
AMPL in the Cloud

Using Online Services to Develop and Deploy Optimization Applications through Algebraic Modeling

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Using Online Services to Develop and Deploy Optimization Applications through Algebraic Modeling

Optimization modeling systems first appeared online almost 20 years ago, not long after web browsers came into widespread use. This presentation describes the evolution of optimization alternatives in what has come to be known as cloud computing, with emphasis on the role of the AMPL modeling language in making models easy to develop and deploy. We start with the pioneering free NEOS Server, and then compare more recent commercial offerings such as Gurobi Instant Cloud; the benefits of these solver services are readily leveraged through their use with the AMPL modeling tools. We conclude by introducing QuanDec, which creates web-based collaborative applications from an AMPL models.

Word cloud, exhibitor descriptions



The Optimization Modeling Cycle

Steps

- ❖ Communicate with problem owner
- ❖ Build model
- ❖ Prepare data
- ❖ Generate optimization problem
- ❖ Submit problem to solver
 - * Gurobi, Knitro, CPLEX, Xpress, CONOPT, MINOS, . . .
- ❖ Report & analyze results
- ❖ ***Repeat!***

Goals for optimization software

- ❖ Do this quickly and reliably
- ❖ Get results before client loses interest
- ❖ ***Deploy for application***

Optimization Modeling Languages

Two forms of an optimization problem

- ❖ Modeler's form
 - * Mathematical description, easy for people to work with
- ❖ Algorithm's form
 - * Explicit data structure, easy for solvers to compute with

Idea of a modeling language

- ❖ **A computer-readable modeler's form**
 - * You write optimization problems in a modeling language
 - * Computers translate to algorithm's form for solution

Advantages of a modeling language

- ❖ Faster modeling cycles
- ❖ More reliable modeling
- ❖ More maintainable applications

Algebraic Modeling Languages

Formulation concept

- ❖ Define data in terms of sets & parameters
 - * Analogous to database keys & records
- ❖ Define decision variables
- ❖ Minimize or maximize a function of decision variables
- ❖ Subject to equations or inequalities that constrain the values of the variables

Advantages

- ❖ Familiar
- ❖ Powerful
- ❖ Proven



Features

- ❖ Algebraic modeling language
- ❖ Built specially for optimization
- ❖ Designed to support many solvers

Design goals

- ❖ Powerful, general expressions
- ❖ Natural, easy-to-learn modeling principles
- ❖ Efficient processing that scales well with problem size

3 ways to use . . .

3 Ways to Use AMPL

Command language

- ❖ Browse results & debug model interactively
- ❖ Make changes and re-run

Scripting language

- ❖ Bring the programmer to the modeling language

Programming interface (API)

- ❖ Bring the modeling language to the programmer

Example: Roll Cutting

Motivation

- ❖ Fill orders for rolls of various widths
 - * by cutting raw rolls of one (large) fixed width
 - * using a variety of cutting patterns

Optimization model

- ❖ Decision variables
 - * number of raw rolls to cut according to each pattern
- ❖ Objective
 - * minimize number of raw rolls used
- ❖ Constraints
 - * meet demands for each ordered width

Roll cutting

Mathematical Formulation

Given

W set of ordered widths

n number of patterns considered

and

a_{ij} occurrences of width i in pattern j ,
for each $i \in W$ and $j = 1, \dots, n$

b_i orders for width i , for each $i \in W$

Roll cutting

Mathematical Formulation (*cont'd*)

Determine

X_j number of rolls to cut using pattern j ,
for each $j = 1, \dots, n$

to minimize

$$\sum_{j=1}^n X_j$$

total number of rolls cut

subject to

$$\sum_{j=1}^n a_{ij} X_j \geq b_i, \text{ for all } i \in W$$

number of rolls of width i cut
must be at least the number ordered

Roll Cutting

AMPL Formulation

Symbolic model

```
set WIDTHS;
param orders {WIDTHS} > 0;
param nPAT integer >= 0;
param nbr {WIDTHS,1..nPAT} integer >= 0;

var Cut {1..nPAT} integer >= 0;

minimize Number:
    sum {j in 1..nPAT} Cut[j];

subj to Fulfill {i in WIDTHS}:
    sum {j in 1..nPAT} nbr[i,j] * Cut[j] >= orders[i];
```

$$\sum_{j=1}^n a_{ij} X_j \geq b_i$$

AMPL Formulation (*cont'd*)

Explicit data (independent of model)

```
param: WIDTHS: orders :=  
       6.77      10  
       7.56      40  
      17.46     33  
      18.76     10 ;  
  
param nPAT := 9 ;  
  
param nbr:  1   2   3   4   5   6   7   8   9 :=  
      6.77    0   1   1   0   3   2   0   1   4  
      7.56    1   0   2   1   1   4   6   5   2  
     17.46    0   1   0   2   1   0   1   1   1  
     18.76    3   2   2   1   1   1   0   0   0 ;
```

Command Language

Model + data = problem instance to be solved

```
ampl: model cut.mod;
ampl: data cut.dat;
ampl: option solver cplex;
ampl: solve;
CPLEX 12.6.3.0: optimal integer solution; objective 20
3 MIP simplex iterations
ampl: option omit_zero_rows 1;
ampl: option display_1col 0;
ampl: display Cut;
4 13    7 4    9 3
```

Command Language (*cont'd*)

Solver choice independent of model and data

```
ampl: model cut.mod;
ampl: data cut.dat;
ampl: option solver gurobi;
ampl: solve;
Gurobi 6.5.0: optimal solution; objective 20
3 simplex iterations
ampl: option omit_zero_rows 1;
ampl: option display_1col 0;
ampl: display Cut;
4 13    7 4    9 3
```

Command Language (*cont'd*)

Results available for browsing

```
ampl: display {j in 1..nPAT, i in WIDTHS: Cut[j] > 0} nbr[i,j];  
:  
       4   7   9  :=  
6.77   0   0   4          # patterns used  
7.56   1   6   2  
17.46  2   1   1  
18.76  1   0   0  
  
ampl: display {j in 1..nPAT} sum {i in WIDTHS} i * nbr[i,j];  
1 63.84   3 59.41   5 64.09   7 62.82   9 59.66      # pattern  
2 61.75   4 61.24   6 62.54   8 62.0          # total widths  
  
ampl: display Fulfill.slack;  
6.77  2          # overruns  
7.56  3  
17.46 0  
18.76 3
```

IDE for Command Language

The screenshot shows the AMPL IDE interface. On the left is a file explorer window titled "Current Directory" showing files like ChvatalD.dat, cut.dat, cut.mod, cutPat.mod, cutPatEnum.run, cutPatEnum100.run, cutSENS.run, HaesslerB.dat, Schrage19.dat, and Sorrentino.dat. In the center is a "Console" window displaying the AMPL command-line interface output. The output shows an AMPL session starting with "ampl: model cut.mod;". It includes solver options ("solver gurobi"), a solve command, and a simplex iteration report. It then displays a matrix "nbr[i,j] [*,*] (tr)" with values such as 6.77, 7.56, 17.46, and 18.76. The session ends with "ampl: |". To the right are two code editors. The top editor is for "cut.mod" and contains AMPL modeling code defining sets, parameters, and a minimize objective. The bottom editor is for "cut.dat" and contains data definitions for parameters WIDTHS, orders, and nbr.

```
ampl: model cut.mod;
ampl: data cut.dat;
ampl: option solver gurobi;
ampl: solve;
Gurobi 6.0.4: optimal solution; objective 20
3 simplex iterations
ampl: option omit_zero_rows 1;
ampl: option display_1col 0;
ampl: option display_transpose 100;
ampl: display Cut;
Cut [*] :=
4 13    7 4    9 3
;

ampl: display {j in 1..nPAT, i in WIDTHS: Cut[j] > 0} nbr[i,j];
nbr[i,j] [*,*] (tr)
:        4    7    9   :=
6.77    0    0    4
7.56    1    6    2
17.46   2    1    1
18.76   1    0    0
;

ampl: |
```

```
set WIDTHS;
param orders {WIDTHS} > 0;

param nPAT integer >= 0;
param nbr {WIDTHS,1..nPAT} integer >= 0;

var Cut {1..nPAT} integer >= 0;

minimize Number:
  sum {j in 1..nPAT} Cut[j];

subj to Fulfill {i in WIDTHS}:
  sum {j in 1..nPAT} nbr[i,j] * Cut[j] >= orders[i];
```

```
param: WIDTHS: orders :=
          6.77    10
          7.56    40
          17.46   33
          18.76   10 ;

param nPAT := 9 ;

param nbr: 1 2 3 4 5 6 7 8 9 :=
          6.77   0 1 1 0 3 2 0 1 4
          7.56   1 0 2 1 1 4 6 5 2
          17.46  0 1 0 2 1 0 1 1 1
          18.76  3 2 2 1 1 1 0 0 0 ;
```

Computing in the Cloud

Client side

- Local computing device owned by the user
 - * Company, organization, university, individual
- Client application run by the user on the local device

Server side

- Remote computing facility owned by a provider
 - * Company, organization, university
- Service running automatically at the remote facility

AMPL

Optimization in the Cloud

Local modeling system, remote solver

- NEOS Server
- Gurobi Instant Cloud

Local analysis tools, remote model

- QuanDec

. . . a variety of AMPL interface alternatives

NEOS Server www.neos-server.org

Network Enabled Optimization System

- Originated 1995 at Argonne National Laboratory
 - * U.S. Department of Energy
- Since 2011 at Wisconsin Institutes for Discovery
 - * University of Wisconsin, Madison

Free “optimization on demand”

- Over 40 solvers
- Several optimization modeling languages

Architecture

Distributed workstations

- Offer varied inputs & solvers
- Process submissions on demand
- Contributed by varied organizations

Central scheduler

- Receives and queues submissions
- Sends submissions to appropriate workstations
- Returns results

Minimal hands-on management

- *Distributed*: Install NEOS software on workstations
- *Central*: Update server database
of workstation locations and abilities

