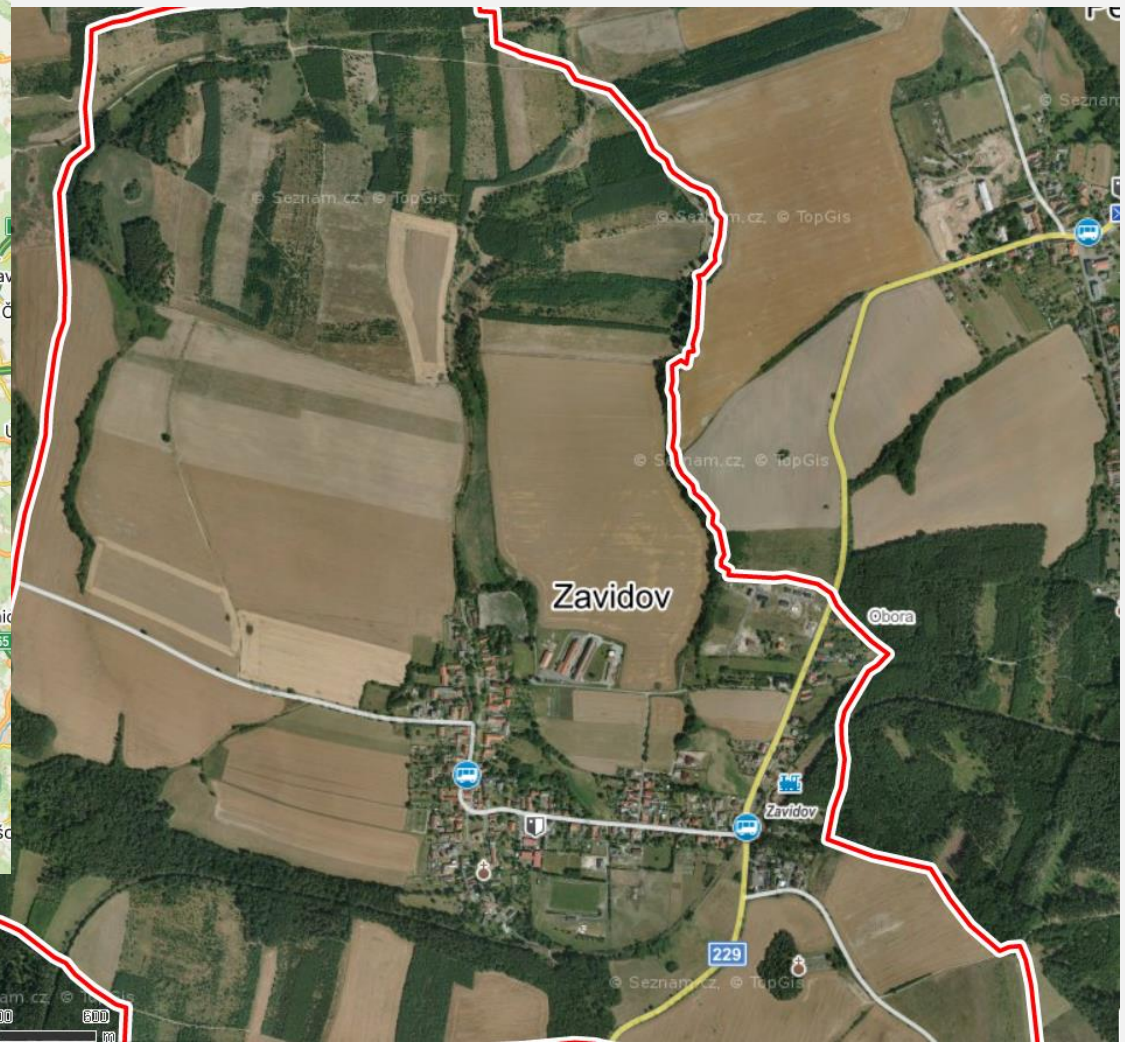
The efficiency of an agrivoltaic system can be determined by the LER - land equivalent ratio. This value shows the efficiency of combined land use, i.e. crop and energy yield relative to individual land use.

Two types of structures - horizontal and vertical structures.

Construction of a vertical photovoltaic system 10-20 cm. 0.5 m of protective strip on each side. The distance between the individual vertical lines is usually 8 - 25 m.

