

INTEGRATION AND AUTOMATION OF EXISTING INTERRELATIONSHIP PROCESSES BETWEEN PHOTOVOLTAIC TECHNOLOGIES, AGRICULTURAL LAND PRODUCTION AND LANDSCAPE PROTECTION: THE GILDA PROJECT

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ABSTRACT: This work aims at presenting a detailed illustration of the key findings, integrated analyses, and methodological and application procedures developed in the context of the creation and management of the complex information assets relating to applications pertaining to the regulation of control procedures for the presence of certified crops in agricultural areas (specifically organic production, production registered with the national quality system for integrated production, production with a designation of origin and geographical indication, fodder produced in the area of origin of the Parmigiano-Reggiano DOP cheese) of the Emilia-Romagna Region affected by photovoltaic systems, aiming at locating these systems.

The extreme complexity of the above-described issues led to the development of the GILDA project, an acronym for Low-zero code Integrated Management of Authorization Applications, specifically based on the use of Low-Code Platforms for the integration and automation of processes. Its aim is to ensure effective, timely and efficient management of the investigation activity, archiving and evaluation processes of requests relating to the verification of the presence of certified crops on agricultural land affected by the construction of photovoltaic and agrivoltaic systems, by virtue of the contribution made by the organizational and technological innovation implemented.

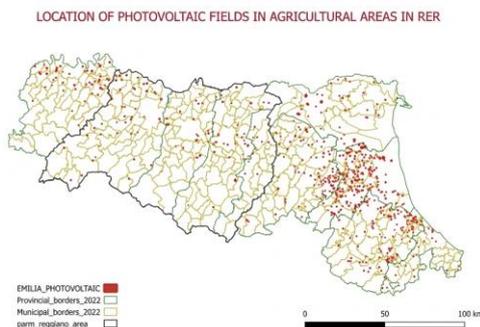
Keywords: Agrivoltaics (AgriPV), Automation, Landscape Protection, Renewable energy sources (RES), Low-No Code Platforms, Artificial Intelligence A.I.

1 INTRODUCTION

Currently, the agricultural and rural sectors are significantly affected by the installation of renewable energy systems, even in areas with vocation for agriculture. This aspect must be carefully evaluated — and, where necessary, implemented — to avoid any harm to agri-food production, particularly to the high-quality products that characterize the Emilia-Romagna region.

Specifically, with regards to the photovoltaic technology, we observe the onset of a complex transition phase, characterized by the likely feasibility of its installation on the ground, on rooftops, or alongside crops—agrivoltaic systems—aiming to optimally and contextually balance agricultural and energy production related to the land on which the agrivoltaic system is located, as well as landscape protection (Fig. 1).

Fig. 1: Location of photovoltaic fields in agricultural areas in the Emilia-Romagna region



It should be recalled, among others and by way of a completely non-exhaustive example, how the Soil Thematic Strategy has identified the loss of organic matter in soils (primarily agricultural soils) and the resulting loss of biodiversity as a serious threat likely to trigger and lead to complete land degradation, even to desertification.

Agricultural soil, in particular, is primarily related to several ecosystem services: food and biomass production;

water purification; regulation of microclimates, biogeochemical cycles, surface runoff and water infiltration; erosion control; groundwater recharge; carbon capture and storage and biodiversity conservation.

While it is essential to achieve a suitable combination of the necessary and complete development of renewable energy, achieved through the construction of related plants, with the preservation and protection of that fundamental resource – albeit vulnerable, limited, and non-renewable – consisting of agricultural land and the excellent agri-food products that characterize the Emilia-Romagna Region, on the other hand, we must not refrain from carrying out a general reflection aimed at understanding the "radically intrinsic and profound" economic motivations connected to energy production in these areas, its relationship with the continuity of the activities carried out there in their multiple aspects, with the structure of production locations within the territory, with the problems of efficiency and equity linked to the consumption of resources and the payment of the costs that the growing demand for plant installations entails.

The serious and alarming ecological and environmental problems, first, and the energy ones, subsequently, have led to the unequivocal recognition and clear observation of a current situation that is no longer defensible or supportable in any way, to the need for a rationally planned and focused articulation of the constraints, to the establishment of regulations no longer organized by rigid apodictic dictates but focused on alternative prescriptions that ultimately allow the needs for control to be reconciled with those of adaptation to temporally and territorially diversified situations.

