Final Report for the IEA/ETSAP Project

A TIMES/MIRO App

CONTRACT NO. RC-2021-IFE-001

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Foreword

This is a final report that describes the developments of the TIMES/MIRO App that have been accomplished in the scope of the IEA/ETSAP project A TIMES/MIRO App (CONTRACT NO. RC-2021-IFE-001). It is not a comprehensive documentation of the TIMES/MIRO App. For the TIMES/MIRO App documentation we refer to the app_README.
1. Introduction

The energy systems analysis community is moving towards open modeling regarding the tool chest and data. An open-source interface to organize runs and analyze inputs and results will contribute to the open-source character of the overall TIMES modeling framework.

This project aims at developing an open-source interface for data input, model solving and results’ analysis for the TIMES modeling framework that supports the deployment and use of TIMES models. The TIMES/MIRO app is based on the deployment framework GAMS MIRO\textsuperscript{1}, which allows building intuitive and user-friendly interfaces that enable efficient interaction with GAMS models and provides extensive visualization capabilities such as charts, time-series, maps, etc.

The TIMES/MIRO app can serve as an open-source GUI to TIMES models as it is published under an open-source license on GitHub. The TIMES/MIRO app can be installed locally or on a MIRO Server and be accessible through the web. When the TIMES/MIRO app is locally installed, a free GAMS demo license is sufficient to use the App and solve large-scale models through the TIMES Cloud Service\textsuperscript{2}.

Hence, the TIMES/MIRO App is an interface that provides ETSAP community the possibility to outreach new users of TIMES in developing countries, where budgeting constraints can be a limitation, or to allow potential interested users in developed countries to try and explore the framework before they decide to move to the more sophisticated VEDA interface. The TIMES/MIRO App becomes an important outreach and dissemination tool for TIMES.

Another important feature of TIMES/MIRO App is that the data input and data output interface is based on GAMS and Python and its code is fully accessible, as it is open-source. This means that the TIMES modellers can customise the TIMES/MIRO App as needed. For example, the TIMES modellers using the App could avoid exposing the full input parameters of the model and present only a subset of them that the users of the models are allowed to change. Similarly, on the output side, the users of the App could create sophisticated views of the basic output parameters of TIMES to provide a more user-friendly and at a higher level presentation of results. For example, instead of letting the user of their model selecting “VAR\_COMNET” and then “CO2” to see the emissions, TIMES modellers could through the App code, create a new output parameter “Annual\_CO2\_emissions” which is then available to the users of their model. Therefore, the open source character of the application allows creating tailor-made applications for TIMES models that can be a powerful dissemination tool for TIMES-based models to stakeholders or clients and opens new possibilities for the ETSAP community in aiding informed decisions for policymaking.

\textsuperscript{1} GAMS MIRO (https://www.gams.com/miro/) is a deployment system to transform GAMS models into so-called MIRO applications that run in common web browsers. MIRO apps allow modifying input data, execute GAMS jobs and browse results.

\textsuperscript{2} The TiMES Cloud Service is an ongoing ETSAP R&D undertaking. The service comprises the Open Source TiMES source code, computing resources, and a GAMS license including GAMS/Cplex and GAMS/Conopt. The service is based on GAMS/Engine (https://www.gams.com/engine/) that communicates via a REST API. At the current time the TiMES Cloud Service is only accessible to ETSAP Partners and their designated representatives.
This report focuses on enhancements and extensions that have been implemented for the underlying prototype\(^3\) in the scope of the IEA/ETSAP Project “A TIMES/MIRO App” (CONTRACT NO. RC-2021-IFE-001).

All enhancements and extensions have been tested with a collection of TIMES models that are publicly available (like the TIMES Demo and the TIMES-DK.COMETS models) or have been provided by the project partners.

\(^3\) GAMS has been working with Evangelos Panos (PSI) and Gary Goldstein (DWI) on a TIMES/MIRO App before this project started. This first prototype of this app has been presented at the July 2020 ETSAP workshop.
2. Usage of the TIMES/MIRO App

The TIMES/MIRO App allows the user to load various data sets, to set TIMES options, to manipulate input data, to analyze output data, and to compare scenarios. The app comes with predefined data sets, e.g. the TIMES_Demo data set (default) and the TIMES-DK_COMETS data sets. Other data sets can be created from *.dd and *.run files produced from VEDA.

The app follows the well-established MIRO App Structure with a navigation bar on the left side to switch between the following views:

- Input View
- Output View
- GAMS Interaction View
- Load Scenarios View
- Compare Scenarios View

The navigation bar also contains a Solve button that initiates a run based on settings and data specified in the Input View.

Further details on how to use the TIMES/MIRO App are explained in the app_README.
3. New Features

The following features have been implemented in the scope of this project and aim to improve the TIMES/MIRO App user experience.

3.1. Data Import

Data can be easily edited inside the TIMES/MIRO App via a powerful input data cube with pivot table features. While the built-in data editing functionality is well suited to vary small amounts of data quickly, larger data sets can be edited outside the App and imported as a complete set of *.dd files together with a *.run file as produced by VEDA. To make this more convenient, a “Create input data” tab has been introduced in the scope of this project where data files can be provided via drag and drop.

