Enhanced Model Deployment and Solution in GAMS

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Introduction

- User interaction provided valuable feedback on:
  - The GAMS IDE
  - Building algorithms (decomposition, linearization) with GAMS code
  - Specific user: BEAM-ME project
- We took this feedback to heart: influenced recent development efforts
  - New user interface: GAMS Studio
  - Embedded Python
  - Updates to Object-Oriented API for Python
  - R/Shiny interface
- Enhanced model deployment and solution

GAMS Studio

- Open source Qt project (Mac/Linux/Win)
  - Published on GitHub under GPL
- First released in May 2018: focus on core functionality
  - Included most/best of the old IDE
  - Some additional features (e.g. column filters in GDX browser)
- Current projects now include new features (e.g. model inspector)
- Philosophy: release early to increase feedback for dev team
- Parallel release in near term: both Studio and IDE

Embedded Python: Why?

- GAMS is built for modeling
  - Syntax for parallel assignment and equation definition is compact, elegant, and efficient
  - Relational data model supports this – well-suited for the task
  - Traditional data structures not needed or available in GAMS – lists, trees, graphs, dictionaries
- String manipulation: useful for massaging data
- Plotting, map integration, other data visualization
- Sorting, permutations, randomization
- Specialized tasks: shortest path, factorization, subtour and cut generation, etc.
- Even more specialized: lexxing and parsing

Split Example – Data

```
Set cc  / "France - Bordeaux",  "France - Lille",
          "France - Toulouse",
          "Spain - Madrid",     "Spain - Cordoba",
          "Spain - Seville",    "Spain - Bilbao",
          "USA - Washington DC",
          "USA - Houston",      "USA - New York",
          "Germany - Berlin",
          "Germany - Munich",   "Germany - Bonn" /
    country / system.empty /
    city    / system.empty /
    mccCountry(cc,country)
    mccCity   (cc,city);
```

Split Example – Embedded Code

```
$onEmbeddedCode Python:
    country = set()
    city = set()
    mccCountry = []
    mccCity = []
    for cc in gams.get("cc"):
        r = str.split(cc, " - ", 1)
        country.add(r[0])
        city.add(r[1])
        mccCountry.append((cc,r[0]))
        mccCity.append((cc,r[1]))
    gams.set("country",list(country))
    gams.set("city",list(city))
    gams.set("mccCountry",mccCountry)
    gams.set("mccCity",mccCity)
$offEmbeddedCode country city mccCountry mccCity
```