Original Facilities

Local submission clients

- Email
- Website
- NEOS submission tool

Problem description formats

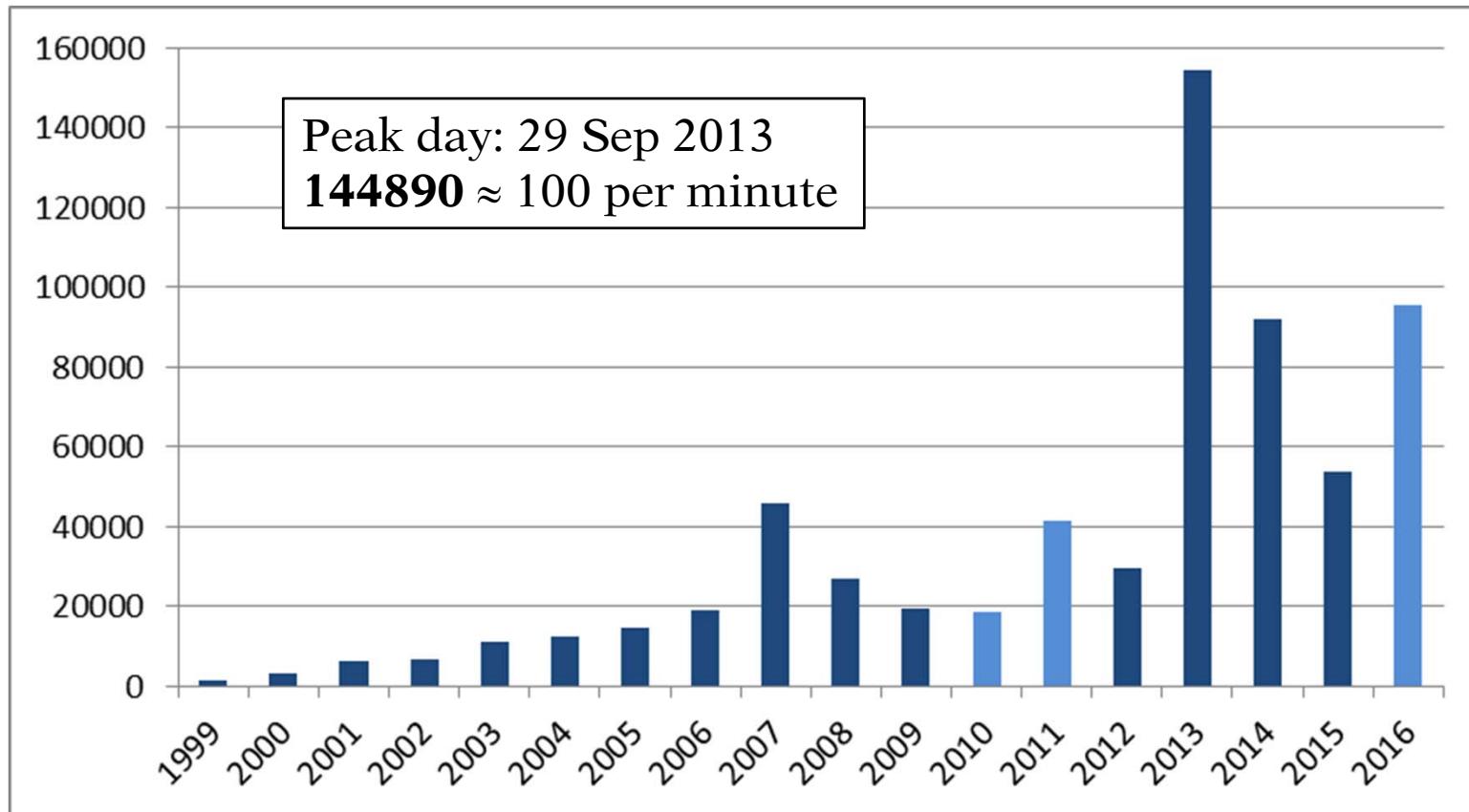
- Linear: MPS and other solver files
- Nonlinear: Fortran or C programs
 - * automatic differentiation of programs

W. Gropp and J.J. Moré, 1997. **Optimization Environments and the NEOS Server.** *Approximation Theory and Optimization*, M. D. Buhmann and A. Iserles, eds., Cambridge University Press, 167-182.

J. Czyzyk, M.P. Mesnier and J.J. Moré, 1998. **The NEOS Server.** *IEEE Journal on Computational Science and Engineering* 5(3), 68-75.

Impact: Total Submissions

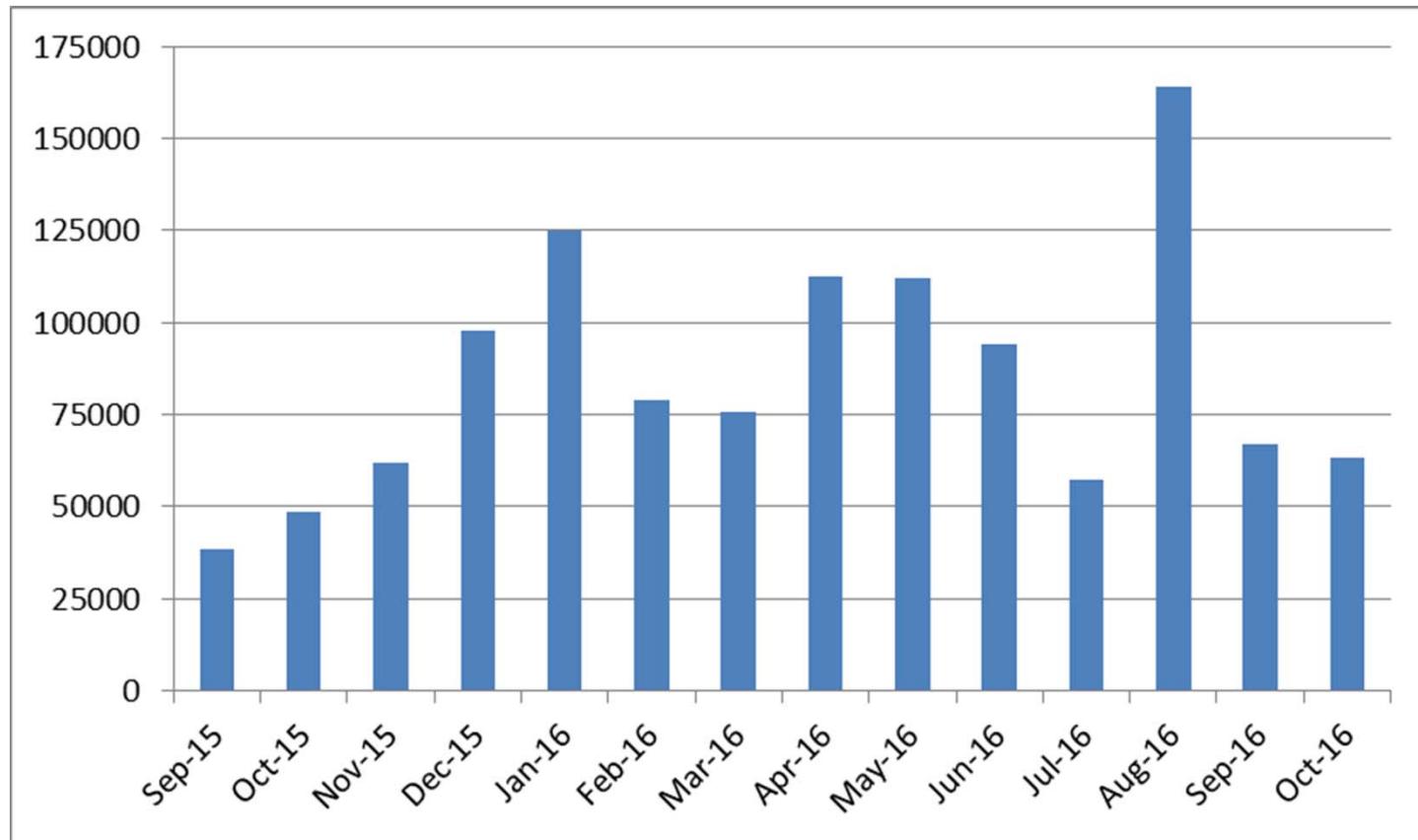
Monthly rates since 1999



45000/month ≈ one per minute

Impact: Recent Submissions

Monthly rates for past year



45000/month \approx one per minute

Assessment

Strengths

- Free
- Choice of solvers
 - * Every popular solver available
- Easy to use
 - * No account setup
 - * No advance scheduling

Weaknesses

- Stand-alone focus: submission of “solve jobs”
- Non-profit management
 - * Limited support & development
 - * No guarantee of confidentiality
 - * No guarantee of performance

Recent Enhancements

More flexible server infrastructure

- Based on HTCondor “high-throughput computing”

Secure user authentication

- Option to register and sign in when submitting
- Potential advantages for registered clients
 - * priority job execution
 - * data security
 - * “more services and better customized experiences”

Modeling Languages in NEOS

Modeling language inputs

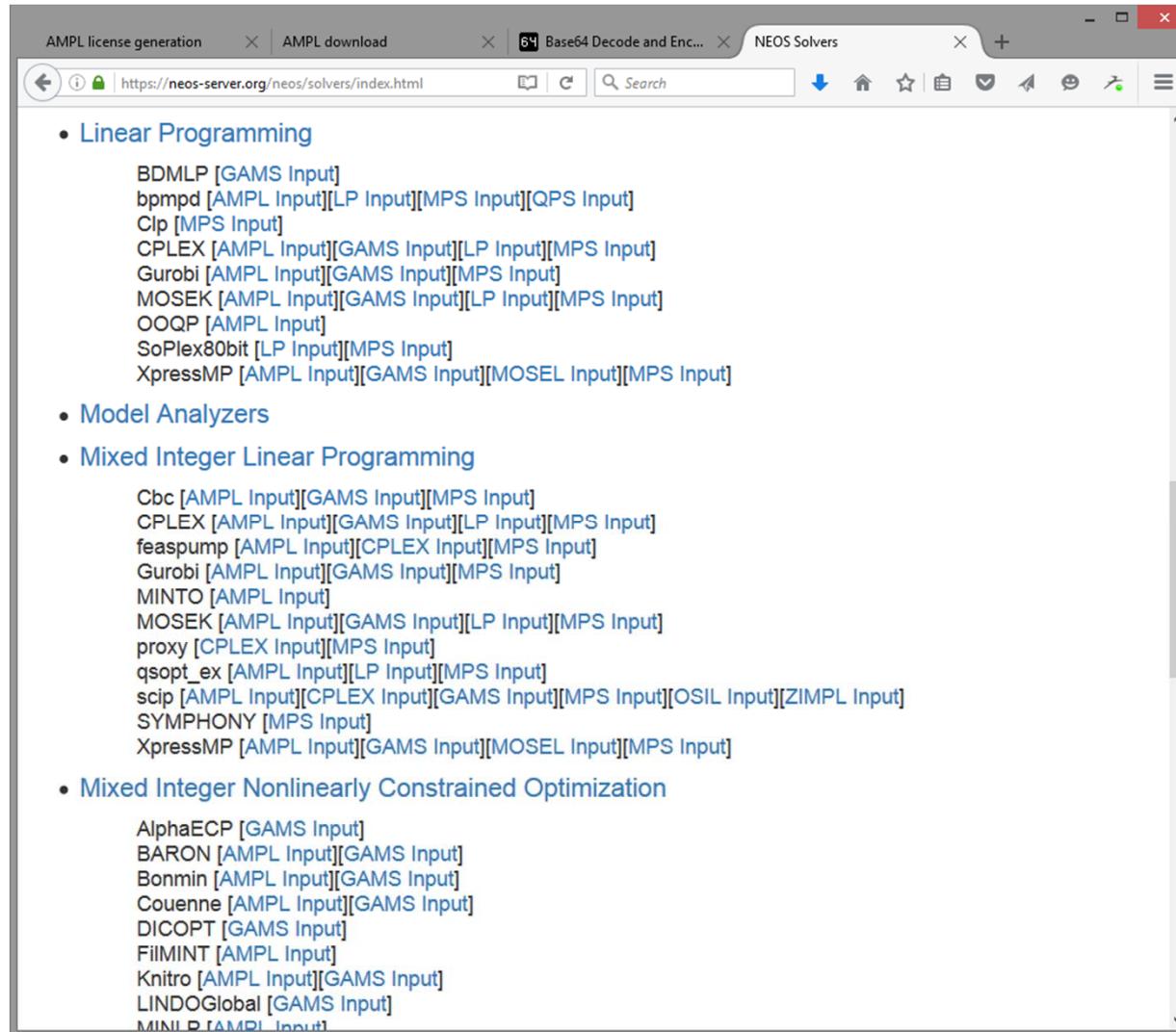
- AMPL model, data, commands files
- GAMS model, options, gdx files

