

PAUL SCHERRER INSTITUT



# The open-source TIMES\MIRO App

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Webinar series on „Possibilities to achieve the 1.50C Target under consideration of open energy system modelling“, 20<sup>th</sup> May 2022

# Open-source: a *must* or a *plus* criterion in research

## Sustainable, secure and competitive energy supply (HORIZON-CL5-2022-D3-01)

Expected Outcome:

Projects are expected to contribute to all the following outcomes:

- ...
- Provide regional, national and European public authorities and network operators, with an **open source tool** to allow them to better plan and optimise the development of renewable and low emission energy sources and the enhancement of infrastructure (including storage) to meet the future energy needs in a geographical area, while minimising the total investment and operation cost, hence satisfying the future final uses of energy (sometimes used as a feedstock) by consumers, at lowest cost and with better quality of service.



## Innovationen für Energiewende: 7. Energieforschungsprogramm

... Die Bundesregierung wird die Vergleichbarkeit und Transparenz energiesystemanalytischer Modellierung durch eine wirksame

**Open-Source-, Open-Data- und Open-Access** Strategie stärken, um die Überprüfbarkeit der daraus abgeleiteten Handlungsoptionen sicherzustellen. Um eine Transparenz der Modellierungsergebnisse auch langfristig zu gewährleisten, wird der Aufbau einer vernetzten, offenen und systematischen Dateninfrastruktur für systemanalytische Forschungsvorhaben unterstützt...

## Research Program Energy-Economy-Society (EWG) Call 2021-2022 for Research Proposals

....

Criteria:

....

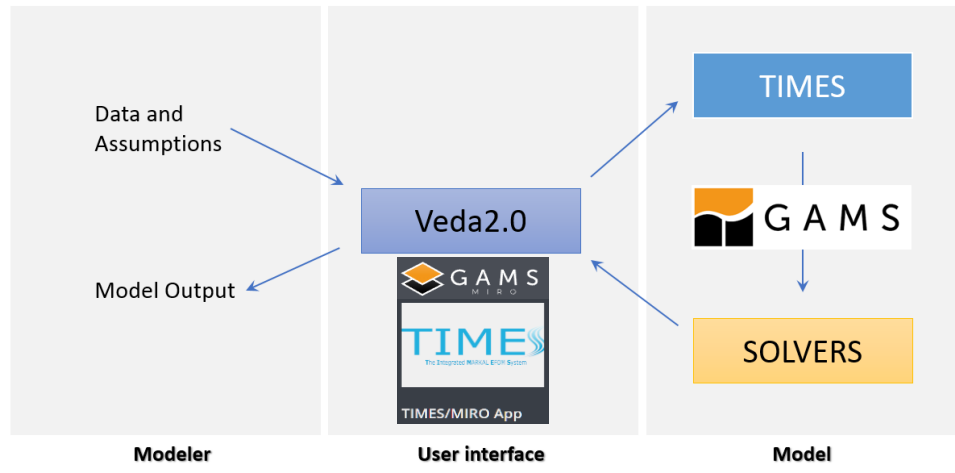
Knowledge transfer:

Are knowledge transfer and publications planned? Is an **open access / data / model strategy** included?



# TIMES: an open-source energy systems modelling framework

- TIMES is a energy systems model generator developed by IEA-ETSAP
- It is used for 15 years in informing energy and climate policy analysis, in more than 50 countries
- TIMES is open-source – since 2019 it is also available in Github
- TIMES is data-intensive and needs an interface to efficiently handle input and output data
- An open-source interface would enhance the open-source character of the framework

