

1 **Supplementary Information for**

2 **Towards a national integrated model for land, energy, agriculture and forest** 3 **systems (TIM-LEAF v1.0)**

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9 This file contains the TIM-LEAF v1.0 User manual.

10 Model release: TIM-LEAF v1.0

11 Repository: <https://doi.org/10.5281/zenodo.22210894>

1. Purpose and scope

TIM-LEAF is Ireland's integrated national model for land, energy, agriculture and forest systems. It extends the TIMES-Ireland Model (Balyk et al., 2022) to illustrate interactions between energy system transformation, land availability, agricultural production, forestry practices and greenhouse gas (GHG) emissions within a consistent optimisation framework.

TIM-LEAF has been developed to allow the analysis of long-term mitigation pathways under alternative climate policy, technology assumptions and carbon budgets constraints. This version of TIM-LEAF is also soft linked to the simple climate model, FaIR v2.1.3 (Smith, 2023), to further assess temperature response of national GHG pathways.

This manual provides a guide for obtaining, configuring and running TIM-LEAF and for inspecting the resulting model outputs. It is intended to accompany the TIM-LEAF model code (Jaggeshar et al., 2026b) and the scientific description of the model (Jaggeshar et al., 2026a; in review).

TIM-LEAF is implemented within the TIMES modelling work under the Energy Technology Systems Analysis Programme (ETSAP); and users unfamiliar with the TIMES working environment can consult the relevant TIMES documentation for general information on TIMES model structure, model building, scenario definition and execution (ETSAP, 2016).

2. Model architecture

A concise model architecture is outlined in the README File, also available at [TIM-LEAF/README.md at main · MaREI-EPMG/TIM-LEAF · GitHub](#). More information is detailed in the accompanying description paper.

3. Software requirements

The following software is required to run TIM-LEAF and, where applicable, to reproduce the temperature response analysis presented:

Table 1: Working environment of TIM-LEAF

Software	Version	Function
Veda Front End (Veda 2.0)	4.2.1.0	Model input and output, scenario runs and results visualisation
GAMS	49.1	Generating and running the optimisation solver
CPLEX	-	Optimisation solver
Python	3.10.14	Data processing and TIM-LEAF-FaIR workflow
FaIR	2.1.3	Temperature response analysis

4. Model inputs and repository structures

TIM-LEAF uses a set of sector-specific baseline input Excel files together with supporting model files, templates and scenario files. The baseline input files provide the starting point from which alternative scenario configurations are developed.

4.1 Sector specific baseline input files

Table 2 lists the main sector-specific baseline input files (*B-Y templates*) included in the model repository. The repository also contains files inherited from or associated with the underlying TIMES-Ireland model.

Users should retain the supplied file names and directory structure when working with TIM-LEAF. Moving, renaming or deleting model files may prevent VEDA from synchronising the model correctly

48 **Table 2. Sector-specific baseline input files**

File	Model component
VT_IE_AGR	Agriculture
VT_IE_IND	Industry
VT_IE_PWR	Power
VT_IE_RSD	Residential
VT_IE_SRV	Services
VT_IE_SUP	Supply
VT_IE_TRA	Transport
VT_IE_FRS	Forest
VT_IE_LULUCF	Land use and land use change
VT_IE_WTL	Wetlands / peatlands

49 **4.2 Supporting model files**

50 In addition to the sector specific files, the repository contains supporting scenario files and
 51 directories, as given in Table 3.

52 **Table 3: Additional files to run TIM-LEAF**

File / Folder	Purpose
AppData	Application / model data
SetRules	System and model settings
BY_Trans	Time slices input
Sets	Model set definitions
SubRES_TMPL	Scenario transformation files
SuppXLS	Supporting scenario files, including trades, demands
TIM-LEAF-FaIR_workflow	Post-processing and TIM-LEAF-FaIR workflow

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5. Obtaining and running TIM-LEAF

- Obtaining and initialising the model

The TIM-LEAF v1.0 model, associated with this release, is available from the Zenodo repository (<https://doi.org/10.5281/zenodo.22210894>). After installing the required software environment, the model can be initialised in VEDA Front-End as follows:

- i. Open VEDA Front End
- ii. Select “Add new model”
- iii. Navigate to the directory containing the TIM-LEAF model files and add them to VEDA
- iv. Start the model synchronisation for all model files to be made available on the interface

- Defining and running a scenario

Scenario cases are defined in the Run Manager module of VEDA. The sector-specific baseline inputs provide the base model configuration and remain unchanged, while the required transformation scenario files are selected according to the assumptions of the scenario being analysed.

Once a scenario case has been defined:

- i. Select the required scenario case in the run manage module.
- ii. Select the model periods to be included in the run (for TIM-LEAF scenarios, we use p54 which is an annual resolution covering the period from 2018 to 2071).
- iii. Select CPLEX as the optimisation solver.
- iv. Execute the model run.
- v. Monitor the run until VEDA reports *Normal Completion*.

TIM-LEAF uses GAMS to generate and solve the optimisation model, with CPLEX used as the optimisation solver.

If the model does not reach normal completion, the GAMS and VEDA output and error messages should be checked to identify the source of the problem.

- Model results visualisation

TIM-LEAF results can be inspected using the Results module in VEDA. After a successful model run:

- i. Open the VEDA Results module.
- ii. Select the relevant scenario.
- iii. Select the required result variable or flow.