Modeling language operation

- User chooses a solver and a language
- NEOS scheduler finds a compatible workstation
- NEOS workstation invokes modeling language system with given inputs
- Modeling language system invokes solver

E.D. Dolan, R. Fourer, J.J. Moré and T.S. Munson,
Optimization on the NEOS Server. *SIAM News* **35**:6
(July/August 2002) 4, 8–9. www.siam.org/pdf/news/457.pdf

Solver & Language Listing



NEOS Server

AMPL Input Page



The screenshot shows a web browser window for the NEOS Server. The URL in the address bar is <https://neos-server.org/neos/solv>. The page content is titled "AMPL Input Page". It features a large banner with the NEOS logo and the word "optimization". To the right of the banner is a box containing links to "NEOS Interfaces to CPLEX", "WWW Form & Sample Submissions", "Email", and "XML-RPC". Below the banner, there is a section titled "CPLEX" with information about the IBM ILOG CPLEX Optimizer. At the bottom, there is a note about using the NEOS Server with AMPL/CPLEX, mentioning requirements for email submissions and XML files.

CPLEX

The NEOS Server offers the IBM ILOG [CPLEX Optimizer](#) for the solution of linear programming (LP) problems that can be modeled in [AMPL](#) format.

For information on IBM Decision Optimization products, including the CPLEX Optimizer, visit [IBM Decision Optimization](#).

For information on all IBM software available to academics, visit the [IBM Academic Initiative](#).

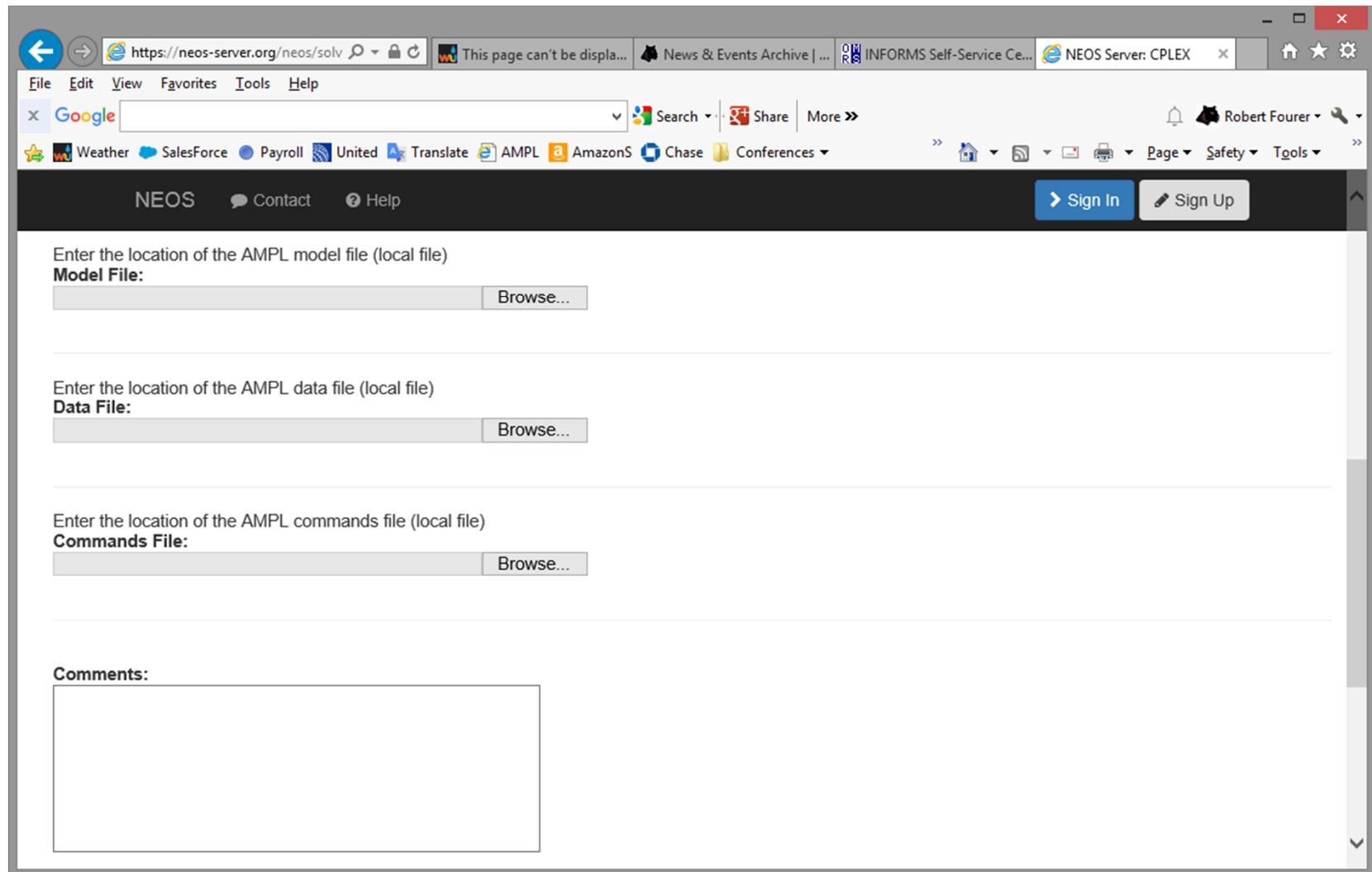
Using the NEOS Server with AMPL/CPLEX

The user must submit a model in [AMPL](#) format to solve a linear program. The [examples section](#) of the AMPL website provides examples of models in AMPL format. The LP problem must be specified by a model file with the options of a data file and a commands file. If the commands file is specified, it must contain the AMPL solve command. However, the command file must *not* contain the `model` or `data` commands. The model and data files are renamed internally by NEOS.

Note: An email address is required for any submissions that use CPLEX. This email address will be forwarded to IBM and may be used by IBM for promotional purposes. If using the XML-RPC interface, you must add the line `<email>your.address@email.edu</email>` into the XML file that is sent to NEOS.

NEOS Server

AMPL Input Page

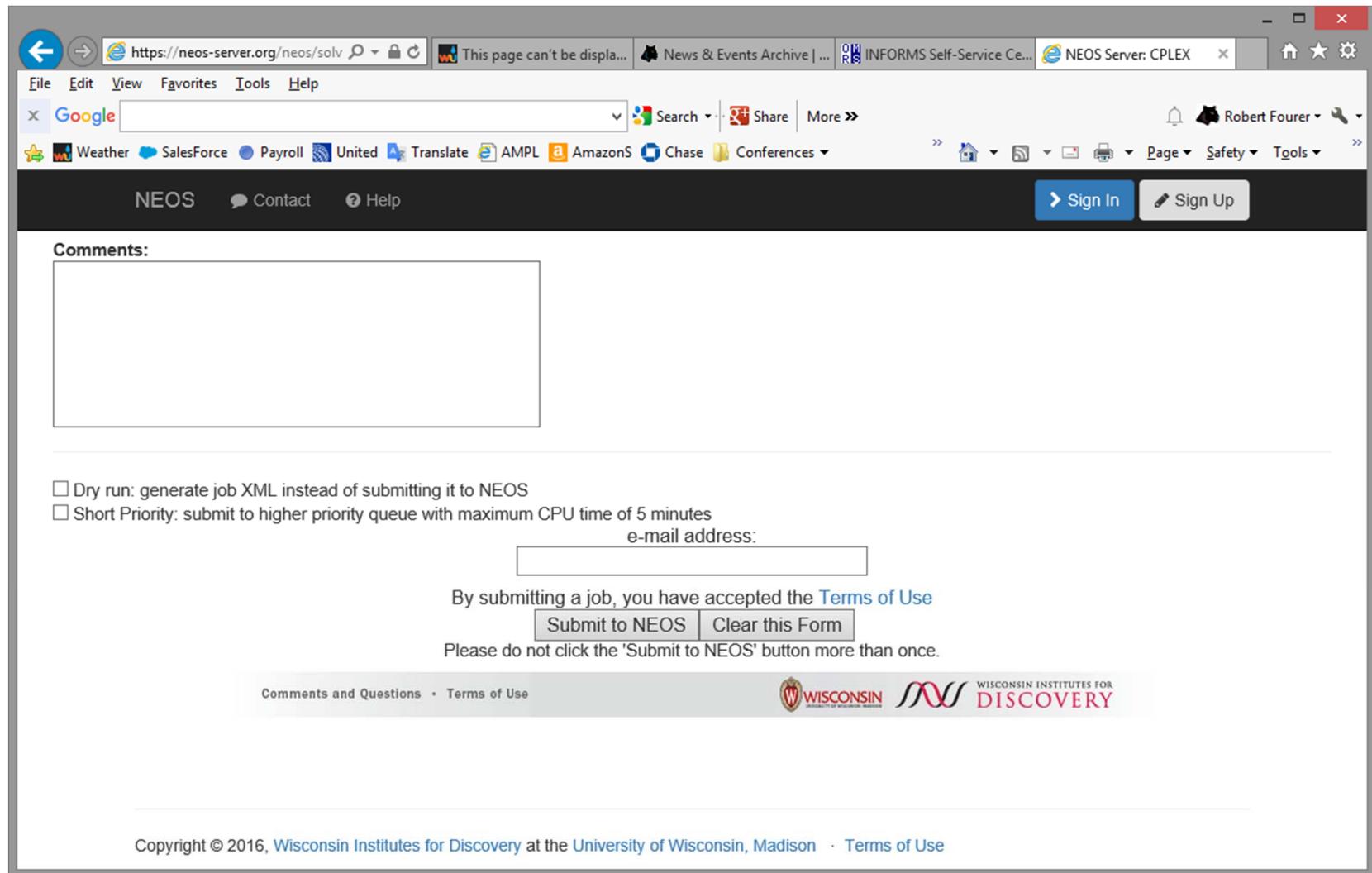


The screenshot shows a web browser window for the NEOS Server AMPL Input Page. The URL in the address bar is <https://neos-server.org/neos/solv>. The page title is "AMPL Input Page". The main content area contains four input fields for file selection:

- Model File:** A text input field with a "Browse..." button.
- Data File:** A text input field with a "Browse..." button.
- Commands File:** A text input field with a "Browse..." button.
- Comments:** A large text area for comments.