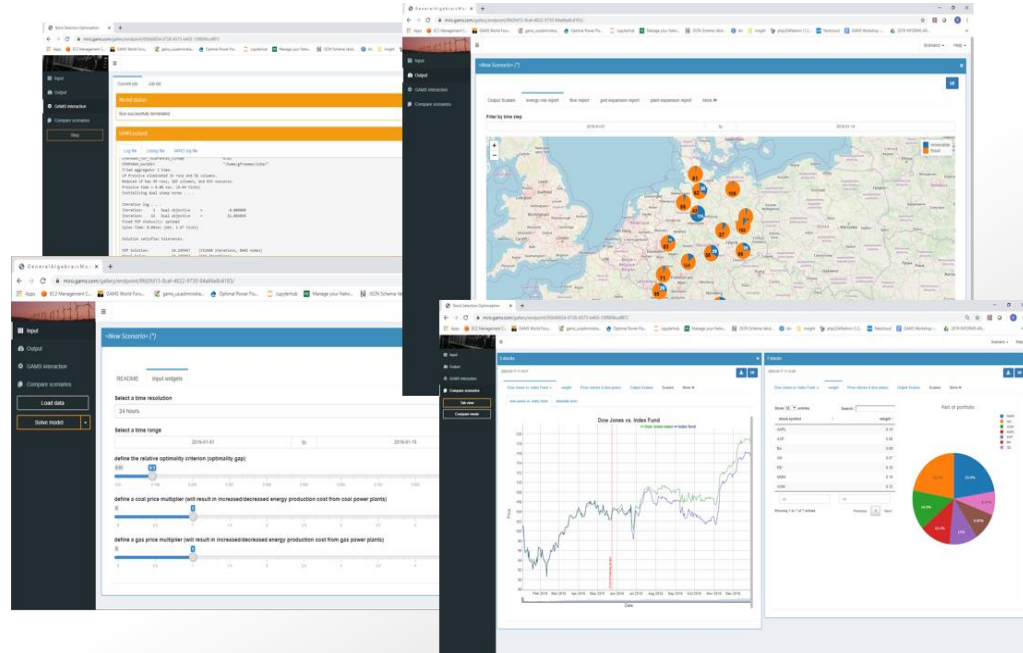


# Design principles of the TIMES/Miro App

- Based on the GAMS MIRO framework
- Intuitive and user-friendly interface
- Easy to import data and TIMES models
- Powerful data exploration and edit
- Efficient interaction with GAMS models
- Support for solving models on the cloud
- Flexible visualizations of the results
- Turn models into interactive applications

# What is the GAMS MIRO

- Deployment, open-source, framework (Github) based on R/Shiny to turn GAMS models into interactive (web) applications
- Can expose selected model parameters and variables to an intuitive user interface
- GAMS MIRO applications are tailored to the end-user needs: input data widgets, maps, charts for visualisations, etc...
- A GAMS MIRO application is deployed in a single self-contained file
- Built-in data/results scenario database



- TIMES\MIRO App code (about 1000 lines) is based on GAMS and Python (Github)
- TIMES\MIRO App is a wrapper around the TIMES code that creates TIMES data and TIMES driver
- The wrapper code is fully customizable regarding the parameters and variables exposed to TIMES\MIRO App

**TIMES/MIRO Wrapper (times\_miro.gms)**

- 1) Input cube configuration**  
(e.g. mapping between GAMS Symbols and input data cube)
- 2) Load data into wrapper**
  - a) if run through MIRO, the data will be loaded from MIRO App (either from the input data cube or from the DD and RUN files specified under 'create inout data'.
  - b) if run through Studio, data specified via --RUNFILE and --DDPREFIX will be read, a GDY file that can be loaded into the MIRO app will be created and the run terminates
- 3) Write TIMES Data (\*.dd files)**
- 4) Write TIMES Driver (timesdriver.gms)**  
(GAMS Options, TIMES Extensions, \*.dd files based on settings made in the app)
- 5) Execute TIMES Driver**
- 6) Collect results and prepare output cube**