The epochal and universal dimensions assumed today by the issues and themes recalled above necessarily imply a complete and integral reconsideration of the existing relationships between anthropic, agricultural and natural ecosystems, due to the rooting of the pre-eminent environmental disasters that have occurred there as well as the reaching of limits, thresholds and rates of development and chronological-temporal divergence that are such as to jeopardize their very own safety.

2 THE POTENTIAL USE OF INNOVATIVE TECHNOLOGICAL SOLUTIONS ALTERNATIVE TO THOSE USUALLY ADOPTED

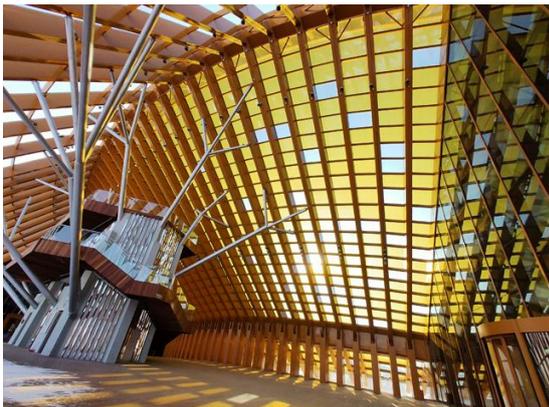
The adoption of photovoltaic solutions compatible with agricultural production represents one of the key challenges for truly integrating agri-food needs and energy transition objectives. In this context, the Sustainable Agriculture Area of the Emilia-Romagna Region is not limited to merely evaluating conventionally proposed solutions in this area, but is committed to evaluating and paying particular attention to the development of innovative modular and scalable systems, to valuable ongoing experimental activities adaptable to different agricultural and climatic contexts, and to the most relevant scientific validation projects related to them. This is done in order to objectively quantify the agronomic, energy, and environmental benefits associated with the use of innovative technologies in the primary sector.

In this regards, it is important to highlight how the use of semi-transparent photovoltaic glass elements installed in a vertical inter-row configuration presents itself as a functional and scientifically promising alternative to conventional agrivoltaic systems.

These modules, based on thin-film technology laminated between two glass panes, guarantee:

- uniform and adjustable transparency (depending on the species grown, latitude, and required photoperiod);
- greater mechanical strength (thanks to the glass-on-glass structure);
- stable energy performance even in suboptimal conditions (low solar angle, dust accumulation);
- enhanced landscape and environmental compatibility thanks to the possibility of tinting without reducing performance (post-active tinting technology, Fig. 2).

Fig. 2: Semi-transparent photovoltaic glass with post-active colouring technology



In vertical configuration, power densities between 100 and 140 W/m² per side are currently possible, with the potential for inter-row installation without decreasing the active agricultural area. This approach allows for a more rational use of cultivable space and reduces the structural and agronomic constraints resulting from suspended or inclined PV systems.

Another key advantage is the solution's high level of application flexibility, allowing for the integration of photovoltaic glass in agricultural greenhouses, machinery shelters, adjustable shading systems, and partial crop protection structures. Selective transparency, which can

be adjusted for different horticultural or floricultural species, optimizes the balance between photosynthesis-relevant radiation and energy production, while maintaining high agricultural quality standards.

The evolution of this technology will be strongly influenced by the integration of advanced photovoltaic junctions, particularly perovskite-based ones, a class of organic/inorganic materials capable of offering high conversion efficiency and selective transparency. Perovskite single-junction cells have already achieved laboratory efficiencies exceeding 31%, pursuing a growth trajectory that will lead to highly promising new application scenarios in agriculture and construction.