NEOS Server

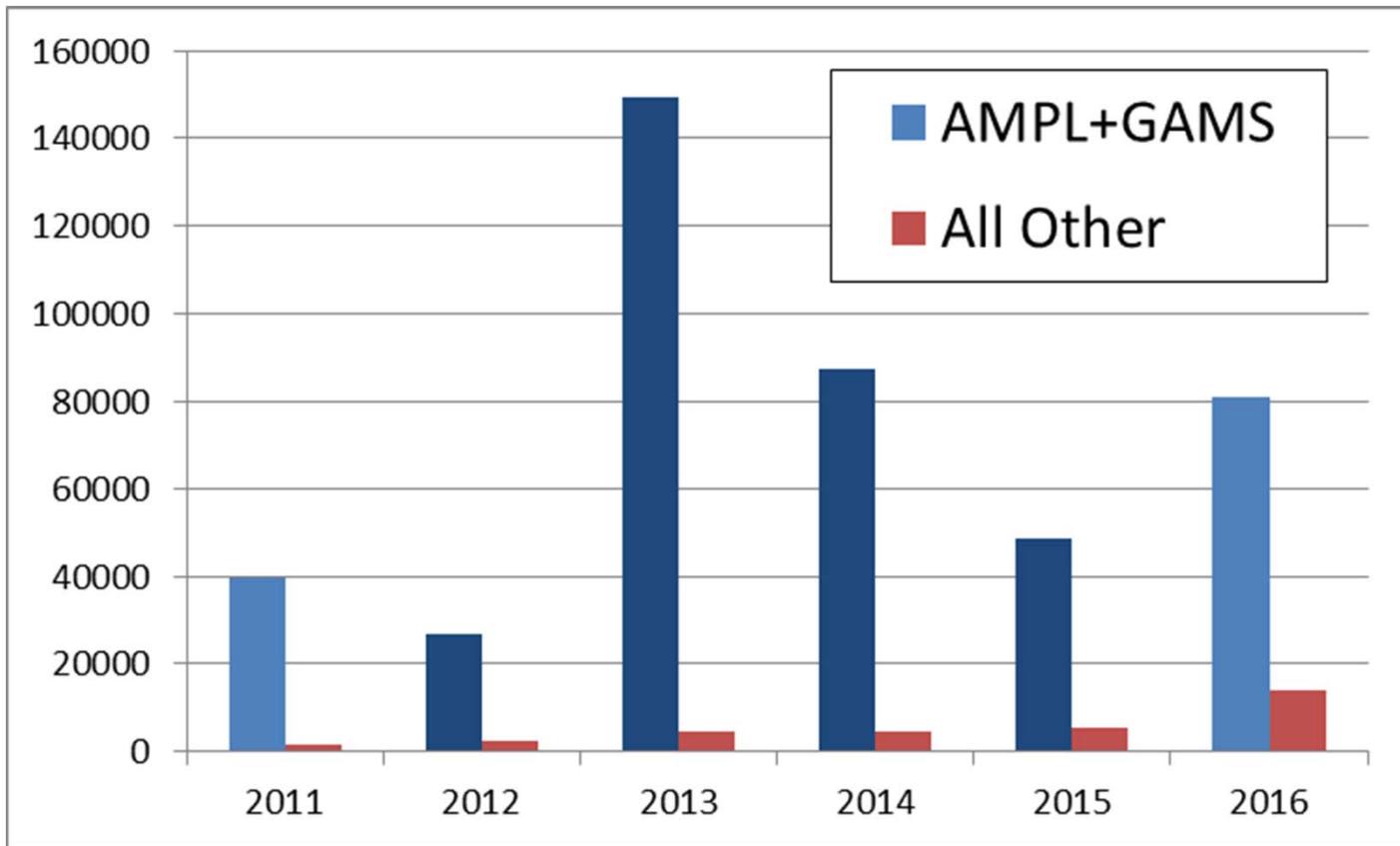
AMPL Input Page



The screenshot shows a web browser window for the NEOS Server AMPL Input Page. The URL in the address bar is <https://neos-server.org/neos/solv>. The page title is "This page can't be displayed". The top navigation bar includes links for "File", "Edit", "View", "Favorites", "Tools", and "Help". A search bar contains "Google". The main content area has a "Comments:" text input field. Below it are two checkboxes: "Dry run: generate job XML instead of submitting it to NEOS" and "Short Priority: submit to higher priority queue with maximum CPU time of 5 minutes". There is also a text input field for "e-mail address". A note states "By submitting a job, you have accepted the [Terms of Use](#)". Below this are "Submit to NEOS" and "Clear this Form" buttons. A note says "Please do not click the 'Submit to NEOS' button more than once." At the bottom, there are links for "Comments and Questions" and "Terms of Use". Logos for "WISCONSIN" and "WISCONSIN INSTITUTES FOR DISCOVERY" are present. The footer copyright notice reads "Copyright © 2016, Wisconsin Institutes for Discovery at the University of Wisconsin, Madison · Terms of Use".

Impact: Modeling Languages

Monthly rates since 2011



Modeling Systems as NEOS Clients

New “solvers”

- Kestrel for AMPL
- Kestrel for GAMS

Familiar operation

- Choose Kestrel as the local “solver”
- Set an option to choose a real solver on NEOS
- Initiate a solve and wait for results

E.D. Dolan, R. Fourer, J.-P. Goux, T.S. Munson and J. Sarich,
**Kestrel: An Interface from Optimization Modeling Systems
to the NEOS Server.** *INFORMS Journal on Computing* **20**
(2008) 525–538. dx.doi.org/10.1287/ijoc.1080.0264

AMPL Interactive Session

```
ampl: model sched1.mod;
ampl: data sched.dat;

ampl: let least_assign := 16;

ampl: option solver kestrel;
ampl: option kestrel_options 'solver=cplex';

ampl: solve;

Connecting to: neos-server.org:3332
Job 4679195 submitted to NEOS, password='JMNRQoTD'

Check the following URL for progress report :

http://neos-server.org/neos/cgi-bin/nph-neos-
solver.cgi?admin=results&jobnumber=4679195&pass=JMNRQoTD

Job 4679195 dispatched
password: JMNRQoTD

----- Begin Solver Output -----

Job submitted to NEOS HTCondor pool.
```

AMPL Interactive Session

```
----- Begin Solver Output -----
```

```
Job submitted to NEOS HTCondor pool.
```

```
CPLEX 12.6.2.0: optimal integer solution; objective 265.9999999999943
135348 MIP simplex iterations
17430 branch-and-bound nodes
```

```
ampl: option omit_zero_rows 1, display_1col 0;
```

```
ampl: display Work;
```

```
Work [*] :=
```

```
 1 16    11 16    36 19    72 20    82 20    106 16   114 20    125 20
 3 16    29 16    66 17    79 19    104 19    112 16   121 16
```

```
;
```

```
ampl:
```

Kestrel Impact

Some success

- 2013 and 2014:
Peaked at over 500,000 submissions
- 2015:
Dropped to only about 30,000 submissions
- 2016:
Up to over 100,000 submissions so far

Kestrel Assessment

Strengths

- Powerful local client for modeling
- NEOS facilities for solving

Weaknesses

- Limited support & development
- Not all NEOS solvers available
- Local solver software is strong competition . . .
 - * Bundled with modeling languages
 - * Free for trial use
 - * Free for course and academic use

More Recently . . .

NEOS in Solver Studio

- Excel add-in using
AMPL/GAMS models, NEOS solvers

Optimization Services

- Fully distributed, decentralized alternative to NEOS

IBM Decision Optimization on Cloud

- “DropSolve” service similar to NEOS
- “DOcplexcloud API” like NEOS API

Gurobi Cloud Services for Optimization

- Gurobi cloud for Amazon Web Services
- ***Gurobi instant cloud***



Gurobi 7.0 Instant Cloud cloud.gurobi.com

Client side

- Standard Gurobi installation
- Cloud license

Server side

- Compute server for Gurobi solver
 - * Single-machine solves
 - * Distributed MIP solves
 - * Distributed tuning
- Server pools with load balancing

... hosted on Amazon Web Services

*"Cloud computing technology is changing quickly.
Please check these documents periodically to ensure
you have the latest instructions for the Gurobi Cloud."*

Gurobi Instant Cloud for AMPL

Client side

- AMPL installation (command-line or IDE)
- Standard Gurobi-for-AMPL installation

Server side

- Gurobi compute server
- Gurobi optimizer

Gurobi Instant Cloud for AMPL

www.gurobi.com

The screenshot shows the homepage of the Gurobi Optimization website (www.gurobi.com). The header features the Gurobi logo and navigation links for PRODUCTS, DOWNLOADS, RESOURCES, ACADEMIA, SUPPORT, and ABOUT, along with>Login and Register buttons. A search bar and language selection are also present. The main banner has a blue background with a world map and the text "An easier way to make better decisions". Below the banner, it says "The state-of-the-art mathematical programming solver for prescriptive analytics". Three main sections are highlighted: "Learn About" (with a magnifying glass icon), "Get Gurobi" (with a hand icon), and "Use Gurobi" (with a wrench and screwdriver icon). Each section contains descriptive text and a red "Get Started Today!" button. A callout box at the bottom left provides information about free training events.

An easier way to make better decisions

The state-of-the-art mathematical programming solver for prescriptive analytics

Learn About

Gurobi builds and supports the best math programming solvers available for all major problem types. It's all we do...

Get Gurobi

We offer versions designed specifically for the needs of commercial, ISV, and academic users...

Use Gurobi

We've worked hard to make it easier to get started with or switch to Gurobi than you may have thought possible...

