Integrated excel templates into streamSAVE platform, and related guidance material

Deliverable D2.5

Version N°1

@streamSAVEplus
www.svn.cz/streamsaveplus
contact@streamsaveplus.eu

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Project coordinator:

SEVEn, The Energy Efficiency Center z.ú.
Americká 17, 120 00, Praha 2, Czech Republic
+420 224 252 115 https://www.svn.cz/streamsaveplus

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1. Executive Summary

1.1. Executive Summary

StreamSAVE+ Streamlining Energy Savings Calculations in the EU Member States + project has the objective to address the gap between trends in energy savings of the Member States and the goals of Article 8 of EED by assisting public authorities in the development of new policies and harmonisation of energy savings calculations across the MS.

The main objective was to transform excel templates prepared for each calculation methodology identified in T2.2 to online interactive version. The newly developed StreamSAVE+ platform integrates total of 15 priority actions.

The StreamSAVE+ is by nature a successor of StreamSAVE project (Predecessor project streamSAVE (2020-2023) received funding from the H2020 Programme under grant agreement N° 890147.).

StreamSAVE+ platform was newly developed because original streamSAVE platform was based on obsolete PHP version 5. This version of scripting language could not be used for security reasons.

The new streamSAVE+ platform combines original streamSAVE calculations (10 priority actions) with new streamSAVE+ calculation (5 priority actions). **However, all calculations were newly transferred from excel templates and coded to the new platform (the original streamSAVE code in PHP5 could not be used at all).**

This document provides a comprehensive overview of the StreamSAVE+ platform. It is designed for project stakeholders, reviewers to understand the concrete outcomes, innovative features, and technical achievements of the platform.

The StreamSAVE+ platform represents a significant advancement in making energy efficiency calculations accessible to a broad audience of energy professionals, consultants, policymakers, and facility managers across EU. By providing specialized calculators covering diverse energy efficiency domains, the platform empowers users to make data-driven decisions about energy-saving interventions.

The example used in chapter 2 (Front-end) uses the Lighting simplified calculation which origins in streamSAVE project. This calculation was used for example for its simplicity. The original numbers of EED articles are used.

The platform serves multiple stakeholder groups:

- **Stakeholders with obligation of energy savings** according to EED
- **Energy Consultants & Auditors**: Professional tools for client assessments and energy audits
- **Facility Managers**: Quick evaluation of potential upgrades and their impact
- **Policy Makers**: Evidence base for energy efficiency policy development
- **Research Community**: Validated calculation methodologies for academic studies
- **EU Project Partners**: Standardized tools for multi-country energy efficiency initiatives

This document is organized into five main sections:

1. **Introduction** (this section) - Project context and goals
2. **Frontend Features** - User-facing functionality with detailed calculator walkthrough
3. **Backend Features** - Administrative capabilities and content management
4. **Technical Architecture** - System design and the standalone calculator library
5. **Conclusion** - Summary of deliverables and future extensibility

2. Fronted Features (User – Facing)

The StreamSAVE+ platform frontend provides an intuitive, accessible interface for energy efficiency professionals across EU. Built with modern web technologies (Vue.js 3, Tailwind CSS, Vite), the platform delivers a responsive, performant user experience across desktop and mobile devices.

2.1. Text Sections

The platform features rich content sections that provide context, guidance, and educational material for users:

Priority Actions: The central navigation element organizes calculators and resources by thematic priority areas. Users can quickly find relevant calculators based on their specific energy-saving focus areas (e.g., building renovation, lighting upgrades, behavioural interventions, industrial processes).

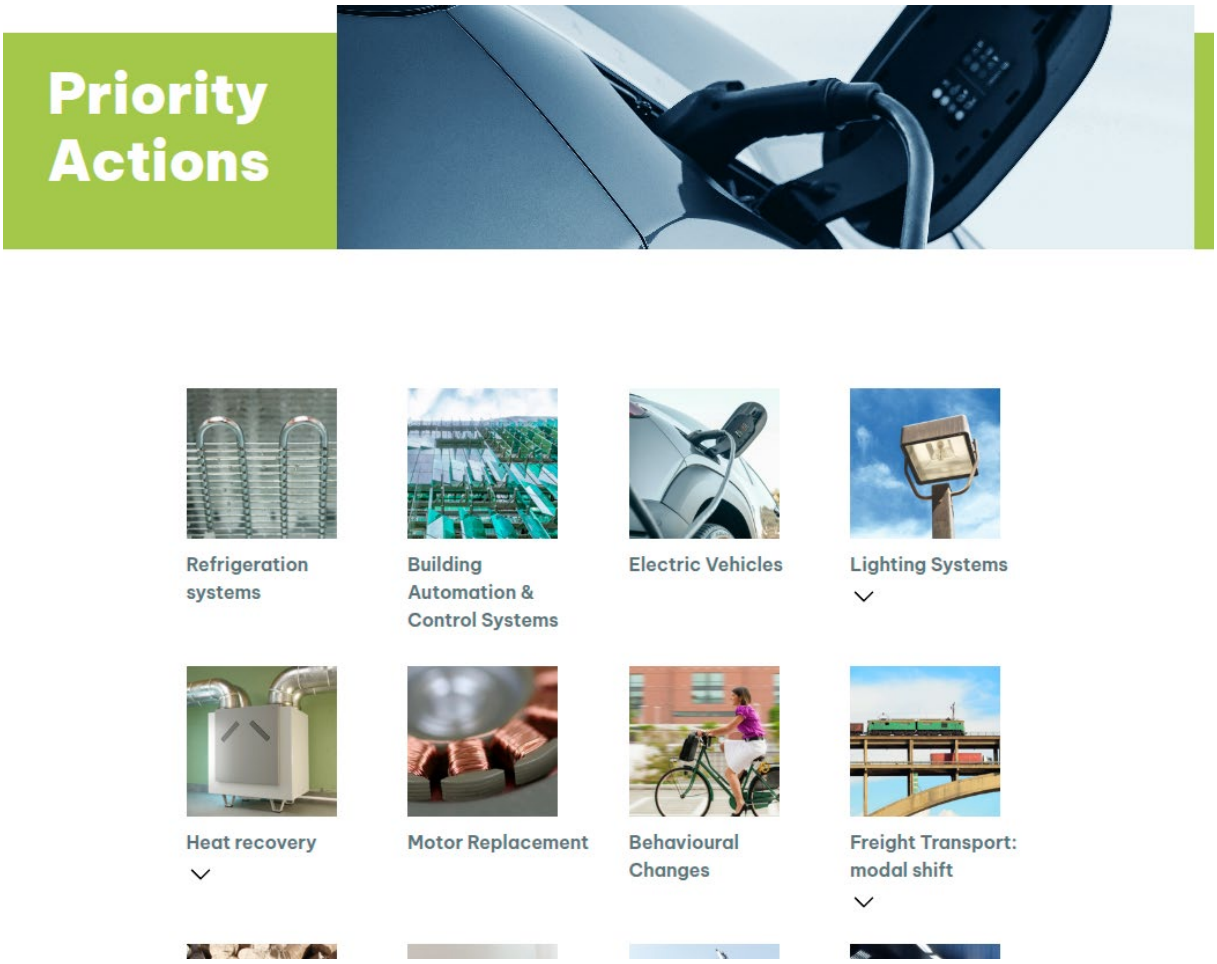


Figure 1 Screenshot of Priority Action section of the website

2.2. User Registration & Authentication

The platform implements a robust user management system that balances accessibility with data security. No external cookies are required as we do not use any third party packages.