**TIMES Driver (timesdriver.gms, similar to \*.RUN file)**

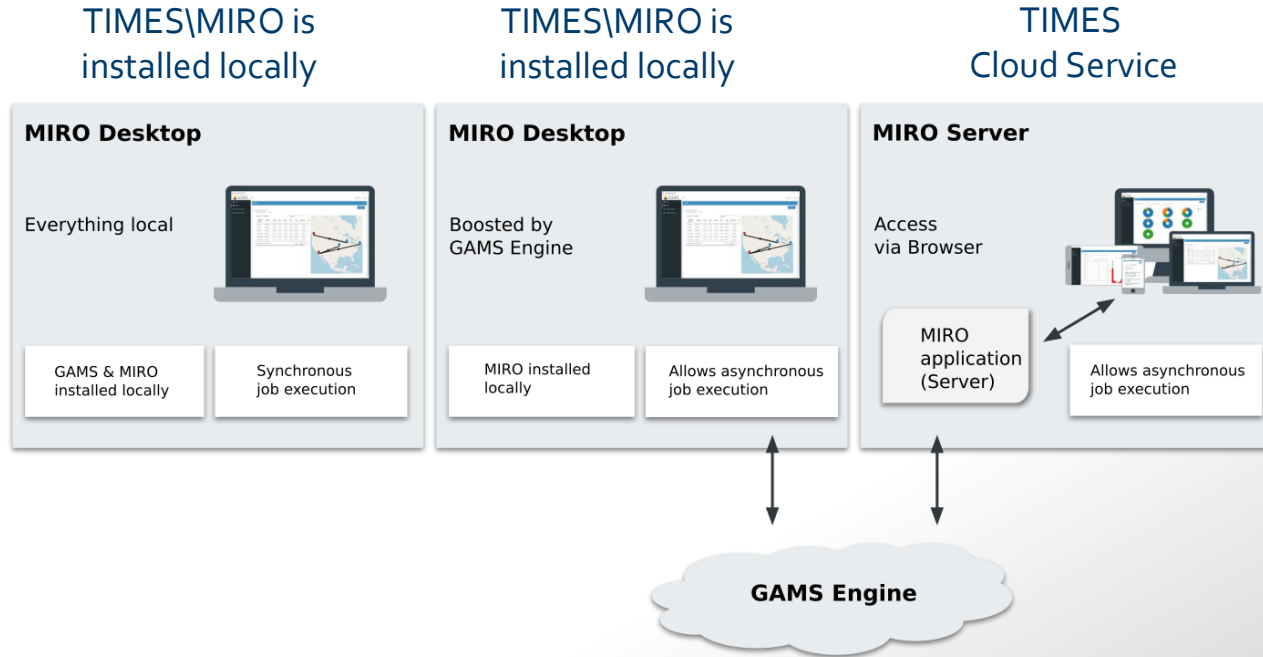
```

$title TIMES -- VERSION 4.5.9
option resLim=1000, profile=1, [...]
$offlisting
[...]
$set OBJ MOD
$set BOTIME 1960
[...]
$batinclude initsys.mod
$batinclude initmtty.mod
$batinclude base.dd
[...]
Set MILESTONYR /
2005,2010,2015,2020,2030,2050/;
$set RUN_NAME demol2
$batinclude maindrv.mod mod

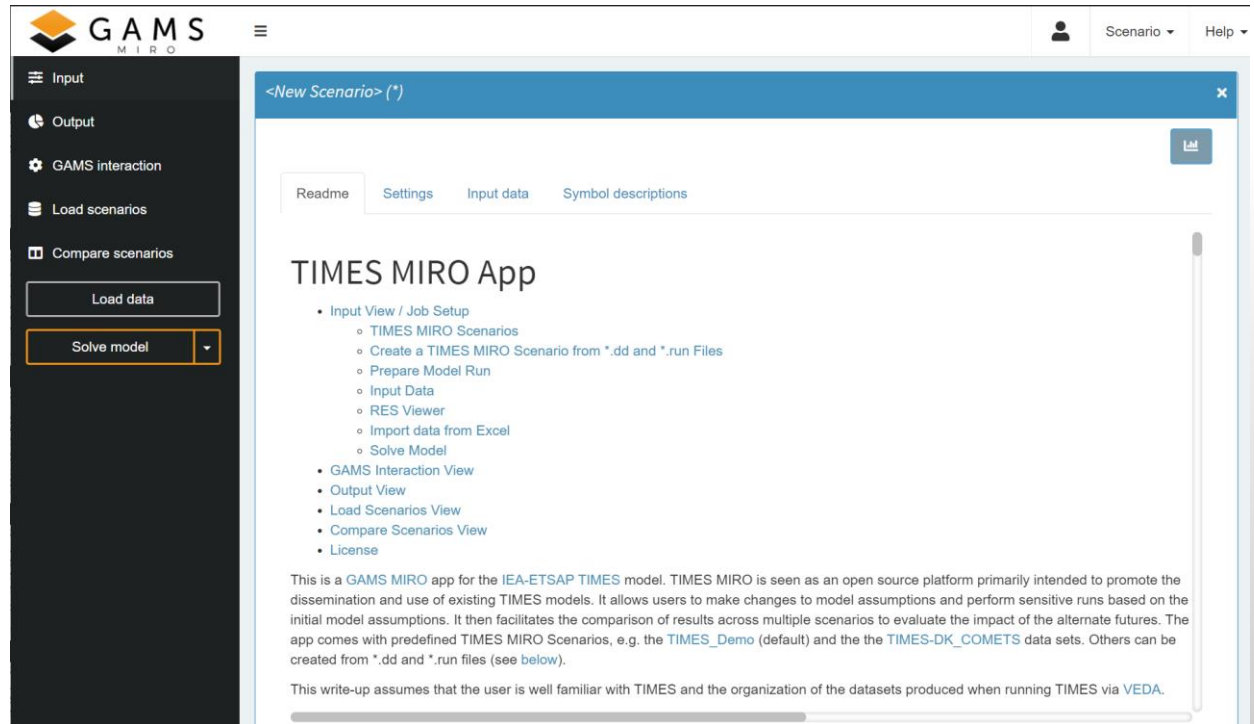
```