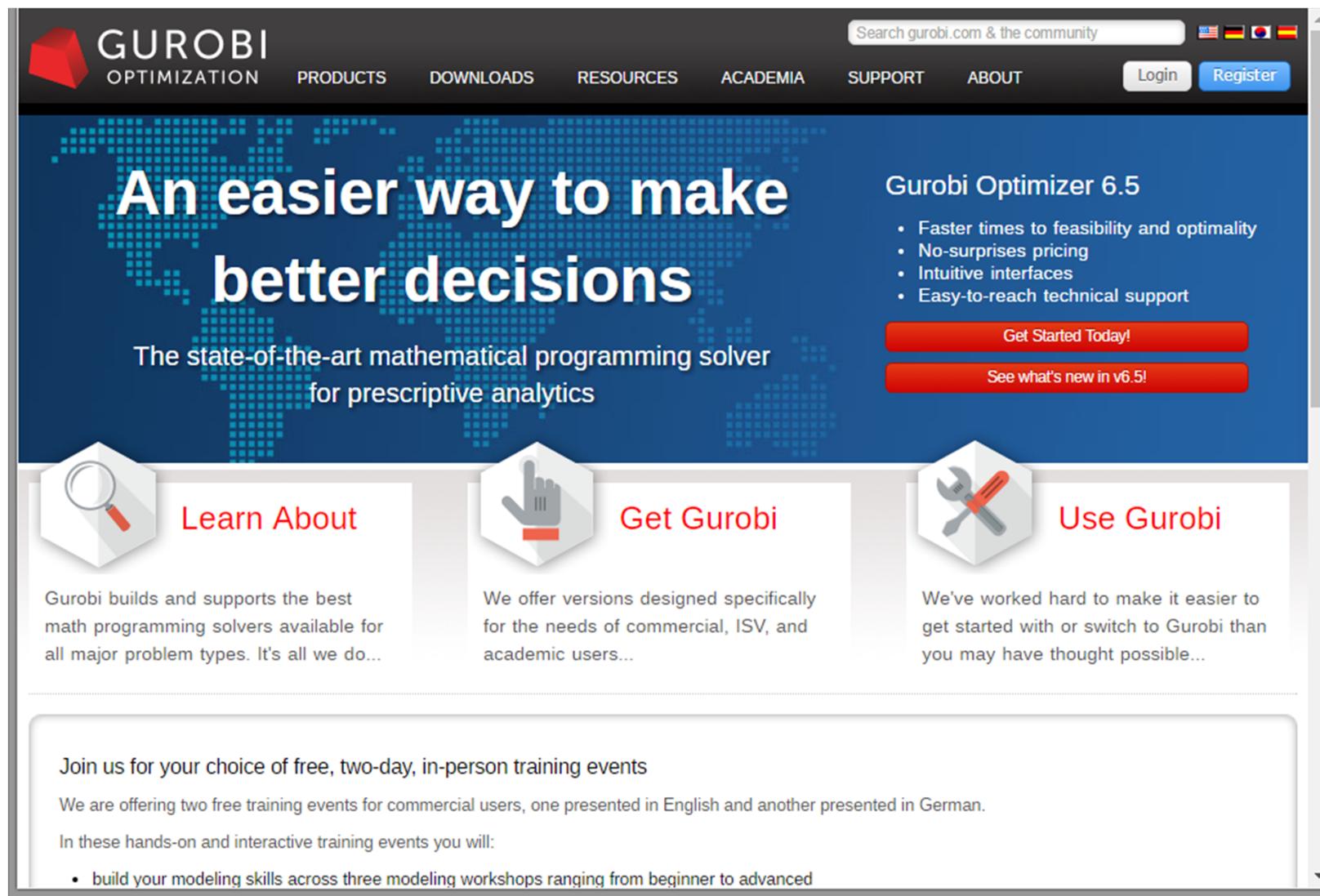
Join us for your choice of free, two-day, in-person training events

We are offering two free training events for commercial users, one presented in English and another presented in German.

In these hands-on and interactive training events you will:

- build your modeling skills across three modeling workshops ranging from beginner to advanced

Gurobi Instant Cloud for AMPL
www.gurobi.com



The screenshot shows the Gurobi Optimization website homepage. At the top, there is a navigation bar with the Gurobi logo, a search bar, and links for Products, Downloads, Resources, Academia, Support, About, Login, and Register. Below the navigation bar, a large blue banner features the text "An easier way to make better decisions" and "The state-of-the-art mathematical programming solver for prescriptive analytics". To the right of the banner, a section for "Gurobi Optimizer 6.5" lists four bullet points: "Faster times to feasibility and optimality", "No-surprises pricing", "Intuitive interfaces", and "Easy-to-reach technical support". Below this are two red buttons: "Get Started Today!" and "See what's new in v6.5!". At the bottom of the page, there are three main sections: "Learn About", "Get Gurobi", and "Use Gurobi", each with an icon and a brief description. A callout box at the bottom left provides information about free training events.

GUROBI
OPTIMIZATION

PRODUCTS DOWNLOADS RESOURCES ACADEMIA SUPPORT ABOUT

Search gurobi.com & the community

Login Register

An easier way to make better decisions

The state-of-the-art mathematical programming solver for prescriptive analytics

Gurobi Optimizer 6.5

- Faster times to feasibility and optimality
- No-surprises pricing
- Intuitive interfaces
- Easy-to-reach technical support

Get Started Today!

See what's new in v6.5!

Learn About

Gurobi builds and supports the best math programming solvers available for all major problem types. It's all we do...

Get Gurobi

We offer versions designed specifically for the needs of commercial, ISV, and academic users...

Use Gurobi

We've worked hard to make it easier to get started with or switch to Gurobi than you may have thought possible...

Join us for your choice of free, two-day, in-person training events

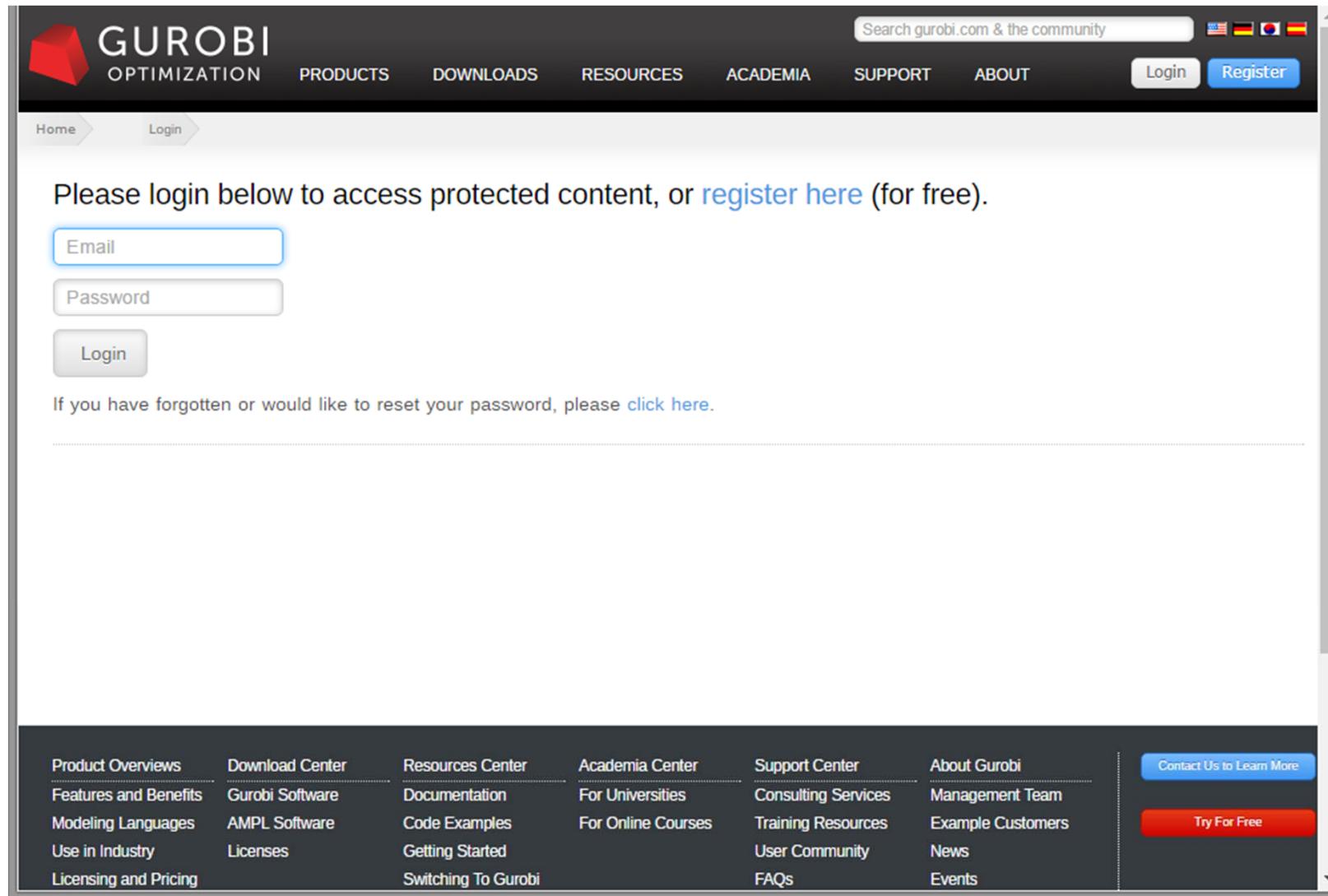
We are offering two free training events for commercial users, one presented in English and another presented in German.

In these hands-on and interactive training events you will:

- build your modeling skills across three modeling workshops ranging from beginner to advanced

Gurobi Instant Cloud for AMPL

www.gurobi.com



The screenshot shows the Gurobi website's login page. At the top, there is a dark header bar with the Gurobi logo, navigation links for PRODUCTS, DOWNLOADS, RESOURCES, ACADEMIA, SUPPORT, and ABOUT, and buttons for Login and Register. Below the header, a search bar and language selection icons are visible. The main content area has a breadcrumb trail from Home to Login. It displays a message: "Please login below to access protected content, or register here (for free)". There are input fields for Email and Password, and a Login button. Below these fields is a link to reset a password. At the bottom of the page is a footer navigation bar with links for Product Overviews, Features and Benefits, Modeling Languages, Use in Industry, Licensing and Pricing, Download Center, Gurobi Software, AMPL Software, Licenses, Resources Center, Documentation, Code Examples, Getting Started, Switching To Gurobi, Academia Center, For Universities, For Online Courses, Support Center, Consulting Services, Training Resources, User Community, FAQs, About Gurobi, Management Team, Example Customers, News, and Events. On the right side of the footer, there are two buttons: "Contact Us to Learn More" and "Try For Free".

Gurobi Instant Cloud for AMPL

ngcloud.gurobi.com

The screenshot shows the Gurobi Instant Cloud homepage. At the top, there's a dark header with the Gurobi logo, navigation links (PRODUCTS, DOWNLOADS, RESOURCES, ACADEMIA, SUPPORT, ABOUT), a user icon, and a "Get Gurobi" button. Below the header is a large blue banner featuring a world map composed of dots and the text "Gurobi Instant Cloud" and "Instant access to powerful optimization software and fast machines". To the right of the banner are two red buttons: "Open Cloud Manager" and "Discuss Your Needs". The main content area is divided into three columns: "Great for...", "Easy and Robust", and "Cost Effective", each with a list of bullet points. At the bottom are three blue buttons: "Learn more", "Cloud Guide", and "Pricing".

Great for...

- Handling spikes in demand
- Solving challenging models
- Meeting periodic optimization needs
- Delivering cloud-based solutions
- Providing cloud-based failover

Easy and Robust

- Automatically start, manage and stop multiple machines
- Access from your existing applications
- Select dedicated machines from a data center near you
- Stay secure with built-in 256-bit AES encryption

Cost Effective

- Use and pay for only what you need
- Reduce or eliminate local data center costs
- Support Windows, Linux and Mac clients
- Access includes Gurobi Support

View Available Licenses

The screenshot shows a web-based interface for managing licenses. At the top, a blue header bar contains the title "Licenses". To the right of the title are three icons: a question mark, a refresh symbol, and a share symbol. Below the header, there is a search bar with the placeholder "Search:" and a dropdown menu showing "Show 10 licenses".

License	Active Machines	Rate Plan	Credit (US Dollar)	Expiration Time	Actions
142032	0	No Charge	\$25	10/30/2016 7:00:00 PM	
121420	0	No Charge	\$24.12	4/28/2016 7:00:00 PM	

Below the table, a message indicates "Showing 1 to 2 of 2 licenses". Navigation links include "First", "Previous", a page number "1" (which is highlighted), "Next", and "Last". At the bottom of the page, there are three blue buttons labeled "CONTACT SALES", "SUPPORT CENTER", and "GETTING STARTED".