Registration Features:

- **Email-based authentication** with secure password requirements
- **Profile management** for storing user preferences and calculation history
- **Organization affiliation** for professional users (consultancies, municipalities, research institutions)
- **Optional fields** for collecting user demographics to support project impact assessment

Benefits of Registration:

- **Calculation History**: Access past calculations and results for comparison and reporting
- **Data Persistence**: Save work-in-progress calculations and return later
- **Personalized Experience**: Customize default energy carrier mixes and reference datasets
- **Calculation Sharing**: Share calculations with colleagues and collaborators

Privacy & GDPR Compliance:

- Clear consent mechanisms for data collection and processing
- User control over personal data with export and deletion rights
- Secure storage of calculation data with access controls
- Transparent privacy policy aligned with EU regulations

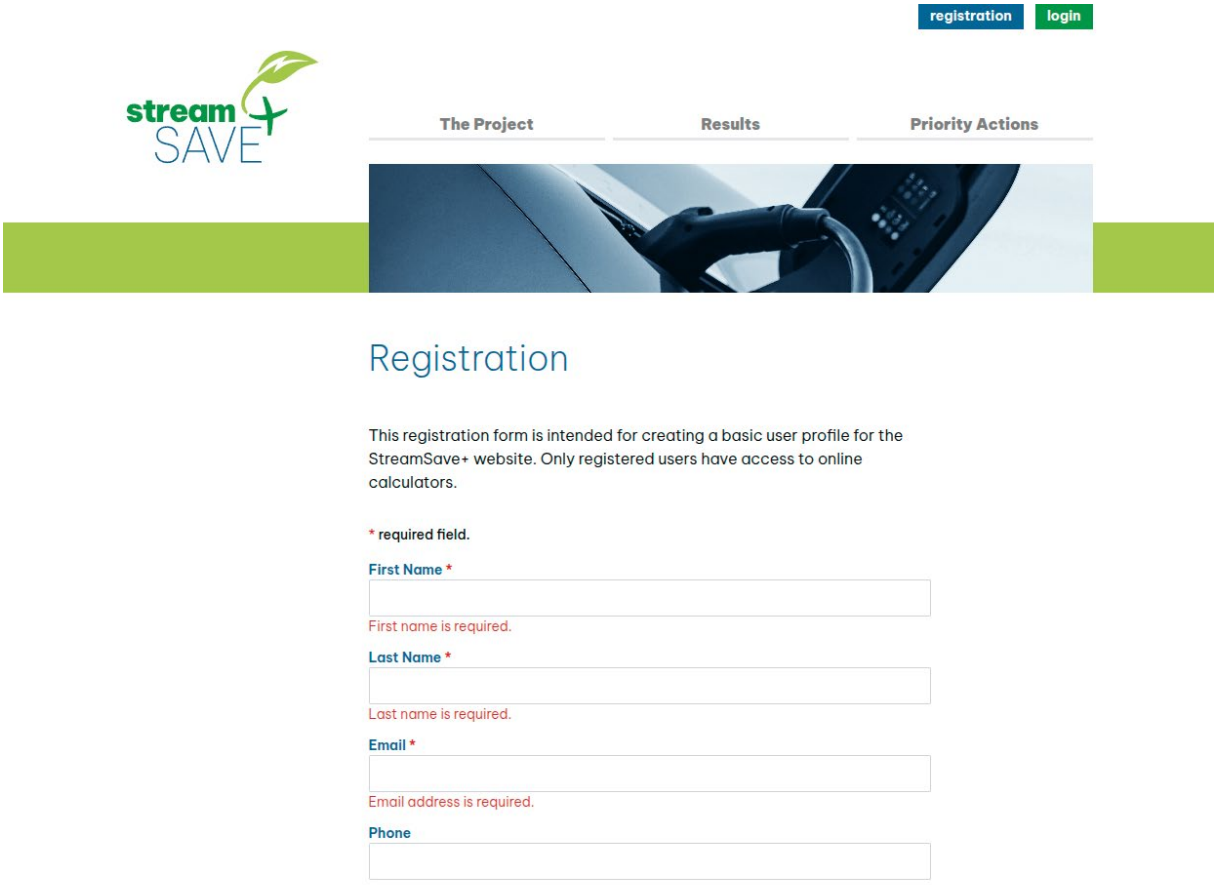


Figure 2 Screenshot of Registration process

2.3. Detailed Calculator Example: Lighting Simplified

The Lighting Simplified calculator serves as a comprehensive example of the platform's capabilities, demonstrating the complete user experience from data entry through results analysis. This calculator helps users evaluate energy savings from lighting technology upgrades (e.g., LED conversions, lighting control systems).

User Journey

The user journey follows an intuitive, step-by-step workflow:

1. **Calculator Selection**: Users navigate to the Lighting Simplified calculator through the Priority Actions
2. **Light Source Configuration**: Users specify the intervention details:
   - Light source technology (Metal-halide MH, high-pressure sodium HPS)
   - Light source power rating
   - Dimming capability (number of dimming hours, no dimming at all)
3. **Energy Carrier Configuration**: Users selects dataset and define the energy mix before and after the intervention (electricity for lighting)
4. **Data Entry**: Users fill either national OR indicative data values (or both for comparison)
5. **Calculation**: System validates inputs and performs calculations using backend PHP calculator classes
6. **Results Review**: Comprehensive results display with metrics for both national and indicative scenarios
7. **History Storage**: Calculation automatically saved to user's history for future reference

Input Forms

The calculator presents a structured, multi-section form organized into three main areas. This format is common for most calculators, providing a consistent user experience across all efficiency measures. Let's take a closer look at the three main sections using the example of the Lighting Simplified calculator:

1. Light Source Configuration (Header Section): The first section captures the basic intervention parameters:

- **Light Source Technology**: Dropdown selection (Metal-Halide MH, High-Pressure Sodium HPS)
- **Light Source Power**: Dropdown with power rating options specific to the selected technology
- **Dimming**: Whether dimming capability is present (hours per day of dimming or no dimming)

These fields drive the auto-population of indicative values in the next section. Once all three are selected, the system automatically fetches reference values from the backend.