TIMES Data	TIMES Source
<b>*.dd files</b>	<b>244 files</b>
base.dd	<b>24,748 lines</b>
nt-agr.dd	<b>→Not touched!</b>
nt-com.dd	[...]
nt-ind.dd	initmtty.mod
nt-rsd.dd	initsys.mod
[...]	maindrv.mod
uc-trn90.dd	[...]

# Ways to use the TIMES\MIRO App



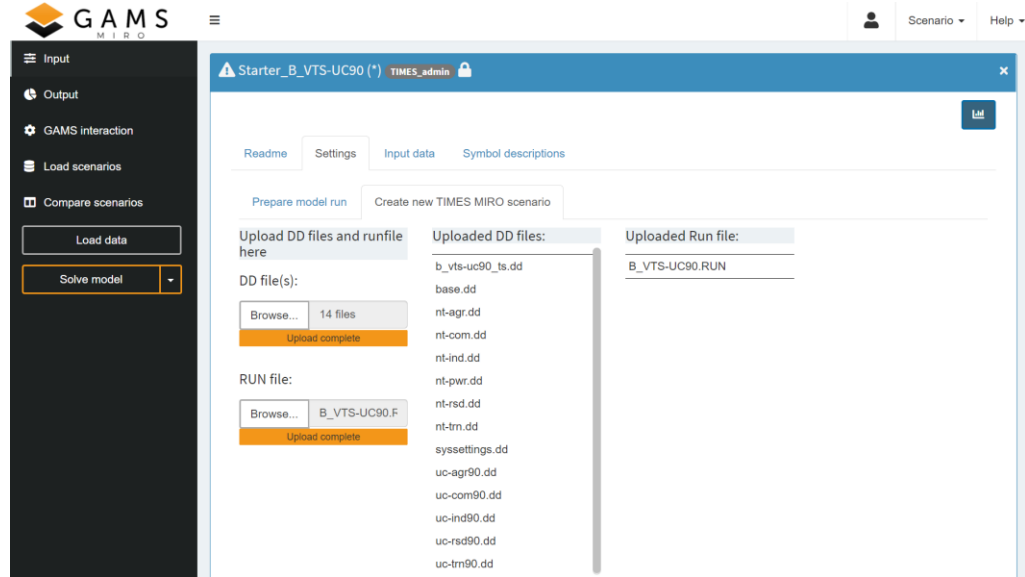
- Navigation bar with the basic modelling tasks
- Tabbed interface for data views and settings
- Tabs functionality depends on the selected modelling task





# Easy to import data of an existing TIMES-based model

a) Via a set of .DD and .RUN files



b) Via an Excel file (flat structure)

siname	typ	dd	uc_n	all_reg	allyear	prc	com_grp	all_ts	lim	cur	uni	uni#1	uni#2	value
ACT_BND	Par	my_dd	-	Starter	2020	EEBIOGAS-CT-X0	-	ANNUAL	UP	-	-	-	-	0.5
ACT_BND	Par	my_dd	-	Starter	2020	EEBIOGAS-CT-X0	-	ANNUAL	LO	-	-	-	-	0.1

# Explore the TIMES-based model structure and data edit

- Powerful reference energy system visualization
- Process-centric view shows for a chosen process input & output commodities and data related to the process
- Commodity-centric view shows for a chosen commodity the processes producing and consuming it, as well as data
- User constraint-centric view shows the definition of a user constraint