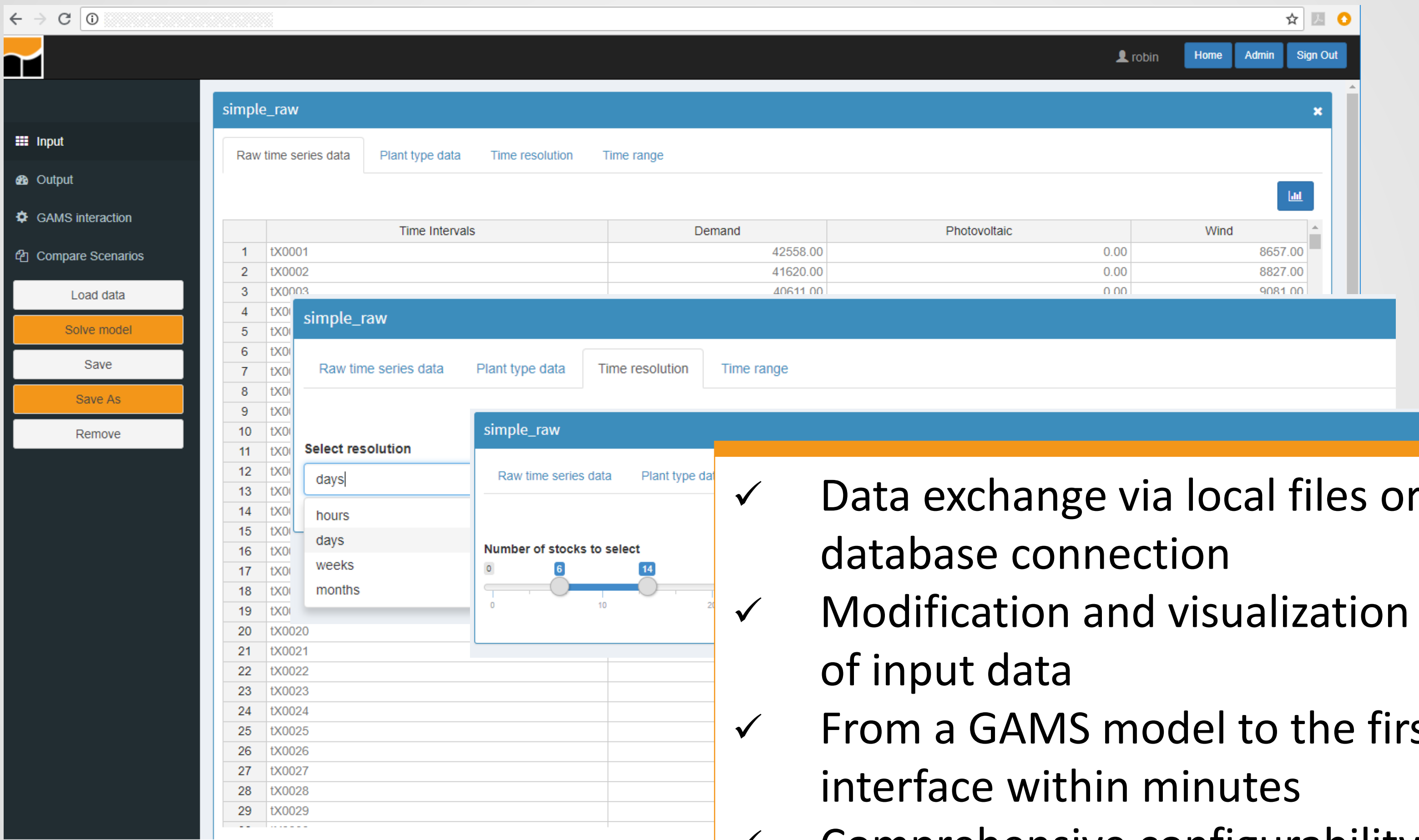
GAMS ModelInstance

- demand(j) .. sum(i, x(i,j)) =g= bmult *b(j) ;

```
# assumes GamsCheckpoint cp
mi = cp.add_modelinstance()
bmult = mi.sync_db.add_parameter(“bmult”,0)
mi.instantiate(“m us lp min z”, GAMSModifier(bmult))
for b in myMultipliers:
        bmult.first_record().value = b
        mi.solve()
```