2. Energy Carriers Section: After configuring the light source, users:

- Select a reference dataset (determines energy carrier conversion factors by country/region). The dataset can be chosen from a set of predefined options or a custom dataset created by the user that reflects national statistics or default data set could be set. There are two default

sets, one for predecessor project streamSAVE "Default StreamSAVE 2021" and one for streamSAVE+ "Default StreamSAVE+ 2023".
- Define the energy mix percentages BEFORE the intervention (e.g., 100% electricity)
- Define the energy mix percentages AFTER the intervention
- System validates that percentages sum to exactly 100% for both scenarios

3. National and Indicative Data (Dual-Column Table): The main data entry section presents two parallel columns for comparison:

National Data Column (left):

- **User-fillable** with manual data entry
- In case of the Lighting simplified calcualation, the fields include:
  - **n**: Number of light sources
  - **P_{ref}**: Reference power per source (W)
  - **P_{eff}**: Effective power per source (W)
  - **ES**: Annual equivalent operating time (hours/year)
  - **F_{BEH}**: Behavioural correction factor (0-1)
  - **LC**: Lighting control factor (0-1)
- Represents calculations using national statistics or user estimates

Indicative Data Column (right):

- **Partially auto-populated** based on header selections
- Only the first field (**n**: number of light sources) is user-editable
- Remaining fields (P_{ref}, P_{eff}, ES, F_{BEH}, LC) are automatically populated from backend based on selected light source technology, power, and dimming
- Represents calculations using reference/typical values for the specified technology
- Disabled fields prevent manual editing to maintain data consistency
- Fill either one or both columns depending on their needs

The smart validation system recognizes which columns contain data and validates accordingly—users can submit with only national data, only indicative data, or both for comparison.

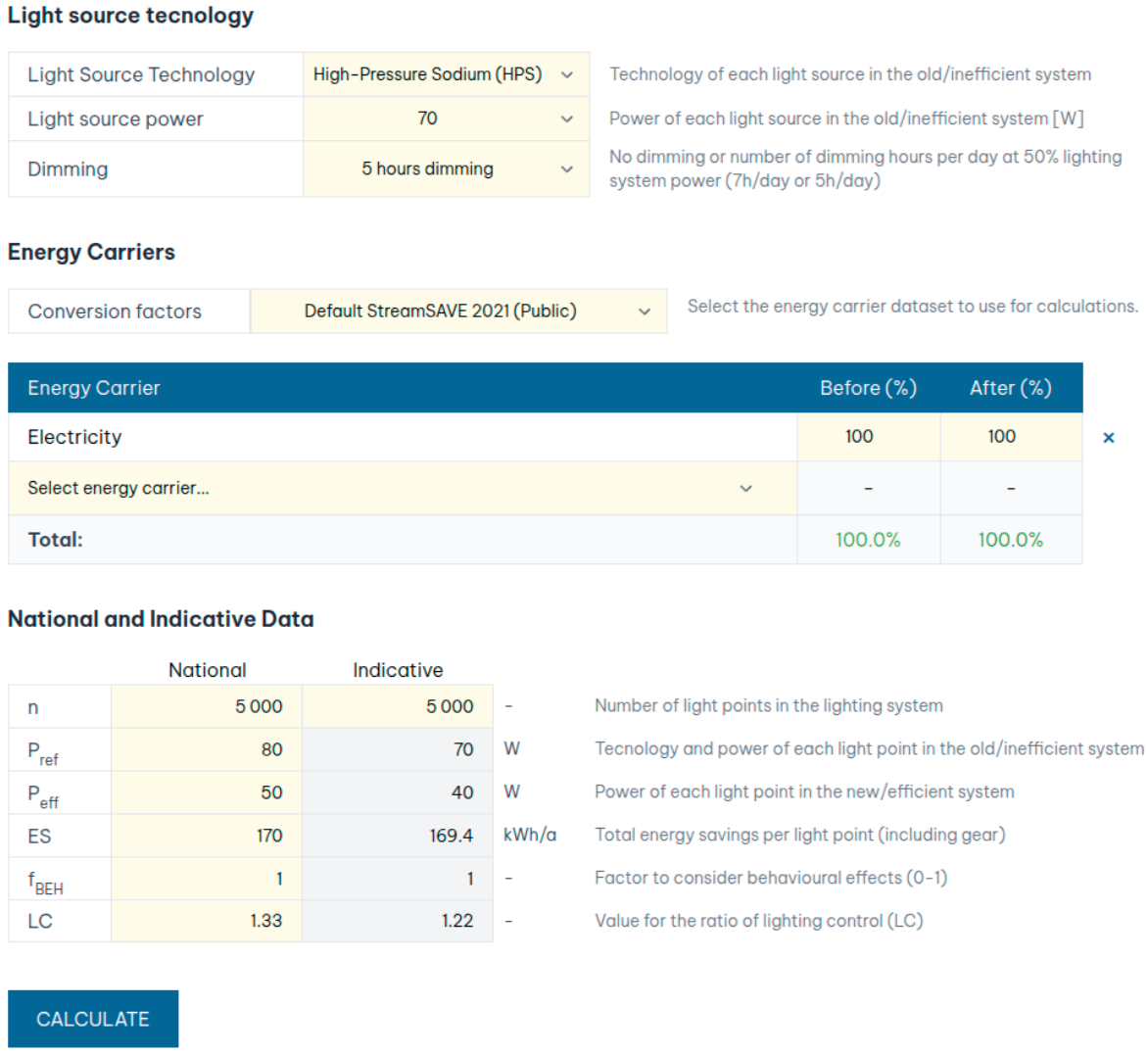


Figure 3 Lighting Simplified input form showing light source configuration, energy carriers, and national/indicative data columns

Form Components: The input forms utilize a suite of reusable Vue.js components:

- FormLabel: Clear field labels with optional HTML content support
- NumberInput: Formatted number entry with validation and locale support
- MetadataSelectInput: Dropdown selections populated from calculator metadata
- FormDescription: Contextual help text with HTML rendering
- FormUnit: Unit indicators (W, hours/year, dimensionless) for clarity
- DatasetSelector: Energy carrier dataset selection interface
- EnergyCarriers: Before/after energy mix management component

Validation

The platform implements sophisticated multi-level validation:

Real-time Field Validation:

- **Type checking**: Ensures numeric fields contain valid numbers

- **Range validation**: Checks values fall within acceptable bounds (e.g., operating hours ≤ 8760/year)
- **Required field detection**: Clearly marks which fields are mandatory
- **Format validation**: Ensures data matches expected patterns (dates, percentages, etc.)