The screenshot displays the GAMS MIRO web interface. On the left is a dark sidebar with navigation options: Input, Output, GAMS interaction, Load scenarios, Compare scenarios, Load data, and Solve model. The main content area is titled 'EEGASNAT-CCCCS' and shows a process flow diagram. The diagram includes a process box 'EEGAS NAT-CCCCS' with an input 'PWRGASNAT' and outputs 'CO2PWR-SEQ', 'CO2PWRX', and 'ELCT'. Below the diagram are buttons for 'NRG', 'MAT', and 'ENV'. On the right, a metadata table lists various parameters for the process.

Scenario	nt-pwr
Type	ELE
SubType	
Activity Unit	PJ
Capacity Unit	
Sets	ELE
TimeSlice	DAYNITE
LVL	
Vintage	FALSE
PCG	ELCT
Region	Starter

At the bottom, a data table is shown with columns for Region, Symbol, and Year (2015-2045). The table contains data for 'ACT\_EFF' and 'NCAP\_COST'.

		Year					
		2015	2025	2030	2035	2040	2045
Starter	ACT_EFF	0.46					
	NCAP_COST	1,518.43	1,518.43	1,518.43	1,518.43	1,518.43	1,518.43

# Flexible setup of a scenario and options for solving it

- Select the data/scenario files to be included in the model run
- Select TIMES model extensions
- Select the years for the model run
- Select solver and options
- Press solve

The screenshot displays the GAMS TIMES MIRO App interface for setting up a new scenario. The interface is organized into several key sections:

- DD Files order / Read \$offEps:** A table listing 13 files to be included in the model run, with columns for Order (to be ignored), DD File, and \$offEps.
- Extensions:** A table of model extensions with columns for Extension and Value (YES/NO).
- Years for model run:** A table for selecting the years to be modeled, with columns for Year, Time, and Value.
- Time slices available:** A table listing available time slices with columns for Time Slice and Value.
- Solver to use:** A dropdown menu currently set to 'cplex', along with fields for 'Time limit for solve [seconds]' (set to 1000) and 'Objective function formulation' (set to AUTO).
- Solver options:** A table of solver options with columns for Solver, Option, and Value.

- From the desktop version of TIMES\MIRO App the user can solve locally or on the server
- The web version of the App solves on the TIMES cloud
- The GAMS execution can be synchronous or asynchronous
- Log and LST files available for each run with error reporting
- Solution results are loaded automatically into TIMES\MIRO App

The screenshot displays the GAMS MIRO web interface. On the left is a dark sidebar with navigation options: Input, Output, GAMS interaction, Load scenarios, and Compare scenarios, along with a 'Stop' button. The main content area shows the 'Model status' section with a message: 'Run did not terminate successfully: There was a compilation error'. Below this is the 'GAMS output' section, which contains a 'Log file' and a 'Listing file'. The 'Listing file' content is as follows:

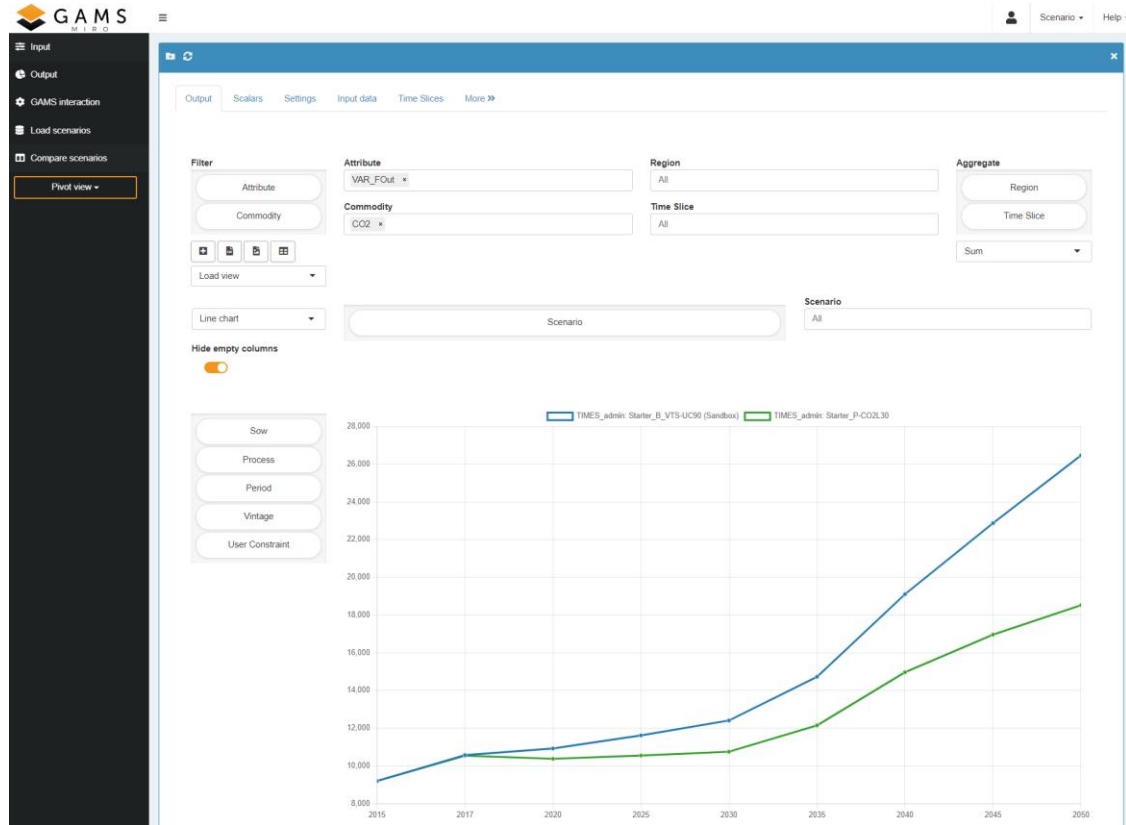
```

--- Job times_miro.gms Start 05/19/22 05:18:19 39.1.0 5f04cd76 LEX-LEG x86 64bit/Linux
--- Applying:
/home/jail/opt/gams/gmsprun.txt
--- GAMS Parameters defined
Input /home/gfreeman/times_miro.gms
ScrDir /home/gfreeman/225a/
SysDir /home/jail/opt/gams/
LogOption 3
License /home/jail/opt/gams/gamslice.txt
ExecMode 0
IDCGDXInput_miro_gdxin_gdx
IDCGDXOutput_miro_gdxout_gdx
--gmsrunopt local
--DDPREFIX dd_files/
License: eng@ddeb1c34c6658f6ea48afdd40b9e095f          S220112|0002CO-GEN
        GAMS Software - TIMES SaaS License             DCE1819
        /home/jail/opt/gams/gamslice.txt
        License Admin: Franz Nelissen, FNelissen@gams.com
        Other time limited license

Processor information: 1 socket(s), 1 core(s), and 2 thread(s) available
GAMS 39.1.0 Copyright (C) 1987-2022 GAMS Development. All rights reserved
--- Starting compilation
--- times_miro.gms(365) 3 Mb
--- Initialize embedded library libembyccl1b64.so
--- Execute embedded library libembyccl1b64.so
### CUBEINPUTDOM=siName,typ,dd,UC_N,ALL_REG,ALLYEAR,PRC,COM_GRP,ALL_TS,LIM,CUR,*,*,*
--- times_miro.gms(383) 3 Mb
--- GDxin=/home/gfreeman/_miro_gdxin_gdx
--- GDx File ($dxIn) /home/gfreeman/_miro_gdxin_gdx
  
```

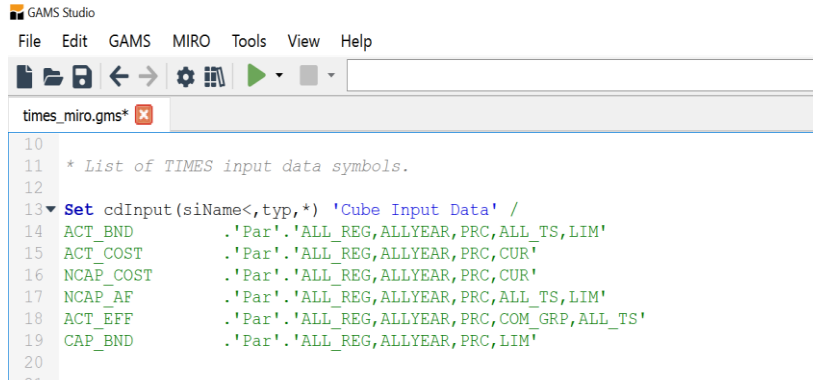
At the bottom of the output area, there is an 'Update' button with a checkmark.