Some additional steps are required to finally import the input data cube and the settings into the TIMES/MIRO App. A detailed description can be found in the app_README.
3.2. Settings Tab

The settings tab has been completely refactored in the scope of this project. It manages various widgets allowing users for example to enable/disable TIMES extensions, to select the solver to be used and to specify corresponding solver options, or to set a time limit for the solution.
3.3. Improved Data Handling and Charting Facilities

The TIMES/MIRO App shows input and output data in powerful Pivot tables that allow slicing and dicing the data as needed. Within the scope of this project, the input data pivot tables have been made editable which allows convenient manipulation of input data by simply double clicking on the corresponding cell.
Furthermore, new chart types have been added and views that are frequently needed can be saved under a custom name like in the following example where a line chart visualizes CO2 emissions over time.
3.4. RES Viewer

In the upper right corner of the Input Data Tab, users find a button that allows them to switch between the input data cube shown in a pivot table and the newly implemented RES network visualization.

The RES viewer provides in itself views that are

- process centric
- commodity centric
- user constraint centric

All displayed items are clickable which allows convenient switching between different views. The corresponding table at the right and the pivot table at the bottom are updated automatically and show related data.
3.5. Asynchronous Execution of Jobs

Jobs can either be executed
- synchronously (wait for the job to finish, watch the log while the job is running, output data updated automatically) or
- asynchronously (submit the job to the TIMES cloud service and collect the results later)

The asynchronous submission has been added to the TIMES/MIRO App in the scope of this project and is particularly useful, if multiple (computationally expensive) jobs should be executed simultaneously. It requires a GAMS Engine backend (like for example the TIMES Cloud Service) and can be used from a local GAMS MIRO installation or through GAMS MIRO Server (like e.g. https://times.gams.com/).

The little arrow in the navigation allows switching between synchronous (“Solve model”) and asynchronous execution (“Submit Job”). When clicking on “Submit Job” a popup occurs that shows the different instance types that are available through the corresponding Engine backend.

Once the user clicks on “Submit”, the job is sent to GAMS Engine for execution. The user can see a list of submitted jobs in the “GAMS interaction” view (“Job list” tab) and download the results once the job has been completed.
3.6. Scenario Comparison Modes

Within the scope of this project, the scenario comparison modes have been extended. Via the “Load Scenarios” view, sophisticated search and filtering mechanisms allow to find the desired scenarios in the database and load multiple scenarios for comparison.

Once a set of scenarios has been chosen, a popup is offering severely ways of comparison.

Select action

What would you like to do with the selected scenarios?

Select columns for naming scenarios

Name

Download data (GDX)  Compare (Pivot)

Cancel  Delete scenarios
The newly introduced Pivot view allows slicing and dicing of multiple scenarios’ results and therefore convenient comparison between multiple scenarios.
3.7. TIMES Cloud Service Backend

As mentioned before, the GAMS MIRO Apps can be used in different ways from entirely local (“MIRO Desktop”) to entirely online (“MIRO Server”) with a hybrid mode (“MIRO Desktop boosted by GAMS Engine”) in between.

Thanks to the TIMES Cloud Service which is based on GAMS Engine, all three setups are already available for the TIMES/MIRO App.

- For the **MIRO Desktop** variant, GAMS and GAMS MIRO have to be installed locally and the user needs a professional GAMS license.
- For the **MIRO Desktop boosted by GAMS Engine** variant, only GAMS MIRO has to be installed locally. The user needs access rights (i.e. credentials and the URL) for the TIMES cloud Service (or any other GAMS Engine that she is entitled to use).
- For the **MIRO Server** variant, nothing has to be installed locally. The TIMES/App can be accessed through the web (https://times.gams.com/) with any common web browser. The user needs access rights for the TIMES cloud Service to which jobs will be submitted.
4. Implementation Details

The underlying technology of GAMS MIRO is based on R/Shiny, and it is already published under an open-source license on GitHub. The source code and all configuration files of the TIMES/MIRO App are published under an open-source license on GitHub.

The fundamental concept of the TIMES/MIRO App is that it builds on top of the well established TIMES concept that separates the TIMES source code from the data of a particular TIMES model which is provided via *.dd files and a *.run file. The heart of the TIMES/MIRO wrap is the times_miro.gms wrapper that combines GAMS and Python Code to implement the connection between TIMES and GAMS MIRO.

5. Documentation

The structure of the TIMES/MIRO App and its usage are documented in detail in the corresponding README files:

- [https://github.com/GAMS-dev/TIMES_MIRO/blob/master/README.md](https://github.com/GAMS-dev/TIMES_MIRO/blob/master/README.md)
- [https://github.com/GAMS-dev/TIMES_MIRO/blob/master/app_README.md](https://github.com/GAMS-dev/TIMES_MIRO/blob/master/app_README.md)