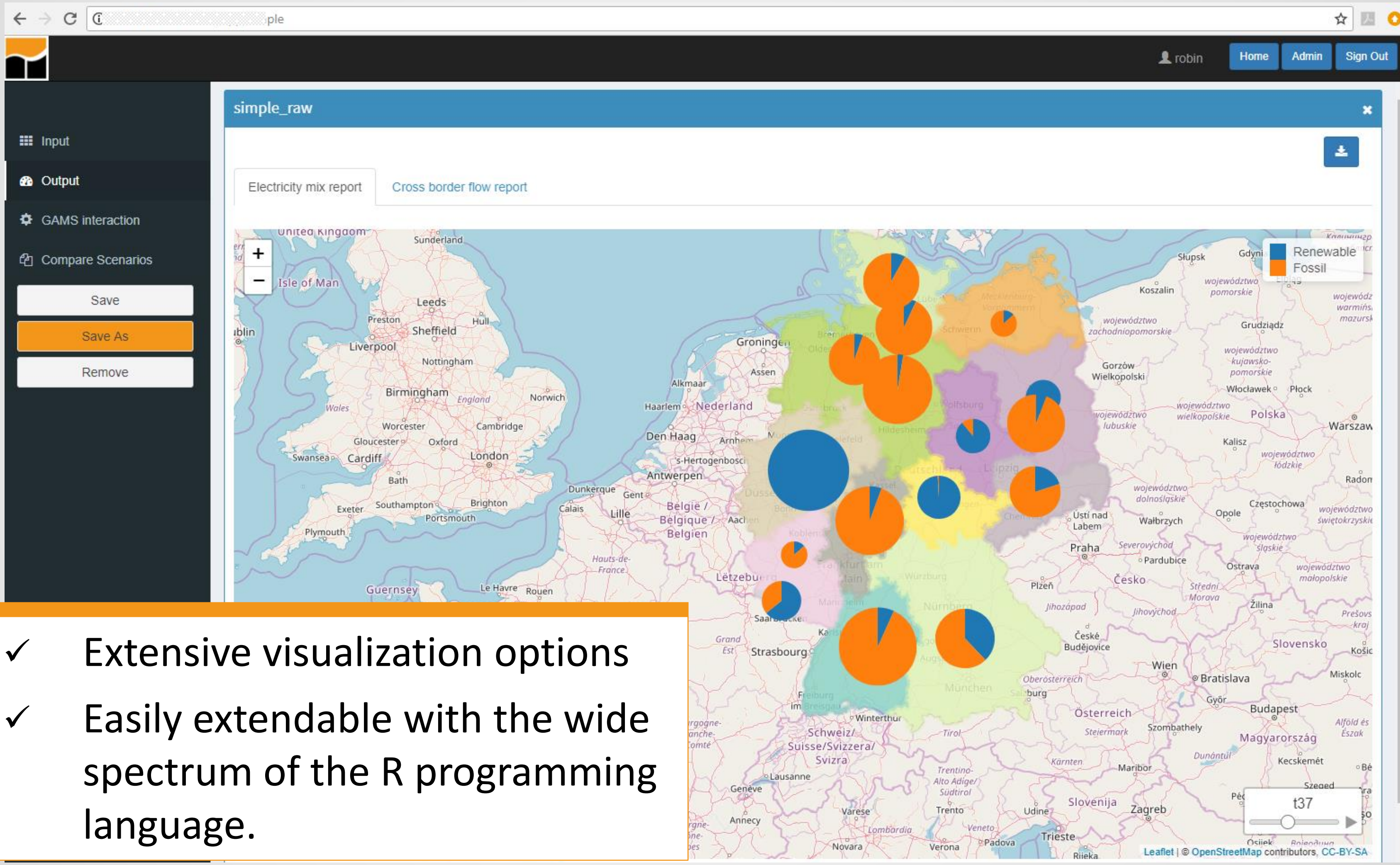
GAMS

Using R/Shiny to deploy GAMS models



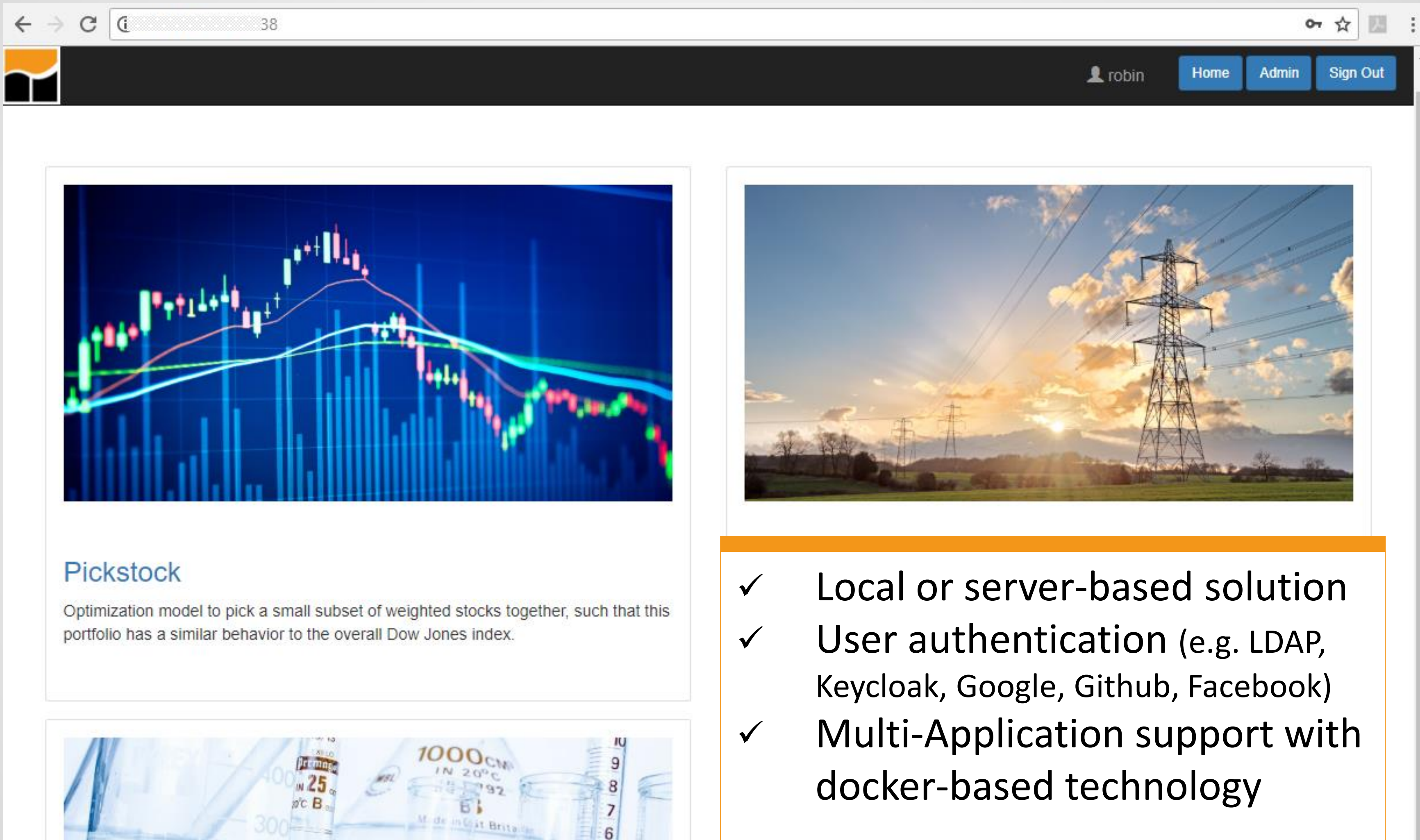
- ✓ Data exchange via local files or database connection
- ✓ Modification and visualization of input data
- ✓ From a GAMS model to the first interface within minutes
- ✓ Comprehensive configurability

Visualization



- ✓ Extensive visualization options
- ✓ Easily extendable with the wide spectrum of the R programming language.

Multiuser, multi-application support



- ✓ Local or server-based solution
- ✓ User authentication (e.g. LDAP, Keycloak, Google, Github, Facebook)
- ✓ Multi-Application support with docker-based technology

BEAM-ME Project

- Project goal: solve large Energy System Models (ESM): LPs
  - Block-diagonal structure with linking constraints and linking vars
  - Start with PIPS-IPM solver, extend as needed (e.g. linking constraints)
  - Use massively parallel hardware (thousands of 24-core nodes)
  - Do the modeling in GAMS
  - Use distributed block-wise model generation:
    - Cut time and memory usage
    - Avoid limitation on model size (maxNNZ is ~2.1e9)

A PROJECT BY

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BEAM-ME Project: benefits

- Embedded Python – this was developed in large part for this project or with this project's needs in mind
- Internal limits removed or relaxed
    - Internal data structures for string storage
    - Size limits imposed by 32-bit array offsets
    - Similar limits for tools and utilities included with GAMS
- Internal organization improved
    - Support for parallel model generation (in special cases)
    - GAMS/MPI – parallel GAMS runs synchronized with MPI
    - Execution-time save facility

Live Demo

- Requires recent GAMS version (25.0.2), current 25.1 even better
- Uses models from GAMS Model Library
- spbenders1 – *Benders example in GAMS, sequential solves, full regen*
- spbenders2 – *submodels solved in parallel in GAMS loop*
  - subproblem.solveLink = %solveLink.aSyncThreads%;
- spbenders3 - *sequential solves, Python modelinstance, no regen*
- spbenders4 – *parallel solves inside GAMS, full regen*
  - via mpi4py
- spbenders5 – *parallel solves, Python modelinstance, no regen*

Thank You