- Search and filtering mechanisms to find and load multiple scenarios for comparison
- Pivot view for slicing and dicing of multiple scenario results and their convenient comparison
- Result views can be saved and reused when results are updated
- Scenario results can be exported as a CSV file for further processing



# Turns models into tailor-made interactive applications

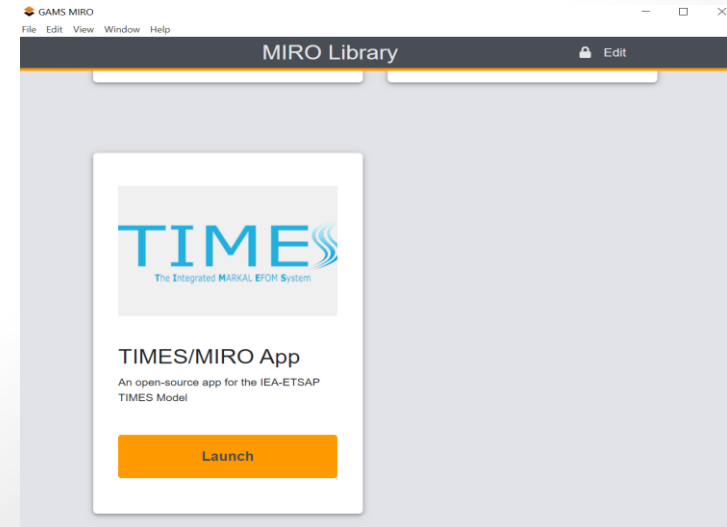
- The wrapper *times\_miro.gms* has a set *cdInput* defining model parameters exposed to TIMES\MIRO
- TIMES modellers can edit the set to include some of the TIMES parameters, or even expose parameters to end-users with a different and user-friendly name
- The modified TIMES\MIRO App can be recompiled in GAMS Studio and re-deployed



```

GAMS Studio
File Edit GAMS MIRO Tools View Help
times_miro.gms*
10
11 * List of TIMES input data symbols.
12
13 ▾ Set cdInput (siName<,typ,*) 'Cube Input Data' /
14 ACT_BND . 'Par'. 'ALL_REG, ALLYEAR, PRC, ALL_TS, LIM'
15 ACT_COST . 'Par'. 'ALL_REG, ALLYEAR, PRC, CUR'
16 NCAP_COST . 'Par'. 'ALL_REG, ALLYEAR, PRC, CUR'
17 NCAP_AF . 'Par'. 'ALL_REG, ALLYEAR, PRC, ALL_TS, LIM'
18 ACT_EFF . 'Par'. 'ALL_REG, ALLYEAR, PRC, COM_GRP, ALL_TS'
19 CAP_BND . 'Par'. 'ALL_REG, ALLYEAR, PRC, LIM'
20
21
  
```

- TIMES\MIRO App is deployed using a single-self-contained file, with a logo and description
- It can be launched locally via the GAMS MIRO software or on the web via the browser



## The open-source TIMES\MIRO App:

- is a lightweight, flexible and powerful interface for TIMES-based models
- extremely smooth learning curve in using it
- based on the innovative open-source GAMS MIRO engine
- can be installed locally or on a MIRO server (TIMES cloud)
- a free GAMS demo license is sufficient to use the App locally and solve on TIMES Cloud servers

## The open-source TIMES\MIRO App can be used to:

- provide an alternative interface for experienced users to interact with large and complex TIMES models
- develop tailor-made interactive applications of TIMES models for stakeholders and end-users
- encapsulate model complexity and hide it from the new and inexperienced users in TIMES
  - can be used for example to develop customized interfaces of TIMES suitable for training purposes
- act as an entry point for institutes and companies in the TIMES modelling at a zero- or low-cost

## Mein Dank geht an

- Fred Fiand (GAMS)
- Markus Blesl (IER)
- Gary Goldstein (DWI)