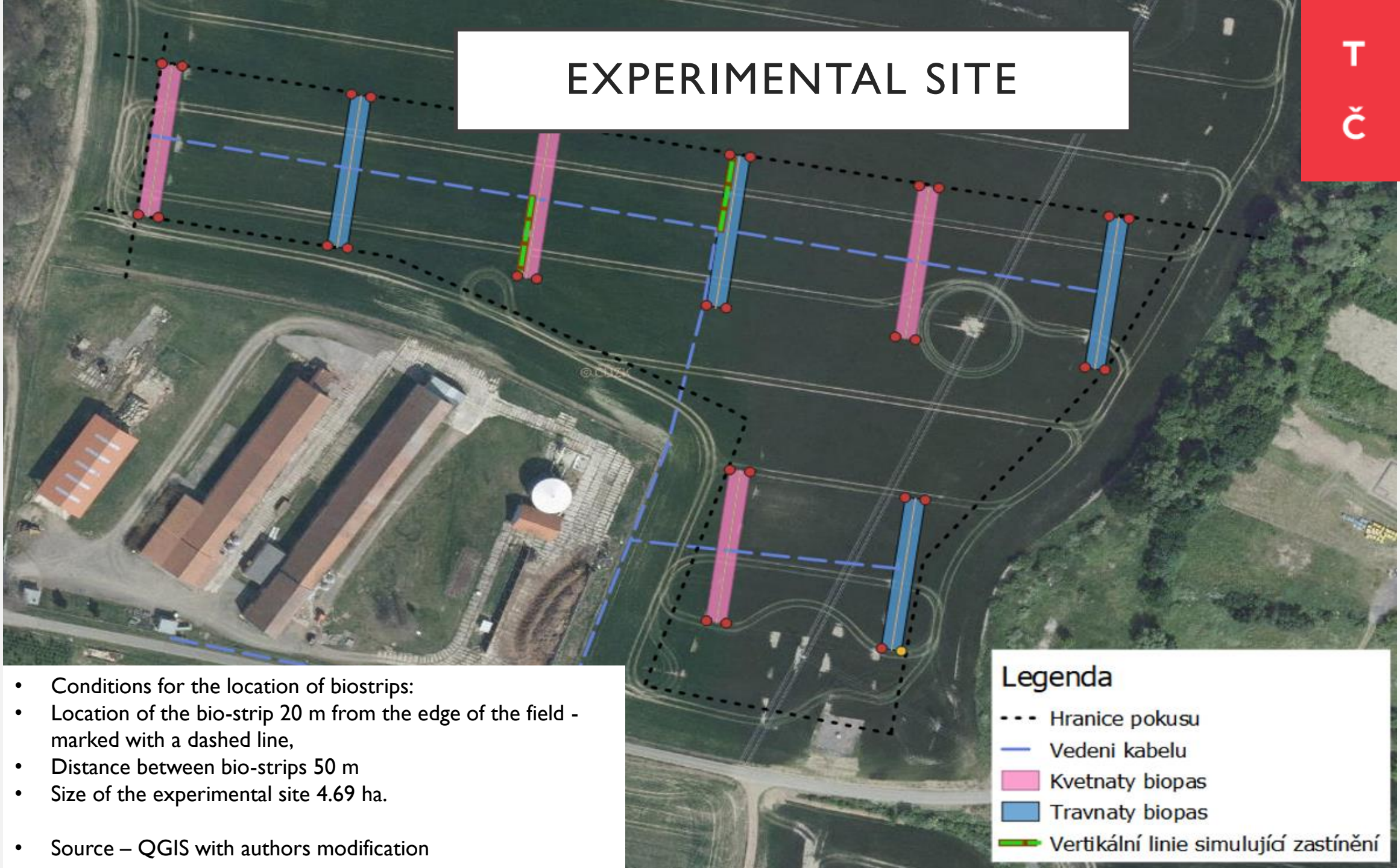
# EXPERIMENTAL LOCALITY CADASTRAL AREA ZAVIDOV, CENTRAL BOHEMIAN REGION




Source: www.mapy.cz

# EXPERIMENTAL SITE




- Conditions for the location of biostrips:
- Location of the bio-strip 20 m from the edge of the field - marked with a dashed line,
- Distance between bio-strips 50 m
- Size of the experimental site 4.69 ha.