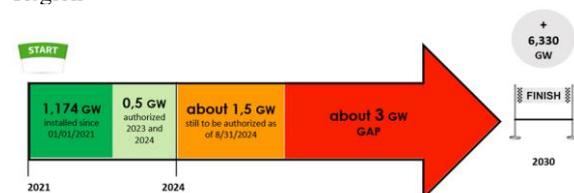
3 THE EXISTING AND EVOLVING REGIONAL REGULATORY FRAMEWORK

In order to actively promote development policies and the maximum diffusion of photovoltaic systems within its territory, the Emilia-Romagna Region, with Legislative Assembly Resolution No. 125 of May 23, 2023, established new criteria for the location of renewable energy plants. The objective is to clarify and integrate the framework resulting from current regional legislation with the provisions regarding suitable areas contained in Legislative Decree No. 199/2021, while identifying appropriate environmental and landscape protections, it aims at the preservation particularly valuable crops that represent the Emilia-Romagna Region's excellent agricultural production, also combating harmful land consumption.

As part of the current legislation regarding the identification of areas and sites suitable for the installation of electricity generation systems using renewable solar photovoltaic energy sources, Regional Council Resolution No. 693/2024 was also approved. This resolution specifies the criteria for identifying areas suitable for certified crops and the control procedures for the installation of photovoltaic systems in agricultural areas.

The aforementioned legislative acts are related to the Ministerial Decree of June 21, 2024, known as the "Suitable Areas" Decree, which defines the criteria that the Regions must observe when developing specific laws to regulate the identification of areas and sites suitable for the installation of renewable energy plants. It also indicates for each Italian region the amount of additional power, compared to the value established in January 2021, deriving from renewable energy sources to be produced by the end of 2030. The latter amounts to 6.33 GW for the Emilia-Romagna region (Fig. 3).

Fig. 3: Trajectory for achieving the overall power target to be achieved by 2030 assigned to the Emilia-Romagna Region



In this regards, a significant contribution, further demonstrating the pioneering and innovative evolutionary tendency pervading the many and diverse organic

approaches to territorial spaces and the interpretative dynamics of the relational components variously pertaining to them implemented by the Emilia-Romagna Region, shall derive from the decisive conversion of the draft Regional Law "Localization of plants powered by renewable energy sources in the regional territory", approved by Council Resolution no. 717/2025, which aims at regulating, among other things, suitable, unsuitable, and ordinary surfaces and areas for the location of renewable energy plants, while ensuring the minimization of impacts on the landscape, the environment, cultural heritage, the territory, and the agricultural sector, with particular reference to the valorization of local agri-food traditions.

Other key elements of the aforementioned draft Regional Law include the regulation of the installation procedure for advanced agrivoltaic systems, which requires the prior submission of a certified agronomic report; the definition of a forward-looking crop plan to be adopted for a period equal to the system's lifespan, including crops suitable for shading consistent with the area's prevailing production systems; the preparation of an agronomic monitoring report; and the assessment of the maintenance of agricultural productivity, carried out by comparing the crops present in the advanced agrivoltaic systems with the same crops grown without photovoltaic systems.

4 THE "GILDA (INTEGRATED MANAGEMENT OF LOW-ZERO CODE AUTHORIZATION APPLICATIONS)" PROJECT

4.1 Objectives and purposes underlying the GILDA project

The primary, broad-based objective is to enable the regional administration — which is variously involved in the multitude of proceedings involving the expression of an opinion/investigative outcome, an authorization, and/or subsidies granted following the preliminary investigation to be completed within extremely tight and timely deadlines — to communicate the procedural outcome in question to the interested stakeholders (citizens, entities/administrations, etc.) in a coherent, effective, timely, efficient manner, and plausibly consistent with similar requests from different senders, even over different time periods.

Specifically, the initial step of this far-reaching project consists in the development of the application for the management of requests relating to the regulation of control procedures relating to the presence of certified crops in agricultural areas (specifically organic productions pursuant to Regulation (EU) no. 848/2018, vegetal productions registered with the National Integrated Production Quality System SQNPI - art. 2 of Law no. 4 of 2011, products with Origin Denomination and Geographical Indication DO/IG, pursuant to Regulation (EU) no. 1151/2012 and Regulation (EU) no. 1308/2013, obtained from vegetal productions cultivated in the regional territory and subject to compliance with the relevant production specifications, fodder produced within the original area of the Parmigiano-Reggiano DOP cheese, identified in the Production Specifications approved with Regulation (EU) no. 794/2011 and subsequent amendments) of the Emilia-Romagna Region affected by photovoltaic systems for the purpose of locating the systems themselves (Fig. 4, Fig. 5, Fig.6).