Get Gurobi License File

```
# This is a license file created by the Gurobi Instant Cloud
# Created on Mon, 17 Oct 2016 20:46:26 GMT
# License Id: 142032
# Place this file in your home directory or one of the following
# locations where XXX is the Gurobi Optimizer version you are using:
#     * C:\gurobi\ or C:\gurobiXXX\ on Windows
#     * /opt/gurobi/ or /opt/gurobiXXX/ on Linux
#     * /Library/gurobi/ or /Library/gurobiXXX/ on Mac OS X
# Or set environment variable GRB_LICENSE_FILE to point to this file
# Do not share this license file because it contains your secret key
```

CLOUDACCESSID=fedf3901-04f1-44d7-9725-e36c1c3f70f6

CLOUDKEY=0v9XdWrDQLiE3EiAAEKtFw

CLOUDHOST=ngcloud.gurobi.com

Use with AMPL: Setup

```
ampl: model multmip3.mod;
ampl: data multmip3.dat;

ampl: option solver gurobi;

ampl: option gurobi_options
ampl?  'cloudid=fedf3901-04f1-44d7-9725-e36c1c3f70f6' \
ampl?  'cloudkey=0v9XdWrDQLiE3EiAAEktFw';

ampl:
```

Use with AMPL: *Startup*

```
ampl: model multmip3.mod;
ampl: data multmip3.dat;

ampl: option solver gurobi;

ampl: option gurobi_options
ampl?  'cloudid=fedf3901-04f1-44d7-9725-e36c1c3f70f6 \
ampl?  cloudkey=0v9XdWrDQLiE3EiAAEktFw';

ampl: solve;

Gurobi 7.0.0: cloudid=fedf3901-04f1-44d7-9725-e36c1c3f70f6
cloudkey=0v9XdWrDQLiE3EiAAEktFw

Waiting for cloud server to start.....
```

Gurobi Instant Cloud for AMPL

Use with AMPL: *Solve*

```
ampl: model multmip3.mod;
ampl: data multmip3.dat;

ampl: option solver gurobi;

ampl: option gurobi_options
ampl?  'cloudid=fedf3901-04f1-44d7-9725-e36c1c3f70f6 \
ampl?  cloudkey=0v9XdWrDQLiE3EiAAEktFw';

ampl: solve;

Gurobi 7.0.0: cloudid=fedf3901-04f1-44d7-9725-e36c1c3f70f6
cloudkey=0v9XdWrDQLiE3EiAAEktFw

Waiting for cloud server to start.....
Capacity available on 'default' cloud pool - connecting...
Established 256-bit AES encrypted connection

Gurobi 7.0.0: optimal solution; objective 235625
289 simplex iterations
25 branch-and-cut nodes
plus 35 simplex iterations for intbasis

ampl:
```

Use with AMPL: *Continue*

```
ampl: display {i in ORIG, j in DEST} sum {p in PROD} Trans[i,j,p];  
:  
DET    FRA    FRE    LAF    LAN    STL    WIN    :=  
CLEV   625    375    550    0      500    550    0  
GARY     0      0      0      400    0      625    375  
PITT   525    525    625    600    0      625    0  
;  
  
ampl: reset data;  
ampl: data multmip3a.dat;  
  
ampl: solve;  
  
Gurobi 7.0.0: clouddid=fedf3901-04f1-44d7-9725-e36c1c3f70f6  
cloudkey=0v9XdWrDQLiE3EiAAEKtFw  
  
Capacity available on 'default' cloud pool - connecting...  
Established 256-bit AES encrypted connection  
  
Gurobi 7.0.0: optimal solution; objective 238450  
163 simplex iterations  
plus 33 simplex iterations for intbasis  
  
ampl:
```

Gurobi Instant Cloud for AMPL

Manage Server Configuration

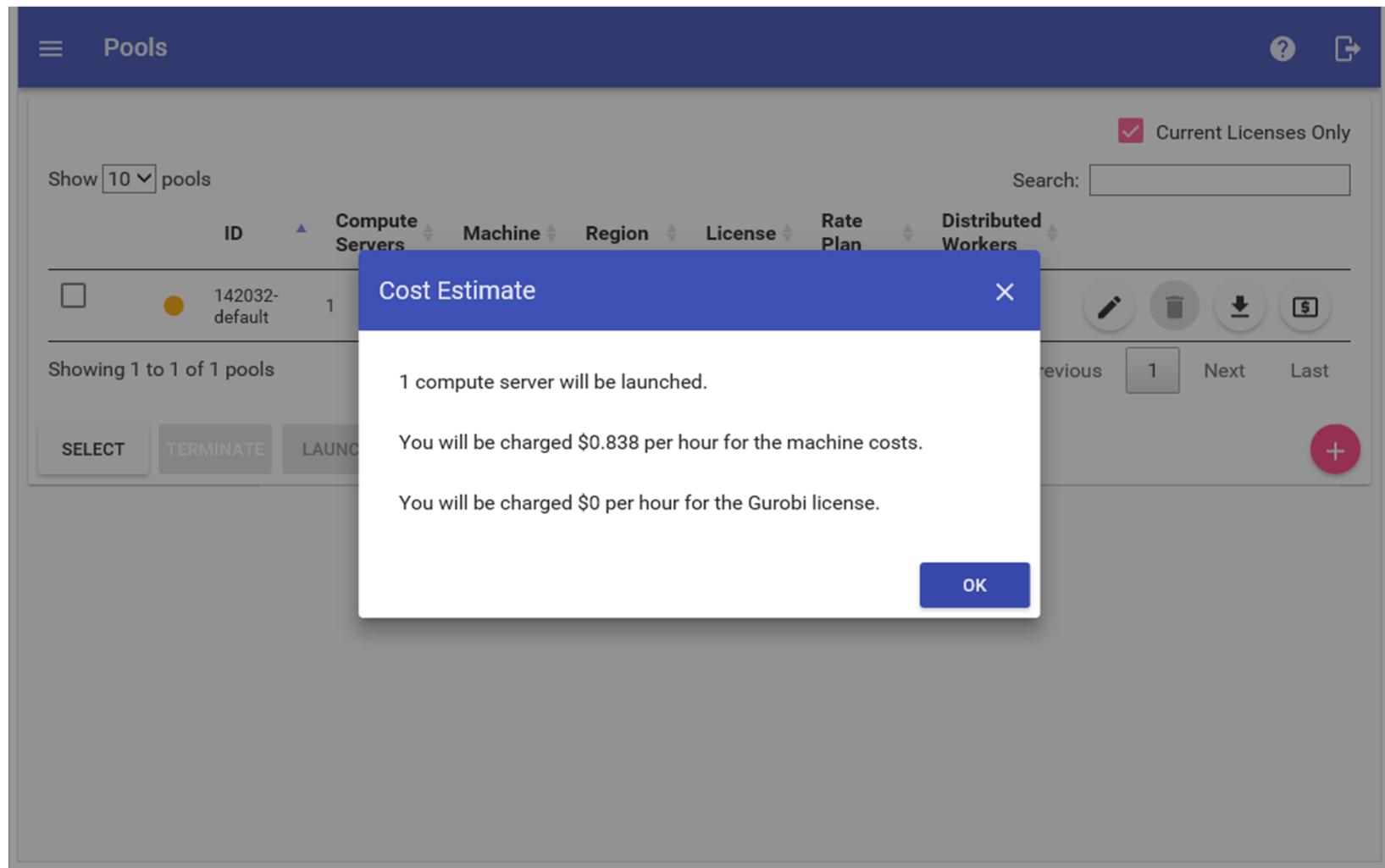
The screenshot shows the Gurobi Instant Cloud for AMPL web interface. On the left, a sidebar menu lists options: Instant Cloud (selected), LICENSES (highlighted in blue), POOLS, MACHINES, MANUAL LAUNCH, HISTORY, and SETTINGS. At the bottom of the sidebar are links for SUPPORT and GETTING STARTED. The main content area displays a table of server configurations. The columns are: Name, Type, Rate Plan, Credit (US Dollar), and Expiration Time. Two rows are visible:

Name	Type	Rate Plan	Credit (US Dollar)	Expiration Time
4er@ampl.com	Machine	No Charge	\$19.75	10/30/2016 7:00:00 PM
	Pool	No Charge	\$24.12	4/28/2016 7:00:00 PM

Below the table are navigation buttons: First, Previous, Next, Last, and a page number input field set to 1.

Gurobi Instant Cloud for AMPL

Check Costs



Gurobi Cloud Costs

Commercial plans

- Annual subscription fee, *plus*
- Hourly rates for use:
 - * Gurobi rate for compute servers
 - * Amazon rate for distributed workers

Trials, academic use, special grants

- Amazon rate only
 - . . . *set up through sales rep*

Gurobi Cloud for AMPL: Assessment

Strengths

- Security
- Reliability (via Amazon)
- Support for multi-server and/or multi-worker pools
- Support for local modeling clients

Drawbacks (compared to NEOS)

- Not free
 - * Budgeting can be complicated
- Solver-specific
- Not quite “optimization on demand”

QuanDec

Server side

- AMPL model and data
- Standard AMPL-solver installations

Client side

- Interactive tool for collaboration & decision-making
- Runs on any recent web browser
- Java-based implementation
 - * AMPL API for Java
 - * Eclipse Remote Application Platform