Block-level Validation:

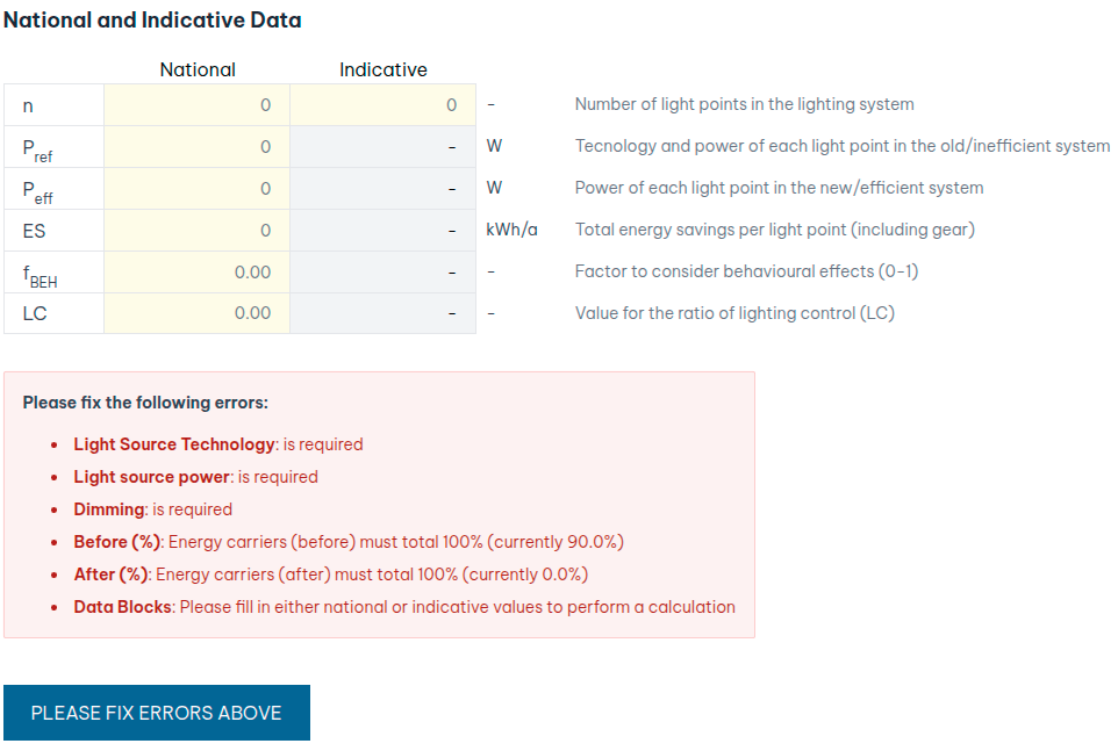
- **Either/Or Logic**: Validates that at least one complete data block (national or indicative) is filled
- **Conditional Requirements**: Fields within a block are only required if that block is being used
- **Cross-field Validation**: Checks relationships between fields (e.g., "after" efficiency must be better than "before")

Energy Carrier Validation:

- **Percentage Totals**: Ensures energy carrier percentages sum to 100% for both before and after scenarios
- **Logical Consistency**: Validates that at least one energy carrier is defined
- **Conversion Factors**: Checks that all selected carriers have valid conversion factors

User-Friendly Error Display:

- Errors appear only after first calculation attempt (not while typing)
- Clear, descriptive error messages in user's language
- Visual indicators (red borders, warning icons) for fields with issues
- Summary of validation errors at form level
- Prevents calculation button activation until all validation passes



National and Indicative Data

	National	Indicative		
n	0	0	-	Number of light points in the lighting system
P_{ref}	0	-	W	Tecnology and power of each light point in the old/inefficient system
P_{eff}	0	-	W	Power of each light point in the new/efficient system
ES	0	-	kWh/a	Total energy savings per light point (including gear)
f_{BEH}	0.00	-	-	Factor to consider behavioural effects (0-1)
LC	0.00	-	-	Value for the ratio of lighting control (LC)

Please fix the following errors:

- **Light Source Technology**: is required
- **Light source power**: is required
- **Dimming**: is required
- **Before (%)**: Energy carriers (before) must total 100% (currently 90.0%)
- **After (%)**: Energy carriers (after) must total 100% (currently 0.0%)
- **Data Blocks**: Please fill in either national or indicative values to perform a calculation

PLEASE FIX ERRORS ABOVE

Figure 4 Validation error display showing field-level errors and error summary

Results Display

After successful calculation, users receive comprehensive results comparing the national and indicative calculation approaches:

Results Table Structure: The results use a flexible, grid-based table layout with:

- **Row Labels**: Metric categories (TFES Article 7, TFES Article 3, EPEC Article 3, GHG Emissions)
- **National Columns**: Results calculated from user-entered national data (value + unit)
- **Indicative Columns**: Results calculated from auto-populated indicative data (value + unit)
- **Side-by-side Comparison**: Allows users to see how their estimates compare to reference values

Metrics Provided:

1. **TFES Article 7 (Total Final Energy Savings per Article 7)**:
   - National result: Energy savings in kWh/year based on national data inputs
   - Indicative result: Energy savings in kWh/year based on reference values
   - Metric aligns with EU Energy Efficiency Directive Article 7 methodology

2. **TFES Article 3 (Total Final Energy Savings per Article 3)**:
   - National result: Alternative TFES calculation (kWh/year)
   - Indicative result: Alternative TFES calculation (kWh/year)
   - Different methodology aligned with Article 3 requirements

3. **EPEC Article 3 (Primary Energy Consumption per Article 3)**:

- National result: Primary energy impact (kWh/year)
- Indicative result: Primary energy impact (kWh/year)
- Accounts for energy carrier conversion factors from selected dataset
- Reflects the energy required at source (power plants, etc.)