Fig. 4: Mapping of DO and IG products in the Emilia-Romagna Region



Fig. 5: Organic crops and DO/IG area boundaries for crops and wine-growing

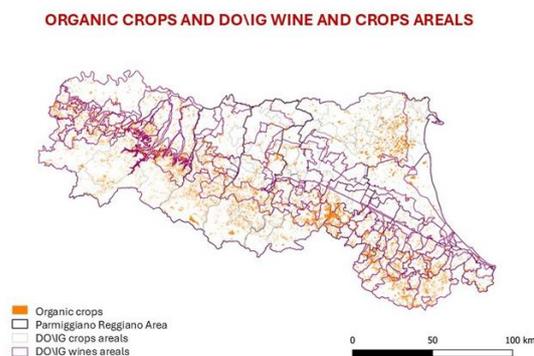
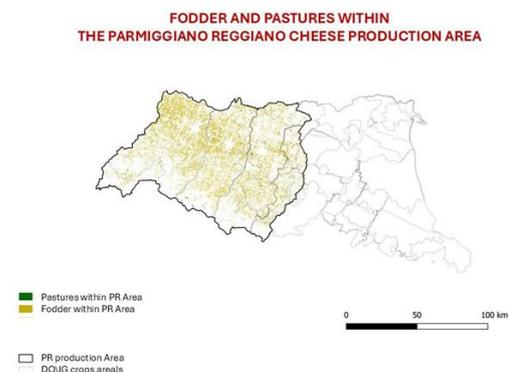


Fig. 6: Fodder crops and pastures within the Parmigiano Reggiano DOP cheese area



This effective achievement, which can only be achieved through careful and in-depth checks, controls, and analyses, lies in the project's fundamental vision and requires a suitable tool to fulfill these processes.

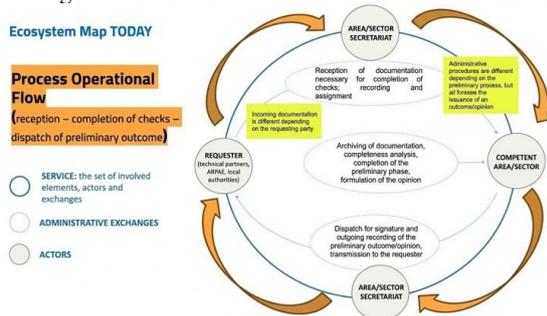
4.2 The operational challenge and the state of the art: description of the current situation (AS-IS)

The current procedure involves a complex series of phases, resulting in a costly, entirely manual process of investigation, verification, control, and feedback. Following the receipt of applications for assignment by the protocol via the AURIGA vertical application, over 5 databases are queried (Table 1). This creates a high risk of human error and processing times ranging from 1 hour to 1 day for each request (Fig. 7).

Table I: Databases consulted for the purposes of carrying out the verification and control procedures envisaged by Regional Council Resolution No. 693/2024

DATABASE DENOMINATION	MANAGER AUTHORITY
REGIONAL REGISTER OF AGRICULTURAL COMPANIES	SIAR
SURVEILLANCE DATABASE	SIAN
REGISTER OF MEMBERSHIP RESULTS/SQMPI CONTROLS	SIAN
AGRIBIO	SIAN
SITIFARMER	AGREA

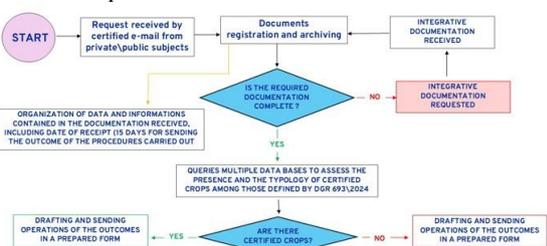
Fig. 7: Current ecosystem map and related document exchange



The actions carried out as part of the procedure described above include (Fig. 8):

- consultation of a large set of project documents archived by the competent authorities (municipalities, ARPAE, MASE, etc.) in various formats (PDF, Word, Excel, shape, etc.) in restricted-access folders on the cloud or dedicated servers;
- review of the documentation (minutes, authorizations, opinions, etc.) produced by the various parties potentially involved in the Services Conference;
- sending the proponent any requests for additional documentation, if necessary;
- individual querying of at least 5 different databases with qualified access, with a high risk of human error and resulting processing times;
- processing, signing, and forwarding via certified email (PEC) to the proponent or the competent authority of the final verification communications, archived in a searchable repository.