- iv. Inspect or export the results as required.

For the diagnostic scenarios supplied with TIM-LEAF, the main outputs of interest include:

- **Energy** : technology deployment and activity, energy CO₂ emissions
- **Land**: land allocation and land use change across activities, LULUCF emissions
- **Agriculture**: Agricultural production, biomass supply, agricultural emissions
- **Forest**: Forest area, afforestation, biomass supply, HWP carbon storage
- **Integrated system**: Total GHG emissions, CDR deployment, net emissions, marginal abatement costs

- Temperature response analysis

To reproduce the climate-response analysis:

- i. Run the required TIM-LEAF scenarios.
- ii. Ensure that the expected .vd output files are available.
- iii. Place the scenario outputs in the specified TIM-LEAF–FaIR scenario directory.
- iv. Run the Ireland country-level FaIR workflow.
- v. Visualise the resulting temperature-response outputs.

More information related to the workflow is available at https://github.com/MaREI-EPMG/TIM-LEAF/blob/main/TIM-LEAF-FaIR_workflow/fair/fair_readme.md.

6. Reproducing diagnostic scenarios

To demonstrate the use of TIM-LEAF and provide a reproducible starting point for users, two example scenarios are described below: the Business-as-Usual (BAU) scenario and Scenario 3 (S3). The remaining scenarios in the repository are defined using the same method, with different combinations of transformation and scenario input files, as summarised in Table 4. A full description and rationale for the scenarios is provided in the documentation paper (Jaggeshar et al., 2026a; in review).

Table 4: Files included in each diagnostic scenario runs

Scenario	Key scenario assumptions	Scenario specific files
BAU	Reference pathway	BY-Templates (Base) Scenario files (hereafter SF) ind_ccs, pwr_dh, pwr_newtechs, rsd-retrofit, rsd_newtechs, srv_dc_excessheat, srv_newtechs, sup_biorefineries, pwr_electricitystorage, sup_hydrogen, sys_othernewtechs, tra_newvehicles, syssettings, a_sys_sad_40ts, a_behistorical, b_sys_additional_assumptions, a_landconversionshares, b_ind_shares.dd, b_agr_shares, b_sys_demands, b_pwr_ccs, b_srv_dc_eh, b_pwr_rnw_potentials, b_sys_historic_bounds, b_rsd_retrofit, b_rsd_uc, b_srv_uc, b_pwr_snsp_limit, b_sup_dombiopot_seai, b_sys_bio_delivcost, b_sys_co2_calibration, b_sys_maxgrowthrates, b_rsd_unitboilers, b_tra_f_modalshares, b_tra_newcars_retirement, b_tra_emissions, b_tra_stock_retirement, b_sys_med_harvestpotential, b_sys_lusink, b_sys_forestseqprofile., for_decliningafforestationlevel, b_tra_ev_parity, b_tra_p_modalshares
S1	Biomass intensive pathway	SF is modified to: a_highBE, b_sys_high_harvestpotential, for_8khaAfforestation level, sys_carbonbudget-CAP24_450MT-nEW
S2	Balanced pathway with reduced biomass availability, afforestation and RE expansion	SF is modified to: a_midBE, b_sys_med_harvestpotential, for_10khaAfforestation level, sys_carbonbudget-CAP24_450MT-nEW
S3	Structural transformation with reduced agricultural demand	SF is modified to: a_lowBE, b_sys_low_harvestpotential, for_25khaAfforestation level, sys_carbonbudget-CAP24_450MT-nEW. The b_sys_demands file is modified to enable the low agricultural demand input table.

Example 1: Business-as-Usual (BAU)

The BAU scenario uses the baseline model configuration and provides the reference pathway for comparison with the alternative diagnostic scenarios. To run the BAU scenario in VEDA:

- i. Open the Run Manager module.
- ii. Define the BAU scenario case by choosing the files listed in Table 4
- iii. Select p54, corresponding to the annual model periods from 2018–2071.
- iv. Select CPLEX as the optimisation solver.

- v. Run the scenario case

Example 2: Scenario 3 (S3)

Scenario 3 represents a structural transformation pathway with reduced agricultural demand. Relative to the BAU configuration, S3 modifies the assumptions of land availability, forest harvesting, afforestation and includes the 450Mt carbon budget constraint. The agricultural demand assumptions are also modified to activate the low agricultural demand input table.

To run S3 in VEDA:

- i. In the `b_sys_demands` file, activate the low agricultural demand table by removing the tilde (~) from the table tag `~FI_T AGR _Demand` and adding a tilde (~) to the table tag of `AGR_Demand_LED`. This switches the active agricultural demand input to the low agricultural demand configuration.
- ii. Synchronise the model in VEDA after making these changes.
- iii. Then go to the run Manager module and define the S3 case by choosing the corresponding scenario files listed in Table 4.
- iv. Maintain the p54 period configuration and CPLEX as the optimisation solver.
- v. Run the scenario

References

- Balyk, O., Glynn, J., Aryanpur, V., Gaur, A., McGuire, J., Smith, A., Yue, X., & Daly, H. (2022). TIM: Modelling pathways to meet Ireland's long-term energy system challenges with the TIMES-Ireland Model (v1.0). *Geoscientific Model Development*, 15(12), 4991–5019. <https://doi.org/10.5194/gmd-15-4991-2022>
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