4. **GHG (Greenhouse Gas Emissions)**:
   - National result: CO_2 equivalent emissions reduction (tCO_2/year)
   - Indicative result: CO_2 equivalent emissions reduction (tCO_2/year)
   - Calculated using emission factors from energy carrier dataset
   - Demonstrates climate impact of the intervention

Interpretation:

- If only national data was filled: only the national column shows results
- If only indicative data was filled: only the indicative column shows results
- If both were filled: both columns populated, enabling direct comparison

Calculation Results	National Results	Indicative Results
TFES Article 7	1 130 500 kWh/a	1 033 340 kWh/a
TFES Article 3	1 130 500 kWh/a	1 033 340 kWh/a
EPEC Article 3	2 579 054.645 kWh/a	2 357 399.67 kWh/a
GHG_{eq}	150.696 tCO_2	137.744 tCO_2

Figure 5 Calculation results table showing TFES A7, TFES A3, EPEC A3, and GHG metrics with national and indicative columns

Additional Features:

- **Automatic History Save**: Calculation automatically saved to user profile
- **Calculation History Section**: Shows recent calculations directly below results for easy loading/comparison
- **Additional Information**: Methodology notes and assumptions displayed below results
- **Load Previous Calculations**: Click any history entry to restore that calculation's inputs
- **Confirmation Modal**: Protects users from accidentally overwriting current work when loading historical data

Transparency: The results display includes:

- Clear indication of which EU Directive articles each metric aligns with
- Energy carrier conversion factors applied (from selected dataset)
- Calculation methodology accessible through additional information section

- Timestamp and unique calculation ID for reproducibility

2.4. Energy Carrier Management

Energy carriers (electricity, natural gas, district heating, renewable sources, etc.) are central to accurate energy efficiency calculations. The platform implements a sophisticated yet user-friendly energy carrier management system.

Core Functionality:

The energy carrier interface allows users to:

- **Duplicate existing datasets**: Choose from a pre-defined set of reference datasets and modify them according to user needs
- **Reusability**: In calculations, the user has access to all pre-defined datasets along with all custom user created datasets created
- **Customization**: Users can create new datasets based on their own data or reference values
- **Validation**: The system validates that all energy carriers have valid conversion factors
- **Flexibility**: Users can define any energy carrier they need (they are not limited to predefined options)

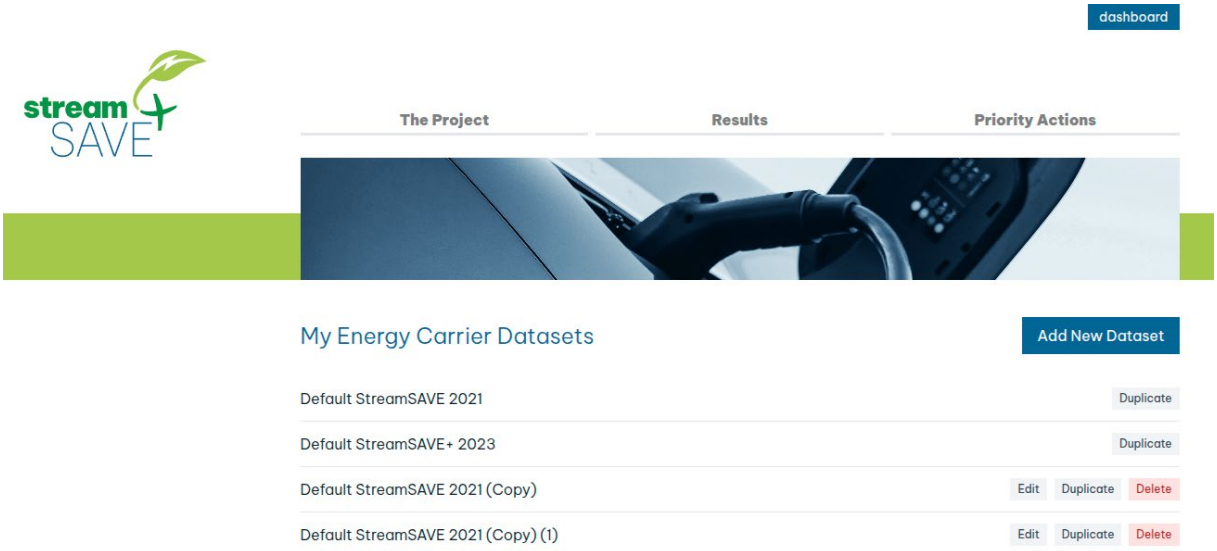


Figure 6 Energy Carrier Management interface showing before/after percentage sliders and validation

Integration with Calculators: Every calculator that involves energy consumption integrates the energy carrier module, ensuring:

- Consistent user experience across all calculators
- Centralized conversion factor management
- Unified approach to primary energy and emissions calculations
- Reusable component architecture reduces code duplication

2.5. User Dashboard & Calculation History

After signing in, registered users have access to dashboard that serves as a central hub for their calculation activities.

Dashboard Overview:

The user dashboard provides:

- **Recent Calculations**: Quick access to the most recent 10-20 calculations
- **Favourite calculations**: Filter calculation history by calculator type or displayed only favourite calculations
- **Profile Management**: Update personal information, organization details, preferences

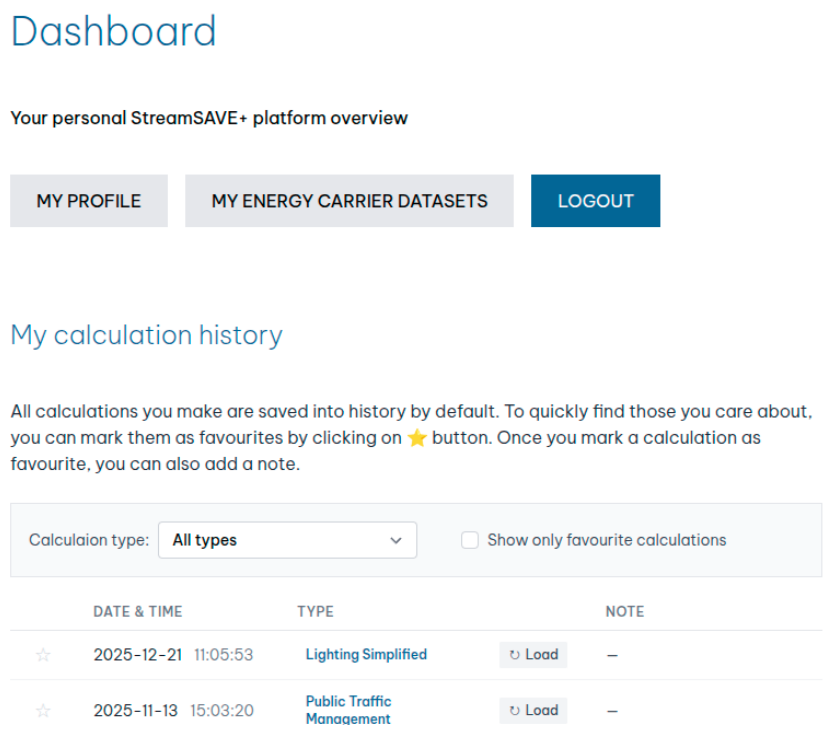


Figure 7 User dashboard showing calculation history, statistics, and quick actions

Calculation History Features:

The history system provides powerful tools for managing past calculations:

List View:

- Searchable, filterable list of all user calculations
- Sort by date, calculator type, favourite status
- Pagination for users with extensive history
- Sharing calculation details with other users

Data are saved in JSON package format, enabling easy export in a structured way understandable in other applications.