- Source – QGIS with authors modification

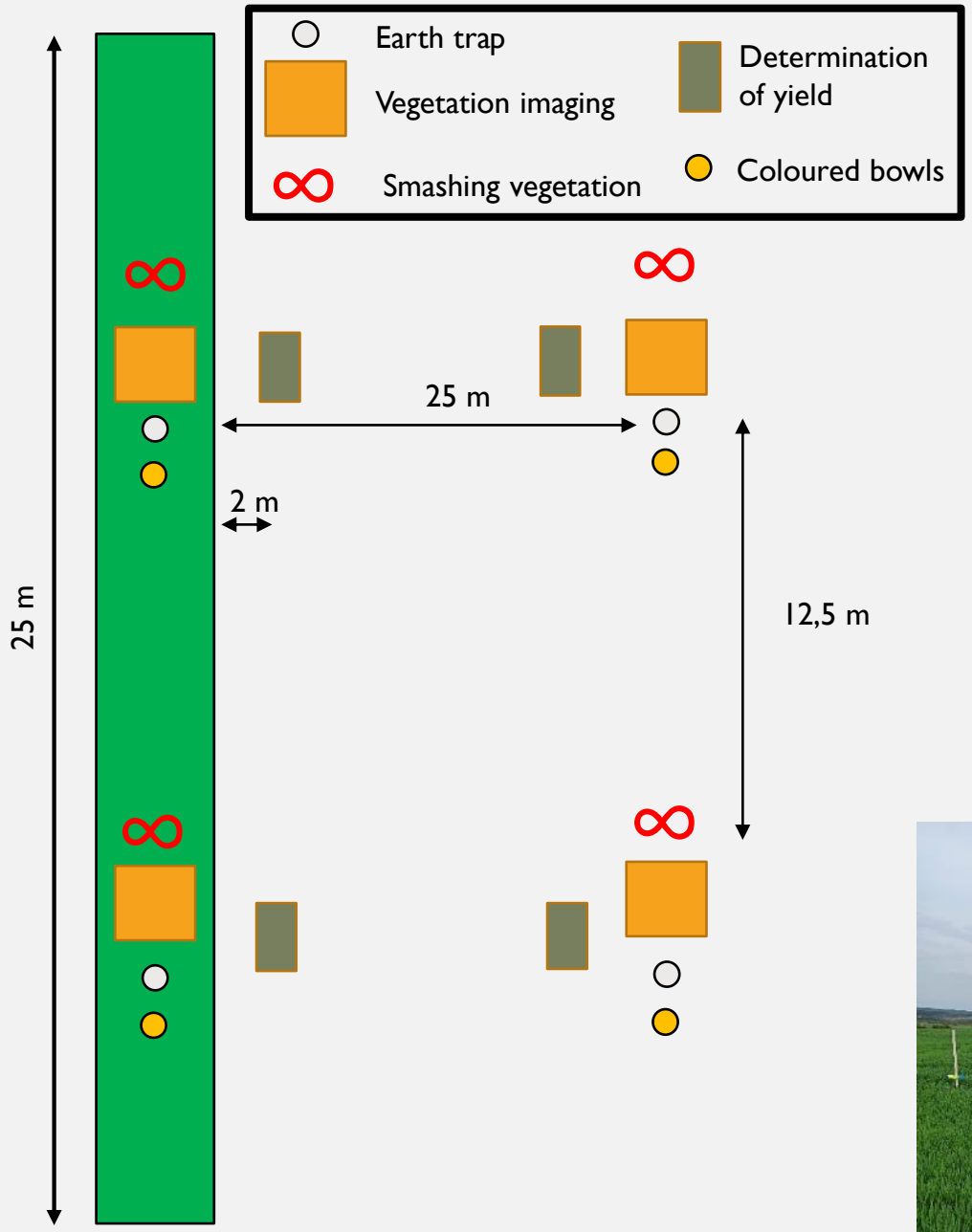
# BIOBELTS ACCORDING TO THE PRINCIPLES OF AECM (AEKO) - AGRO-ENVIRONMENTAL-CLIMATIC MEASURES

- The project includes both types of vegetative strips –
- Nectar-producing bio-strips – conditions – seed composition, age of seed mixture, seed certification, growth time, dates of establishment, mowing, maintenance, prohibition of moving equipment.
- Fodder bio strips – conditions – seed composition, age of seed mixture, seed certification, growth time, establishment dates, mowing.