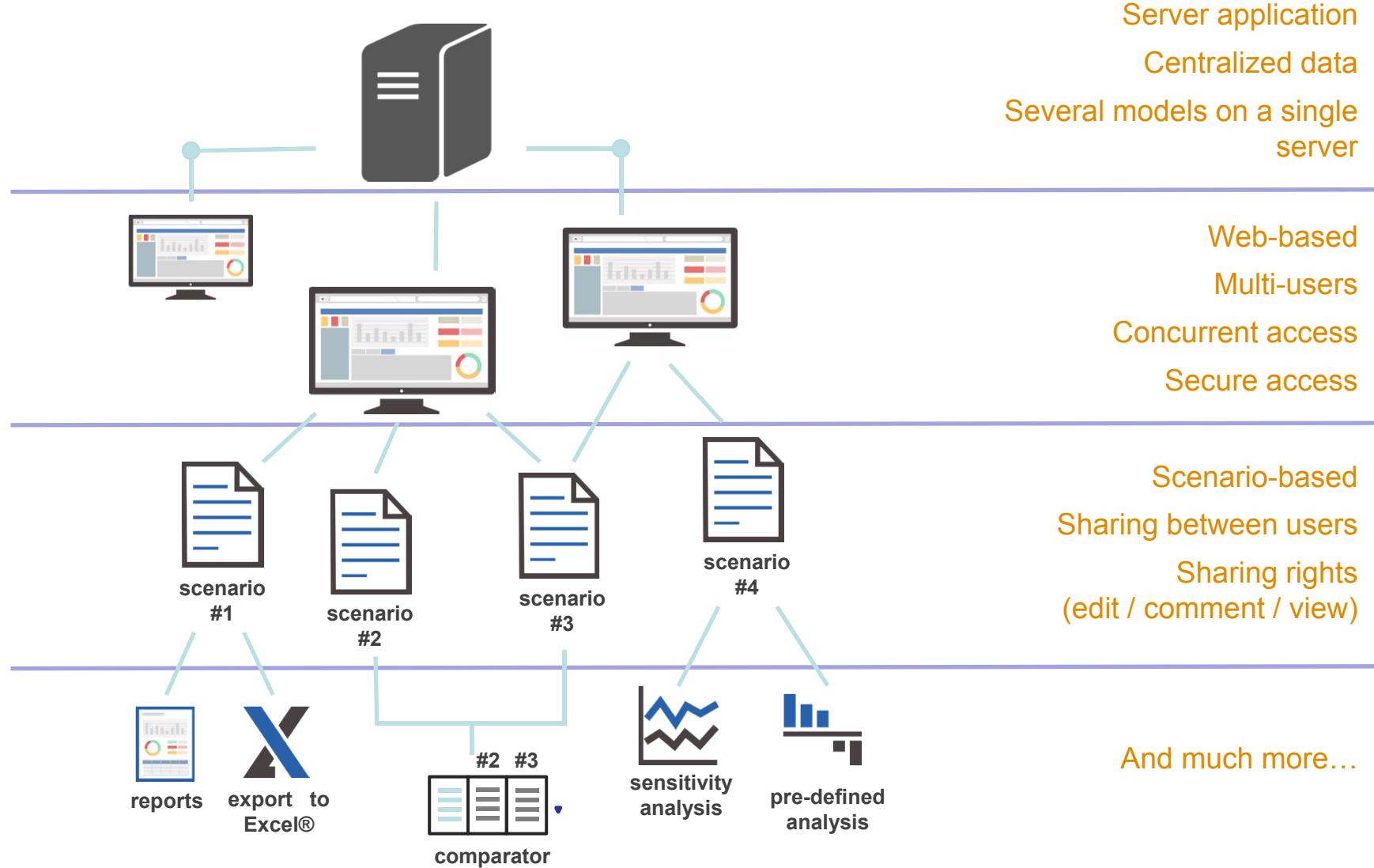
. . . developed / supported by Cassotis Consulting



The web-based graphical interface
that turns optimization models written
in AMPL into decision-making tools.



Features

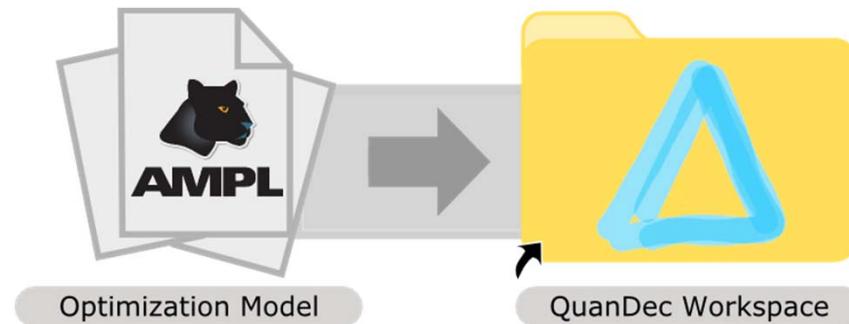


Getting started

step 1: install QuanDec on a server

step 2: copy & paste your model files (.mod and .dat) into
QuanDec's workspace

step 3: create AMPL tables and link them to QuanDec explorer





E-mail :

Password :

[Forgot?](#)

Enter your email to login

Version 2.3.1

[CASSOTIS consulting](#)

[Login](#)

Web-application

Multi-user

Secure access

Concurrent access

The screenshot shows the QuanDec software interface. At the top, there is a navigation bar with links for 'Workspace' and 'Admin', and buttons for 'Switch workspace', 'New Master', 'Import Master', and 'Compare'. The QuanDec logo is in the top right corner. Below the navigation bar, there are two tables:

This week

Name	Owner	Last change
BUDGET 2016	Mary Torres	September 9, 2016 4:59 PM
My Scenario	Me	Today 10:54 AM

All

Name	Owner
BUDGET 2015	Mary Torres
BUDGET 2016	Mary Torres
My Scenario	Me
FORECAST 2017	Mary Torres

A modal dialog box titled 'Share with others' is open on the right side of the screen. It contains the following fields:

- 'Anyone can comment' dropdown menu
- 'People or groups' section with a list item 'Robert Finn can edit' followed by a red 'X' button
- 'OK' button at the bottom right