2.6. UX/UI Innovations

The platform implements several innovative user experience features that distinguish it from traditional calculation tools:

1. Responsive Design:

- Fully functional on desktop, tablet, and mobile devices. Although some larger tables might be cumbersome to use on smaller screens.
- Touch-optimized input controls for field use
- Adaptive layouts that reorganize based on screen size

2. Real-time Feedback:

- Instant validation as users enter data
- Progress indicators during calculations

- Loading states that communicate what's happening
- Visual cues for completed vs. incomplete sections

3. Progressive Disclosure:

- Complex calculators broken into manageable sections
- Advanced options hidden until needed
- Contextual help text appears when relevant
- “Learn more” links to detailed methodology documentation

4. Visual Data Presentation:

- Color-coded results for quick interpretation
- Icons and visual indicators supplement text
- Consistent design language across all calculators

5. Error Handling & Recovery:

- Graceful degradation when services unavailable
- Auto-save drafts to prevent data loss
- Clear error messages with suggested solutions
- Retry mechanisms for failed API calls

Technical Foundation: These UX/UI innovations are powered by:

- **Vue.js 3 Composition API**: Reactive, performant component architecture
- **Tailwind CSS**: Utility-first styling for consistent, maintainable design
- **Vite**: Lightning-fast development and optimized production builds
- **Pinia State Management**: Reactive stores with excellent developer tools
- **Component Library**: Reusable UI components ensure consistency

The result is a platform that combines professional-grade calculation capabilities with consumer-grade usability, making complex energy efficiency assessments accessible to a broad audience.

3. Backend Features (Administration)

The StreamSAVE+ platform includes a comprehensive administration backend that enables non-technical staff to manage content, users, and reference datasets without requiring developer involvement. This section describes the administrative capabilities and the design decisions behind them.

3.1. Content Management

The platform separates content into two distinct categories, each with purpose-built management tools.

Static Pages

Structural pages (About, Contact, Methodology Documentation, Legal Information) are managed through a dedicated static pages system. Administrators can create hierarchical page structures, organize navigation menus, and update content using a visual editor. This separation ensures that foundational platform content remains stable and is managed separately from frequently-updated editorial content.

Articles & News

Editorial content such as news articles, announcements, and educational materials is managed through a full-featured article management system. Key capabilities include:

- **Publication Scheduling**: Articles can be prepared in advance and scheduled for automatic publication with configurable publish-from and publish-until dates
- **Category Organization**: Content can be organized into thematic categories, with support for multiple category assignments and primary category designation
- **Rich Media Support**: Each article can include gallery images with automatic thumbnail generation, downloadable document attachments, and cover images for article listings
- **Editorial Workflow**: Draft mode allows content preparation before publication, with clear visual indicators of publication status

This design enables content teams to maintain an active, engaging platform presence without technical expertise. The separation of structural and editorial content ensures that routine content updates cannot accidentally affect core platform functionality.

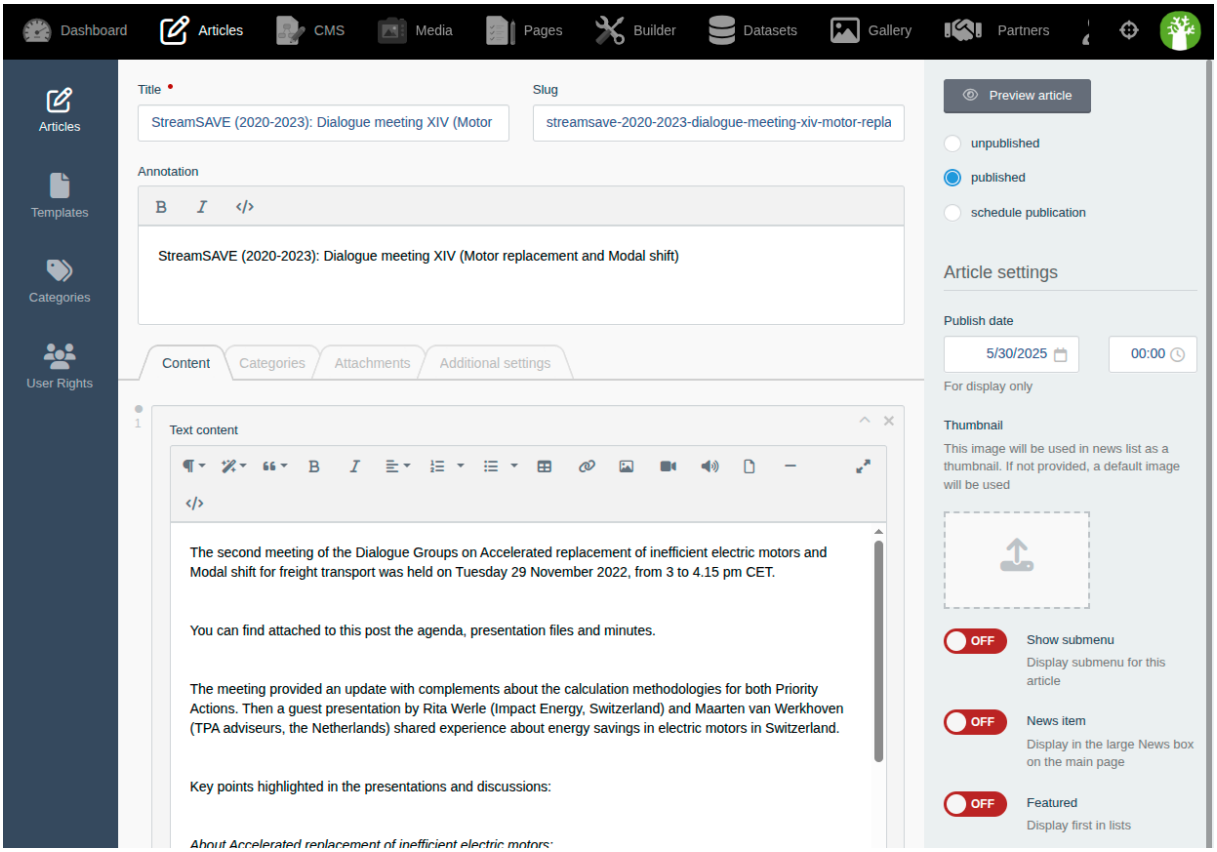


Figure 8 Backend article editor showing publication scheduling and category assignment

3.2. User Management

The platform implements user management with privacy and data integrity as core principles.