Fig. 8: A simplified current process for verifying certified crops



In order to prevent the implementation of the "tacit approval" mechanism by silent consent, the aforementioned requests must be responded to within 15 days, as there is a high risk of human error given the huge number of certified email (PEC) requests sent daily to the Sustainable Agriculture Area - since May 2024, over 250 from private individuals and over 90 from public bodies, corresponding to a total of approximately 350 requests covering a cultivated area of approximately 4,500

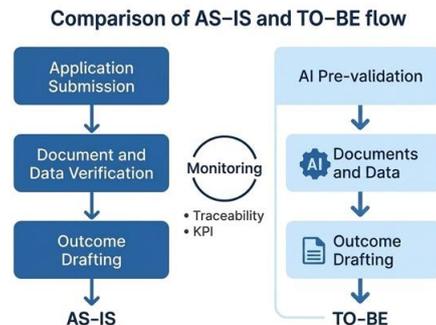
hectares (Used Agricultural Area) and with an additional power output obtainable from the installation of the relevant plants estimated to be in the order of 2.9 - 3.3 GW.

4.3 Genesis of the TO-BE enabling solution: the conception and design of GILDA, a strategic platform aimed at accelerating workflows and administrative procedures, optimizing and automating the authorization process through the use of a Low-Code/No Code platform and the integration of Artificial Intelligence tools

The methodology adopted for GILDA is based on an AS-IS process analysis, followed by the definition of a TO-BE architecture based on Low-/No-code components and AI agent integration (Fig. 9). Functional requirements (categorization, archiving, workflow automation), regulatory constraints and interoperability opportunities with regional and national databases have been identified.

The solution designed will allow the manual processes described above to be digitized and automated, providing for the configuration of a back-end service created using Power App and/or Low Code/No Code technology, appropriately integrated with the Auriga system for registering requests. The automated investigation service oversees the management of emails, certified emails and related documents, verifying them, archiving them in Sharepoint portal (or any other repositories to be evaluated), managing plausible queries from various databases and providing support for the investigation outcome, using text analytics and reporting with artificial intelligence tools.

Fig. 9: Comparison between AS-IS and TO BE operational flows



The resulting evidence is easily deducible: it is not a matter of simply eliminating jobs, but rather of transferring value by freeing technicians and decision makers from repetitive, high-volume activities to focus on high-value ones, thus placing them in the optimal position to make the related strategic decisions, improving the efficiency and accuracy of the service and its scalability towards other processes.

The evolution and digital transformation of what currently consists of an extremely burdensome manual process in terms of workload, resource usage, error rates, etc., will also allow:

- to greatly speed up the process - 95% reduction in the average verification times existing due to automated pre-validation - fully meeting the essential need to respect the unavoidable deadlines set, also avoiding the establishment of repeated exchanges of documents or explanatory/clarifying letters and guaranteeing end-to-end traceability;

- to minimize the workload of internal users by optimizing it to the greatest extent and in the best way achievable in relation to the limited human resources dedicated to it;
- to achieve the best qualitative performances in the improvement of company organizational and procedural processes.

5 THE GRADUAL EVOLUTION OF THE PATH TOWARDS A DIGITAL AND SMART PA, FOCUSED ON TARGETED EFFICIENCY, ON THE CREATION OF A COMPLETE ECOSYSTEM BASED ON AI AND ON THE CONSTRUCTION OF A SYSTEMIC AND CONTINUOUS DEVELOPMENT CAPACITY

5.1 The extensive evolution of the GILDA project

The broad, extensive evolution of the GILDA project could consist of the implementation of a prototype aimed at automating complex administrative procedures also within other sectors of the regional structure, potentially interoperable with similar services offered by other Administrations.