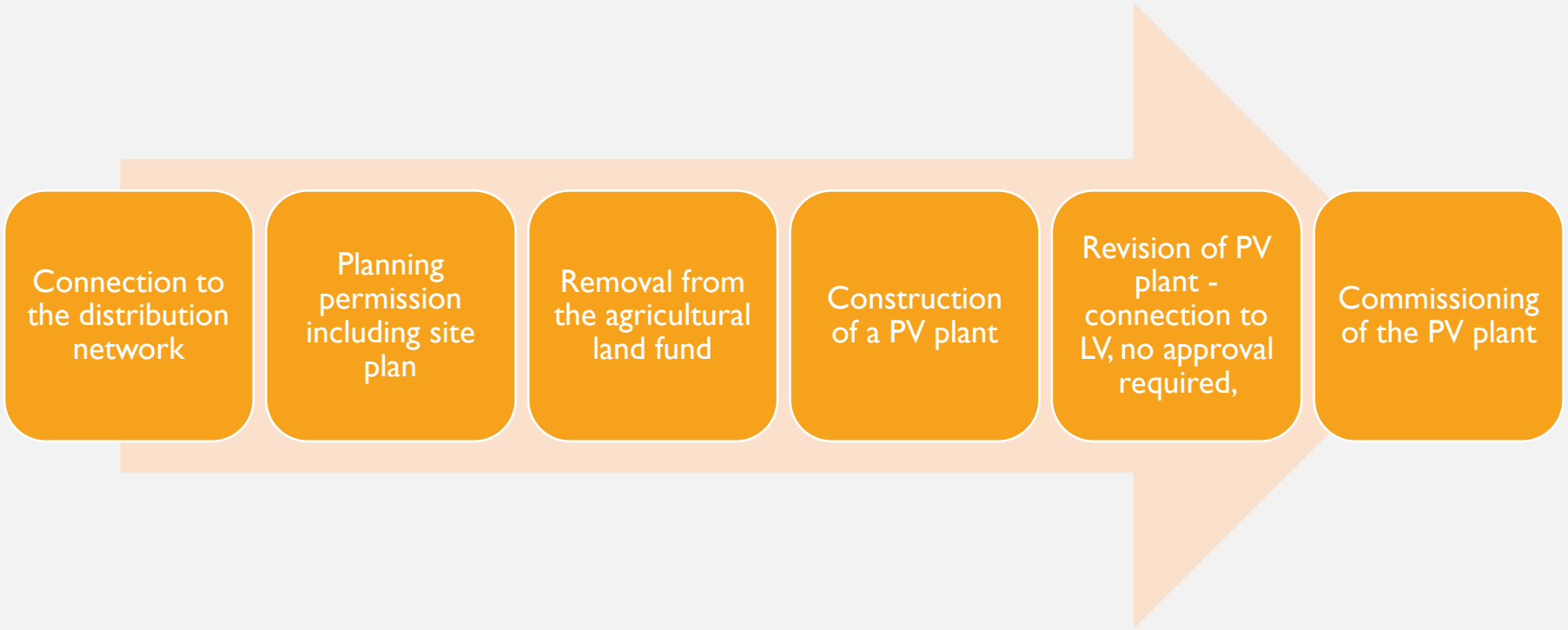
| Type biostrip | Species | Seeding [kg/ha] | Variety |
|---|---|---|---|
| Fodder bio strips | oves setý | 65 | Rertag C1 |
| | proso seté | 15 | Rubikon C1 |
| | kapusta krmná | 0.8 | Boma C1 |
| | pohanka obecná | 15 | Kora C2 |
| | lesklice kanárská | 15 | Judita C1 |
| | svazenka vratičolistá | 5 | Boratus C1 |
| | len olejný | 20 | Floral C1 |
| | hrách setý pravý | 30 | Eso C1 |
| Nectar-producing bio-strips | jetel luční (diploidní druhy) | 15 | Garant c1 |
| | úročník bolhoj | 15 | Atyl |
| | vičenec ligrus | 15 | |
| | vikev setá | 15 | Nukian C2 |
| | vojtěška | 15 | Giula C1 |
| | hořčice setá | 1 | Andromeda C1 |
| | pohanka obecná | 5 | Kora C2 |
| | svazenka vratičolistá | 1 | Boratus C1 |
| | kmín kořenný | 3 | Rekord C1 |

# DESIGN OF BIODIVERSITY MEASUREMENT AT THE SITE– VÚRV, P.R.I.

Collection methods – ground traps, coloured bowls, skidding, vegetation imaging




# PROCEDURE FOR APPROVING AN EXPERIMENTAL PVPP



# SUMMARY

- In 2022 and 2023, simulations and measurements were installed and simulations were carried out, a substantial part of the first and second phases of the project was implemented (yield monitoring at the experimental site, implementation of biostrips, measured biodiversity of arthropods and plants after sowing biostrips, modelling and determination of PV plant output, yields and more). In 2024, we continue to work on the implementation of the experimental PV part of the project,
- Preliminary results of the PROJECT for 2023
  - 1) do not confirm the statistically demonstrable a decline in grain yield and quality,
  - 2) do not confirm a statistically demonstrable increase in biodiversity (insects and plants),
  - 3) confirm the increase in the cost of agricultural work.
  - **THESE ARE PRELIMINARY RESULTS THAT MUST BE VERIFIED.**

# CONCLUSION

- Thanks to all members of the research team and workers involved in the project.
- Questions?

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