Account Management

Administrators can manage user accounts, including activation/deactivation, password reset capabilities, and profile information updates. User accounts support organization affiliation for professional users from consultancies, municipalities, and research institutions.

Calculation History & Data Integrity

Every calculation performed by a user is automatically saved with complete input data, including:

- All parameter values entered by the user
- Energy carrier selections and their conversion coefficients at the time of calculation
- Calculation type, timestamp, and unique identifier
- Full results for all output metrics

This snapshot approach ensures **data integrity over time**: past calculations remain accurate and reproducible even if reference datasets are updated in the future. Users can mark important calculations for quick reference, add notes, and protect calculations from accidental deletion.

Privacy & GDPR Alignment

User data is isolated by account—users can only access their own calculation history.

3.3. Dataset Management

Energy carrier datasets are central to accurate energy efficiency calculations. The platform provides flexible dataset management that balances standardization with regional customization.

Pre-defined vs. Custom Datasets

The platform includes EU-standard reference datasets with default primary energy factors and greenhouse gas emission factors for common energy carriers (electricity, natural gas, district heating, various renewable sources). Additionally, administrators and users can create custom datasets reflecting national statistics or specific regional conditions.

Dataset Structure

Each dataset defines energy carriers with their associated conversion coefficients:

- Primary energy factors for primary energy consumption calculations
- GHG emission factors for carbon footprint calculations

Time-Saving Design

Once a user or administrator selects a dataset, all conversion coefficients are automatically applied across calculations. Users do not need to manually enter emission factors or primary energy coefficients for each individual calculation—they simply select the appropriate dataset and the system handles the rest. This dramatically reduces data entry time and eliminates transcription errors.

Ownership Model

Datasets can be designated as public (available to all users) or user-owned (private to the creator). This allows organizations to maintain proprietary regional data while still benefiting from shared EU-standard datasets.

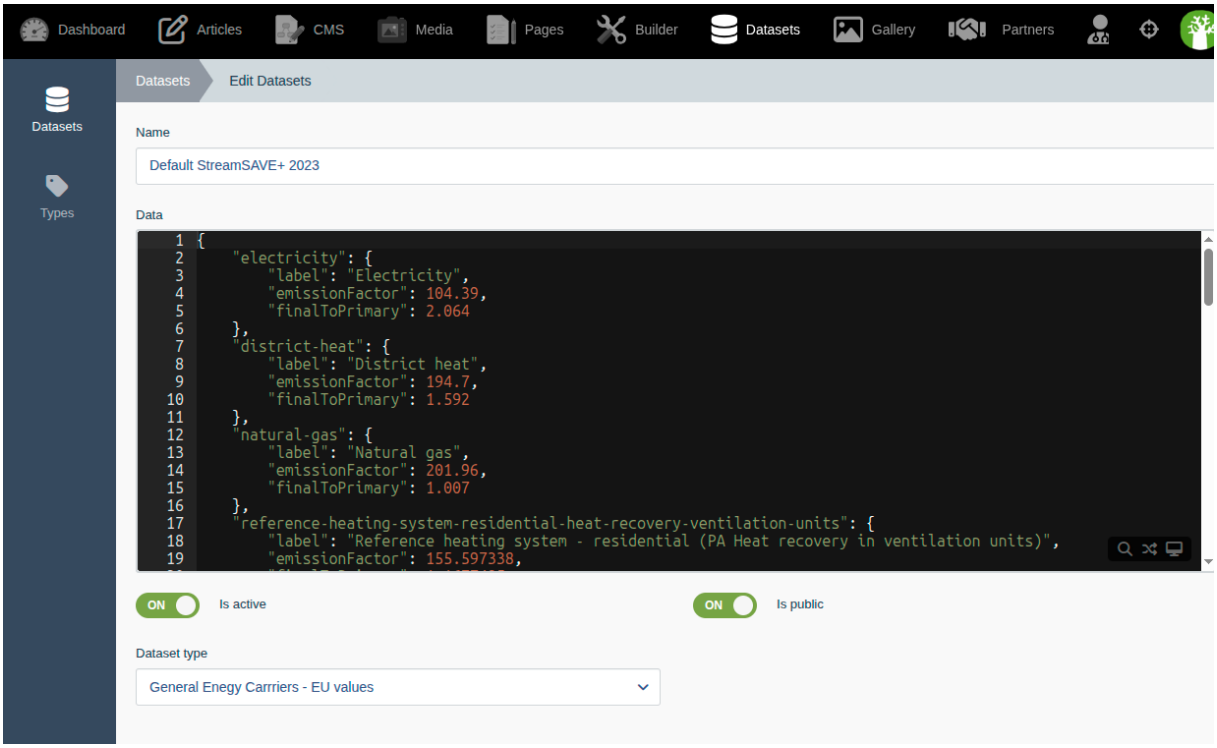


Figure 9 Dataset management interface showing energy carrier configuration

3.4. API Architecture

The platform exposes its functionality through a versioned REST API that cleanly separates the frontend interface from backend calculation logic.

Key Characteristics

- **Versioned Endpoints**: All API routes are versioned (e.g., /api/v1/) to enable future enhancements without breaking existing integrations
- **Authentication-Protected**: All endpoints require user authentication, ensuring calculation data privacy
- **Standardized Formats**: Consistent JSON request/response structures across all calculator types

Design Rationale

This clean separation between frontend and backend ensures that calculation logic remains centralized and auditable. All calculations are performed server-side using validated algorithms, preventing client-side manipulation of results. The API-first architecture also enables potential future extensions such as mobile applications and allows the backend calculators to be used by third parties, integrated into their applications.

4. Technical Architecture

This section describes the technical architecture of the StreamSAVE+ platform, with particular emphasis on the standalone calculator library designed for reuse in other applications.

4.1. Streamsave-Calculators Library

The heart of the StreamSAVE+ platform is a standalone PHP library that encapsulates all energy efficiency calculation logic. This library was intentionally designed as an independent component that can be used outside the StreamSAVE+ platform.