The proposed architecture consists of a scalable platform designed to serve as a single point of access for administrative procedures. Its core asset is a comprehensive mapping and categorization of the entire regional administrative framework, integrating a headless front-end (Table II) and a centralized knowledge hub to create a vast, unified internal dataset. Other key elements include an end-to-end administrative workflow digitalization engine, along with specialized artificial intelligence agents dedicated to document pre-validation, metadata extraction and CUUA Unique Farm Codes, multi-database querying, autonomous execution of complex checks, and automatic drafting of investigation results, transforming manual processing into intelligent automation.

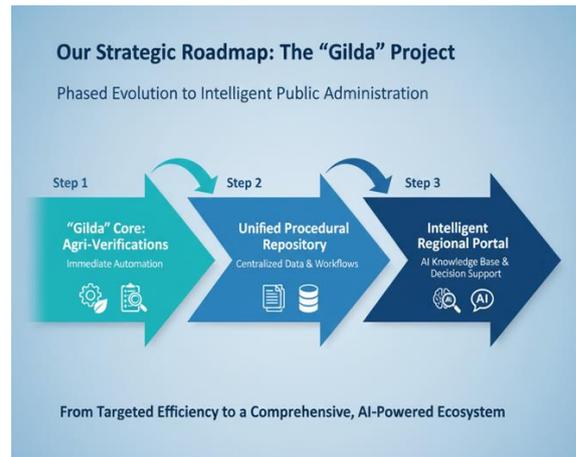
The front-end will connect via API (Application Programming Interface) to the back-end as well as to any database (e.g., Dataverse/Oracle), making it custom, agnostic, and decoupled, respecting data neutrality while meeting the critical requirement of storing regional data on non-proprietary platforms, avoiding vendor lock-in.

Table II: Benefits of implementing a custom headless portal

ADVANTAGES of a CUSTOM HEADLESS portal		
ARCHITECTURAL advantage	STRATEGIC advantage	ECONOMIC advantage
The front-end connects via API to the back-end and any database (e.g., Dataverse/Oracle)	Creates a library of pre-approved components for all future services	Avoid creating an unsustainable OPEX model for a unified public-facing portal.
Agnostic and decoupled	Standardized design system	Removes the cost-per-user barrier
Custom front-end	Coherent and familiar user experience	Ensures long-term financial sustainability
Back-end LOWCODE	Built once, deploy many times	Achieve profitability by decoupling costs from user growth
Data neutrality	Accessibility "By Design"	

Pursuing the outlined Roadmap for the gradual evolution of the path towards a digital, unified, scalable, and smart PA (Fig. 10), focused on targeted efficiency, the target to aim for, starting from the aforementioned MVP - Minimum Viable Product - consists of the creation of an AI-based ecosystem within which data, platforms, and people work synergistically, simultaneously equipping itself with a systemic, structured, and continuous capacity to develop solutions that reach broad perspectives centered on a fully strategic vision.

Fig. 10: Strategic roadmap towards a digital, unified, scalable and smart PA



5 CONCLUSIONS

From the above, it is easy to see that the project outlined does not merely concern the digitization of legacy processes. It consists of a technological framework specifically designed to provide large-scale public value and support high-level policies and strategic planning. It also constitutes a replicable model for the digitization of procedures. Given these unique and distinctive characteristics, GILDA can effectively represent a strategic framework and a valuable opportunity to transform regional public administration processes.

While not failing to give due and appropriate importance to the imperative requirement underlying any decision-making process, consisting in the need to be able to access, and use, structured and organized information rationally and efficiently, it is also necessary to avoid formulating the erroneous assumption that the current considerable availability of advanced tools and methodologies can in itself allow for the systematic, explicitly rigorous and timely identification of solutions concerning the most dissimilar and varied problems.

The system in question, together with the procedures and application methodologies developed, constitute valuable tools for contextually considering the multitude of variables and constraints that need to be coordinated. The proposed approach promotes transparency, reduced operating times, efficiency, process replicability, optimal management of complex procedures, reallocation of resources to higher-value activities, and the establishment of a knowledge hub to support planning. This lays the foundation for a more resilient Public Administration oriented toward the energy transition, while also creating the conditions for artificial intelligence to become an integral part of business processes and decisions.

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10 LOGO SPACE