Scenario-based environment

Sharing system

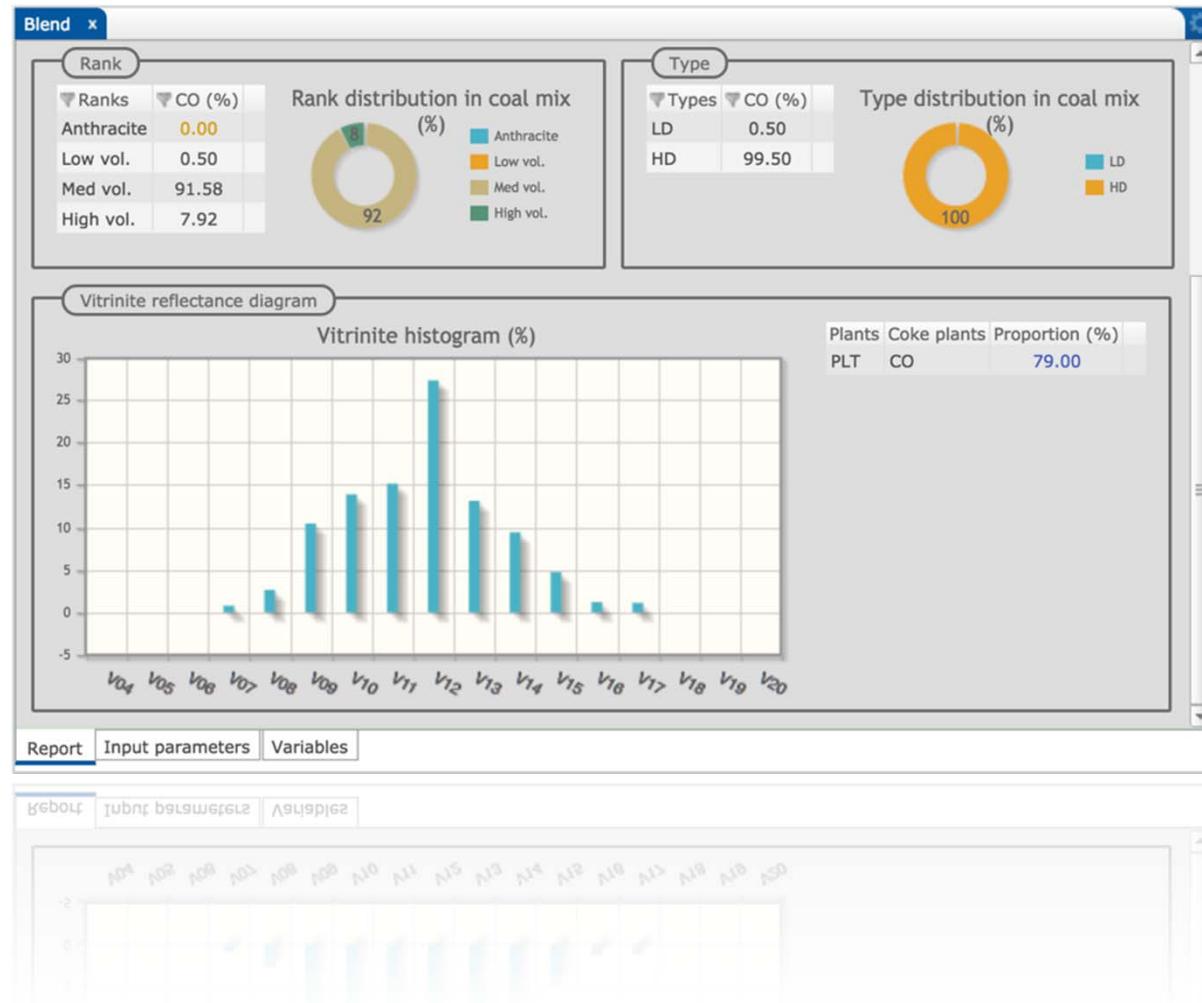
**Permission:
Edit – Comment - View**

- 3 levels:**
- Report
 - Input parameters
 - Variables

Chart and tables

Colored values
for easier analysis

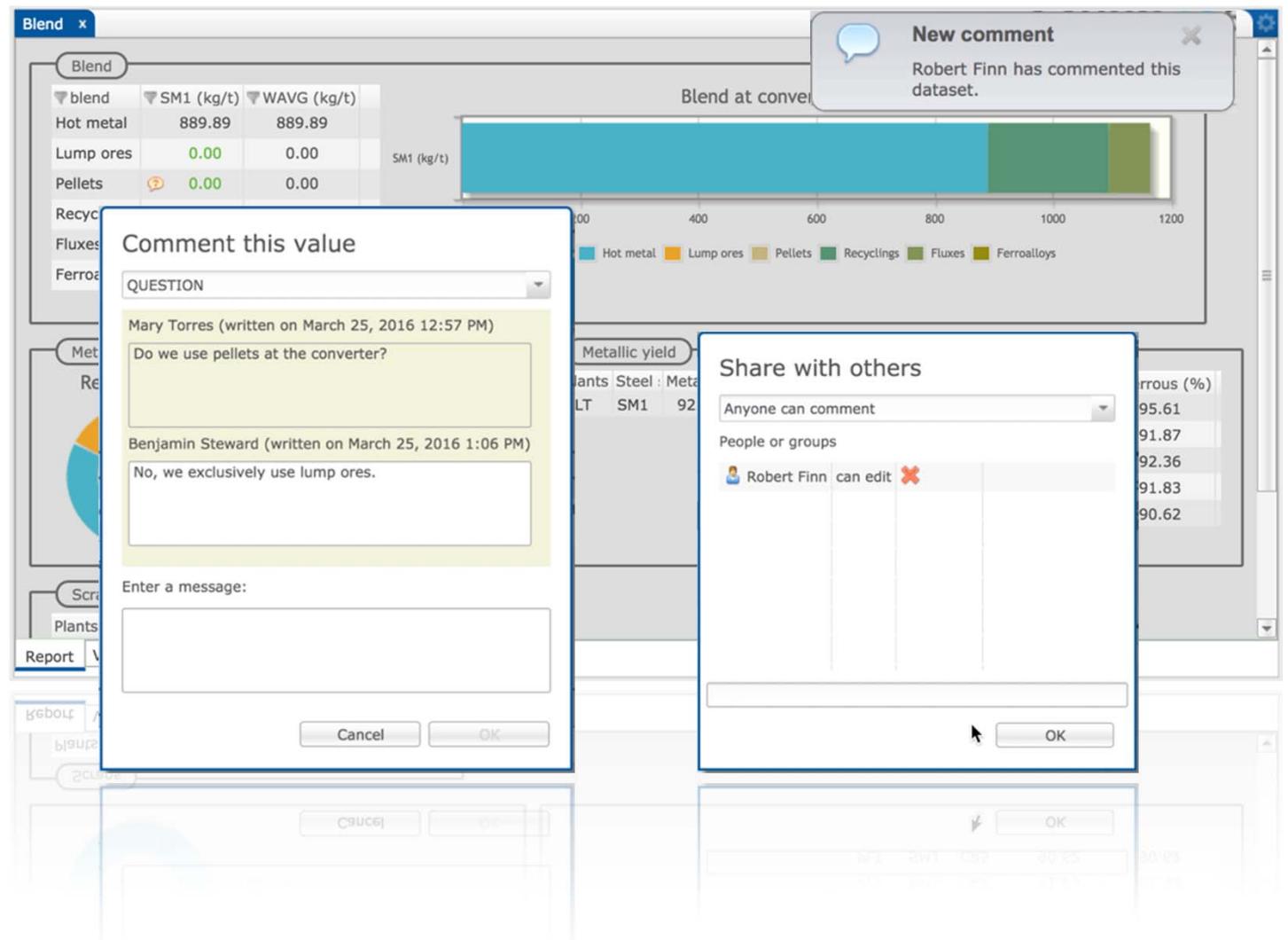
Constraint (min/max)
on any variable



Collaborative work

Notification system

Comments between users



Coke plants x

Operating costs

Plants	Coke plants	Costs	Fixed (MUS\$/year)	Variable (US\$/t)
PLT	CO	Maintenance	7.75	0.90
PLT	CO	Labour costs	3.95	0.00
PLT	CO	Utilities	0.05	0.11
PLT	CO	Water treatment	7.78	0.00
PLT	CO	Court yard	5.36	0.00
PLT	CO	Services	0.02	0.94
PLT	CO	Indirect costs	2.57	0.00
PLT	CO	Depreciation	4.92	0.00
PLT	CO	Electricity	0.00	0.03

Report Input parameters Variables

Journal Bounds Regressions Comments Error Log

Operating cost at coke plant	PLT, CO1, co_elec, Variable	0.03	Today 11:26 AM	by Arthur Turner	X
CO operational costs	PLT, co_elec	Electricity	Today 11:26 AM	by Arthur Turner	X
CO operational costs	PLT	co_elec	Today 11:26 AM	by Arthur Turner	X
Vitrinite reflectance inside of range at coke plant	PLT, CO1	MAX 79.00	Today 10:49 AM	by Arthur Turner	X

Arthur Turner QuanDec STEEL BUDGET 2016 My Scenario

Scenarios with changes history

Traceability and undo system

Workspace Admin

New Report Show/Hide differences Export to Excel

Scenarios comparison

All variables can be compared

Display of relative difference

Custom reports

The screenshot shows the QuanAec software interface with several windows open:

- Scenarios comparison:** A modal dialog titled "Select the scenarios to compare:" lists "BUDGET 2015", "BUDGET 2016" (selected with a checked checkbox), and "FORECAST 2017".
- Variable Comparison:** A table titled "Economics and Production" comparing variables between "BUDGET 2016" and "My Scenario".
- Report History:** A table titled "Reports" listing various reports with their users, dates, and actions.
- Custom Reports:** A table titled "Custom Reports" listing various reports with their users, dates, and actions.

Profit and Sales

Exchange rates

Currencies	Exchange rates (US\$)
eur	1.14
usd	1.00
brl	0.29

Horizon Days (d) 365.00

Add a comment
Add a constraint
Add to a regression
Analyse sensitivity
Export the table
Download the template

Sensitivity analysis

Parameter : Exchange rates

Index : 'brl'
From : 0.3
To : 1
#Pts : 3

Cancel OK

Sensitivity analysis

For both parameters
AND variables

QuanDec

Workspace Admin

Back to edition New Report Show/Hide differences Export to Excel

Comparator

Variable	Unit	0.30	0.65	Diff	1.00	Diff
Executive summaries						
Costs and Revenues						
Profit and Sales						
Economics per int. plant	MUS\$					
'PLT' 'costs'	MUS\$	1515.39	1544.99	1.95%	1633.34	7.78%
'PLT' 'revenues'	MUS\$	1754.70	1679.96	-4.26%	1670.71	-4.79%
'PLT' 'profit'	MUS\$	239.31	134.97	-43.60%	37.37	-84.38%
'PLT' 'margin'	%	13.64	8.03	-41.09%	2.24	-83.60%
Global economics	MUS\$					
External costs per process	MUS\$					
External costs per type	MUS\$					
Detailed external costs	MUS\$					
External revenues per process	MUS\$					
External revenues per type	MUS\$					
Detailed external revenues	MUS\$					
Detailed revenues	MUS\$/t					
Production costs						
Material blends						
Coke plants						
Sinter plants						
Blast furnaces						
Steel shops						
Power plant						
Raw materials						
Gases						

Economics and Production

Variable	Index	Unit	0.30	0.65	Diff	1.00	Diff
Economics per int. plant	'PLT' 'costs'	MUS\$	1515.39	1544.99	1.95%	1633.34	7.78%
Economics per int. plant	'PLT' 'revenues'	MUS\$	1754.70	1679.96	-4.26%	1670.71	-4.79%
Economics per int. plant	'PLT' 'profit'	MUS\$	239.31	134.97	-43.60%	37.37	-84.38%
Economics per int. plant	'PLT' 'margin'	%	13.64	8.03	-41.09%	2.24	-83.60%
Production cost of product	'PLT' 'coke'	MUS\$/t	164.51	161.52	-1.82%	162.71	-1.10%
Production cost of product	'PLT' 'sinter'	MUS\$/t	77.68	83.23	7.15%	88.16	13.50%
Production cost of product	'PLT' 'hotmetal'	MUS\$/t	194.23	198.43	2.16%	202.93	4.48%
Production cost of product	'PLT' 'slab'	MUS\$/t	287.62	307.33	6.85%	326.85	13.64%
Production cost of product	'PLT' 'electricity'	MUS\$/MWh	125.62	125.73	0.08%	125.74	0.09%
Production level of product	'PLT' 'coke'	kt	1818.81	1815.95	-0.16%	1815.95	-0.16%
Production level of product	'PLT' 'sinter'	kt	4115.36	4007.25	-2.63%	4006.24	-2.65%
Production level of product	'PLT' 'hotmetal'	kt	5105.94	5051.71	-1.06%	5052.00	-1.06%
Production level of product	'PLT' 'trhotmetal'	kt	5025.36	4972.09	-1.06%	4972.37	-1.05%
Production level of product	'PLT' 'crudesteel'	kt	5657.39	5402.17	-4.51%	5372.49	-5.04%

Report Structure

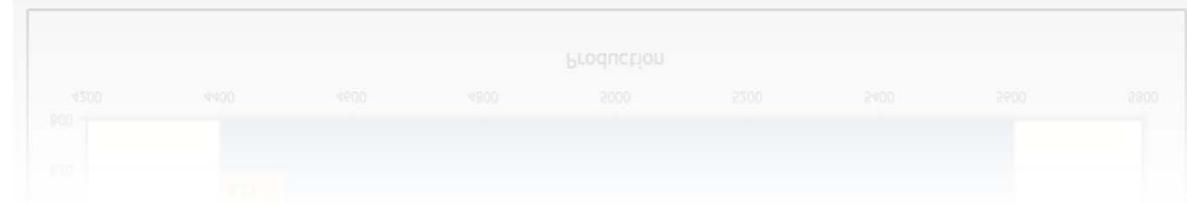
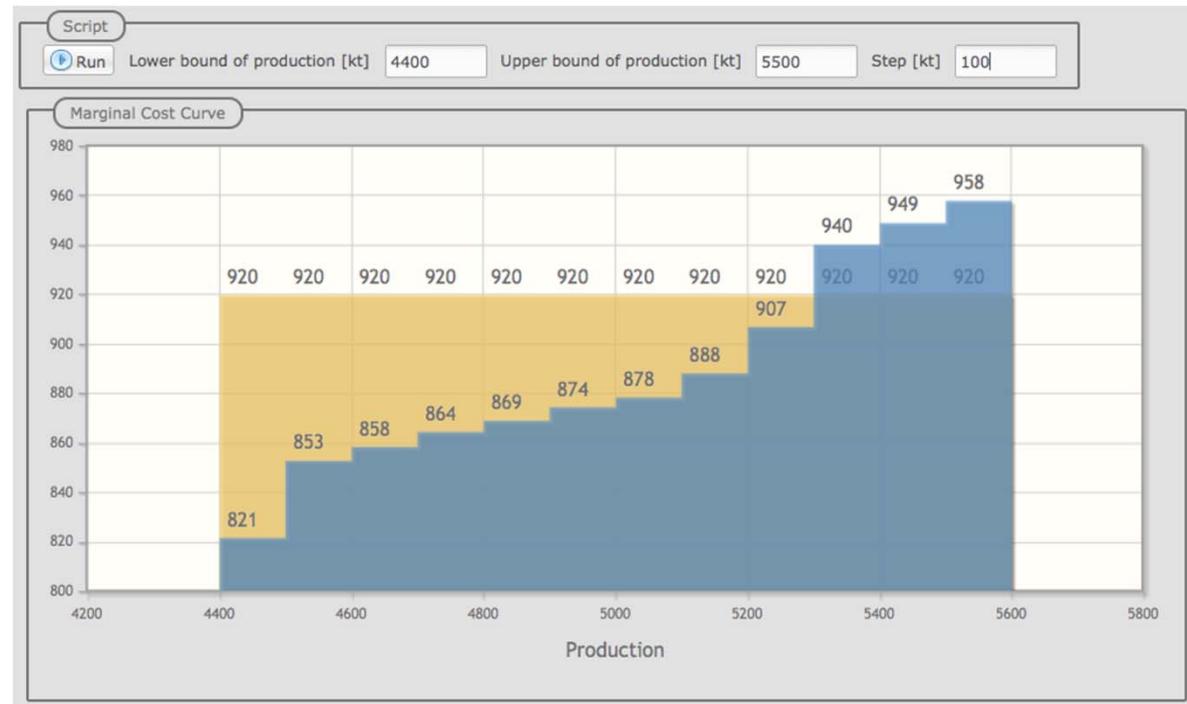
Reports

Name	User	Date	Action
Sulfur cycle	Benjamin Steward	March 18, 2016 3:45 PM	X
Metallic blend at CV	Me	February 21, 2016 4:51 PM	X
Raw material use at Reduction	Me	January 15, 2016 4:36 PM	X
Economics and Production	Mary Torres	September 13, 2016 4:53 PM	X
Flux consumption at Torpedo	Mary Torres	April 3, 2016 4:44 PM	X
Slab sales	Robert Finn	January 30, 2016 5:30 PM	X
Silicon cycle	Benjamin Steward	July 5, 2016 4:17 PM	X

Arthur Turner QuanDec STEEL BUDGET 2016 My Scenario About QuanDec...

Predefined analyses

Script parameters



QuanDec Availability

Ready now for commercial applications

- Free trials available
- Pricing keyed to number of models & users

First year's support included

- Tailored setup support from Cassotis Consulting
- Customizations possible

. . . contact sales@ampl.com for details