Design Philosophy

The library follows several key principles:

- **Zero External Dependencies**: Pure PHP with no external package requirements, making it portable across different PHP environments and frameworks
- **Self-Contained Reference Data**: All indicative values, default parameters, and reference coefficients are included within the library as JSON files—no external database or API connection is required

Library Structure

The library is organized around a factory pattern:

- **CalculatorFactory**: The main entry point that instantiates calculator objects by type
- **Calculator Classes**: Individual classes for each of the supported calculation types (LightingSimplified, Refrigeration, ThermalRefurbishment, BehaviouralChanges, etc.)
- **MetadataProvider Classes**: Companion classes that define form field structures, validation rules, and field options for each calculator type
- **Definition Files**: Configuration files that specify field labels, dropdown options, and parameter constants
- **Reference Data**: JSON files containing indicative values and default parameters for EU-standard calculations

Calculation Methodology

Each calculator implements the scientifically-validated methodologies aligned with EU Energy Efficiency Directive requirements. Calculations produce standardized outputs:

- **TFES Article 7**: Total Final Energy Savings per Article 7 methodology
- **TFES Article 3**: Total Final Energy Savings per Article 3 methodology
- **EPEC Article 3**: Primary Energy Consumption impact
- **GHG**: Greenhouse gas emission reductions

4.2. Integration Architecture

The StreamSAVE+ platform uses a hybrid frontend-backend architecture that separates user interface concerns from calculation logic.

Hybrid Frontend-Backend Approach

Backend (PHP):

- Hosts the calculator library and executes all calculations server-side
- Ensures calculation integrity—results cannot be manipulated client-side
- Handles data persistence (calculation history, user accounts, datasets)

- Provides API endpoints for frontend communication

Frontend (Vue.js):

- Delivers responsive, interactive user interfaces
- Provides real-time form validation and user feedback
- Manages application state and user interactions
- Communicates with backend exclusively through REST API calls

This separation ensures that complex calculations remain centralized and auditable, while the user experience benefits from modern frontend capabilities.

Extensibility

Because the backend API is independent from the Vue.js frontend, other parties can build alternative interfaces using the same calculation engine. This enables development of mobile applications, desktop tools, or integration into third-party platforms—all consuming the same validated calculation API.

Data Flow

A typical user interaction follows this sequence:

1. **User fills header fields** (e.g., light source technology, power)
2. **Frontend requests indicative values** → API returns reference values based on selections
3. **Form auto-populates** with indicative data while user can still enter national values
4. **User completes inputs** including energy carrier configuration
5. **Frontend submits calculation request** → API validates and processes
6. **Backend executes calculation** using CalculatorFactory → Calculator → Results
7. **Results saved and returned** → Frontend displays comprehensive results table

4.3. Standalone Library Benefits

The decision to architect the calculator library as a standalone PHP package was deliberate. This design enables the StreamSAVE+ calculation methodology to be adopted by other organizations and projects.

Usability in Other Applications

Organizations wishing to integrate StreamSAVE+ calculations into their own systems can do so with minimal effort:

1. Simply copy the library files into any PHP project—no external packages or framework required
2. All calculation parameters and indicative values are included as JSON files within the library
3. The library accepts simple associative arrays as input and returns results as associative arrays
4. Unit tests can run without spinning up any framework or server environment

Example Integration

Integrating the library into another PHP application is straightforward:

```php
use StreamSave\CalculatorFactory;

$factory = new CalculatorFactory();

// Input: simple associative array
$inputs = [
    'lightSourceTechnology' => 'led',
    'lightSourcePower' => '40',
    'n' => 100,
    'p_ref' => 60,
    'p_eff' => 40,
    'ES' => 2500,
    // ... other parameters as needed
];

$calculator = $factory->create('lighting-simplified', $inputs);

// Output: simple associative array
$results = $calculator->calculate();
// Returns: ['tfes_a7' => 5000, 'tfes_a3' => 4800, 'epec_a3' => 12000, 'ghg' => 2.4, ...]
```

By providing the calculation engine as a reusable library, the StreamSAVE+ project extends its impact beyond the web platform itself, enabling broader adoption of harmonized energy efficiency calculation methodologies across Europe.

5. Innovation & Impact

The StreamSAVE+ platform incorporates several innovative architectural decisions that distinguish it from traditional energy calculation tools. These innovations contribute to the platform's usability, maintainability, and potential for broader adoption across the EU.

5.1. Modular Calculator Architecture

The platform supports distinct calculator types through a unified factory pattern architecture. Rather than building each calculator as an isolated application, all calculators share common infrastructure: the same API endpoints, the same frontend component patterns, the same validation framework, and the same results display system.

Adding a new calculator type requires only implementing the calculator class itself plus its metadata provider—the surrounding infrastructure automatically handles form rendering, validation, API routing, history storage, and results display. This modular approach ensures that new calculators inherit the quality and consistency of existing ones, while dramatically reducing development effort for each addition.

The practical impact is sustainable maintenance: as the calculator portfolio grows, the codebase remains manageable because common functionality is centralized rather than duplicated.

5.2. Hybrid Frontend-Backend Model

Traditional web calculators often perform calculations entirely in the browser (JavaScript) or entirely on the server with page reloads. The StreamSAVE+ platform takes a hybrid approach.

All calculation logic executes server-side in PHP, ensuring that results cannot be manipulated by modifying client-side code. This is essential for applications where calculation integrity matters—energy efficiency assessments often inform policy decisions, funding allocations, and regulatory compliance.

Meanwhile, the Vue.js frontend delivers a rich, responsive user experience with instant validation feedback, dynamic form behaviour, and smooth interactions. Users receive immediate feedback as they enter data, without waiting for server round-trips on every keystroke.

5.3. Metadata-Driven Form Generation

Each calculator in the platform is defined not just by its calculation logic, but by a comprehensive metadata specification. This metadata describes every form field: its type, validation rules, options (for dropdowns), dependencies on other fields, and display characteristics.

The frontend Vue.js components read this metadata and dynamically render the appropriate form elements. This means that changing validation rules or modifying dropdown options requires only updating the metadata definition. The frontend automatically adapts without code changes.

This single-source-of-truth approach eliminates the synchronization bugs that plague systems where validation rules are duplicated between frontend and backend. It also enables rapid iteration on calculator designs and ensures consistency across all calculator types.

5.4. Future Extensibility

The platform architecture anticipates future growth and change:

- **New Calculator Types**: The modular architecture means new calculators can be added without modifying existing calculator code or core infrastructure
- **Alternative Frontends**: The API-first backend design enables future mobile applications, desktop tools, or integrations into other platforms without changes to calculation logic
- **Evolving Methodologies**: As EU directives evolve, calculation methodologies can be updated in the centralized library, automatically applying to all platform users
- **Standalone Library Adoption**: Organizations can adopt the calculation library independently, extending the project's impact beyond the web platform

This forward-looking architecture ensures that the StreamSAVE+ platform can adapt to future requirements—new energy efficiency measures, updated regulatory frameworks, emerging technologies—without fundamental restructuring.

CONTACT THE PROJECT

@streamSAVEplus

svn.cz/streamsaveplus

contact@streamsaveplus.eu

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