

# Microsoft Office Excel Solver Add-in and Prescriptive Analytics

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More than 1.2 billion people use Microsoft Office, which means nearly that many use Excel. Not surprisingly, many businesses also use Excel for their S&OP, Capex and other planning activities. If spreadsheet products like Excel suddenly disappeared, even many well-run companies would find it challenging to quickly adopt an alternative approach.

However, relying on Excel for critical business planning also comes with risk. Businesses can be large and complex, so it follows that using Excel for planning results in a large and complex set of worksheets, linked together by hundreds of calculations and lookups. Often, many related workbooks are then linked together for some common purpose.

## The Excel Solver Add-in

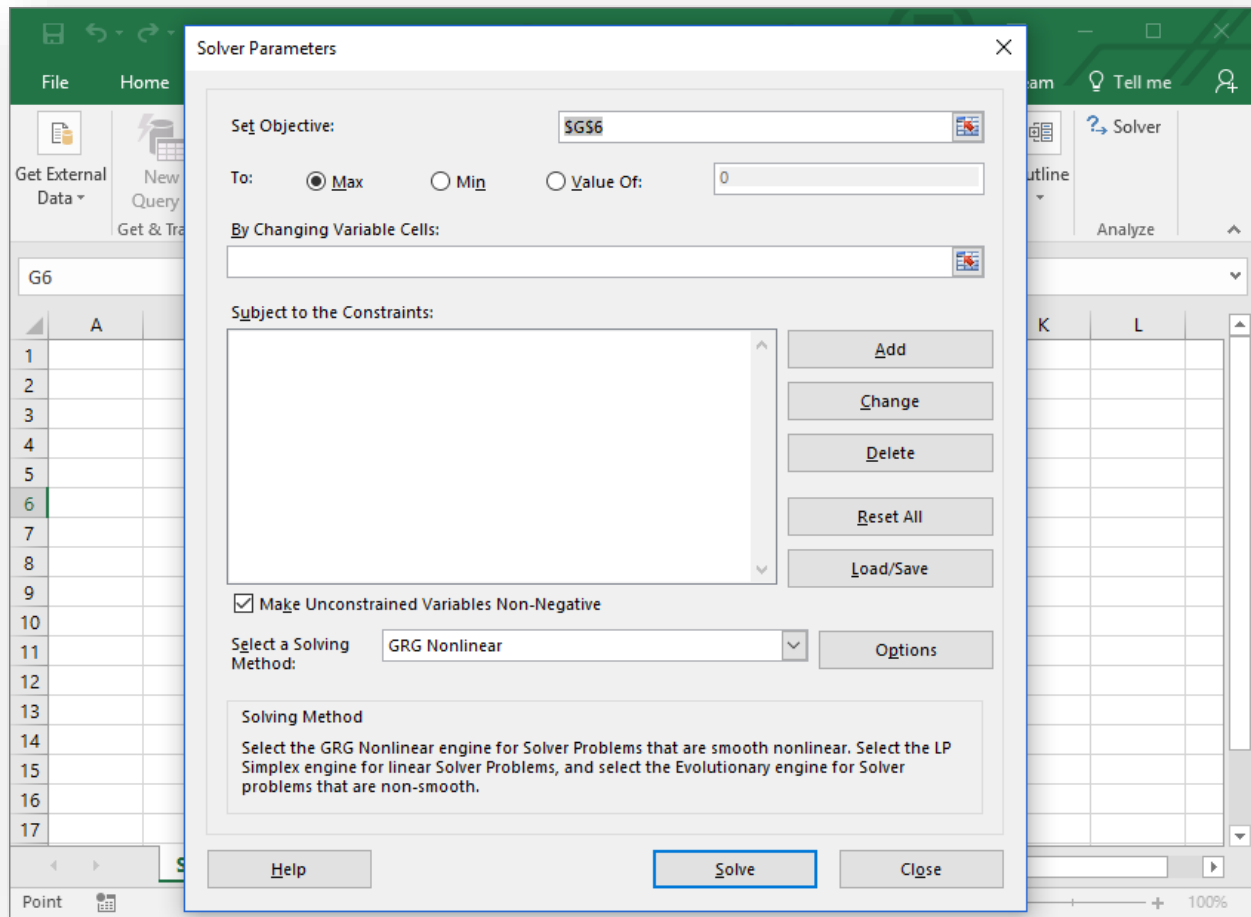
Enlightened managers are always asking “How can we do better?” But Excel was never designed to answer the “How?” question, even less the “Why?” question that inevitably follows it. Still, some companies try anyway.

As highlighted in a previous blog [Microsoft Office Excel Scenario Manager and Prescriptive Analytics](#), Excel *can* be used for rather rudimentary scenario analysis, with some significant drawbacks.

Another less known but important feature is Excel’s ability to solve [prescriptive analytics](#) problems based on **optimization** techniques — e.g., linear programming. Prescriptive analytics problems apply mathematics and algorithms to data and suggests a preferred course of action. Typical goals often include maximizing profits or minimizing inventory stock levels. This free Excel add-in tool — created and owned by Frontline Systems — is called **Solver**. This document will focus on the features, benefits and limitations of Excel Solver.

Solver can be useful for anyone wanting to solve a prescriptive analytics problem and use Excel as their primary data store. Most people use Solver because they learned it in their MBA class; the data already exists in Excel; their company has a limited budget, or any number of other reasons.

The free version is included in Excel, is extremely easy to activate, and requires no special licensing from either Microsoft or Frontline. If necessary, it can also be downloaded from the Microsoft Office store. Other advanced Excel-based products, all branded under the Analytic Solver name, can be purchased directly from the vendor. Prices range from €250 to €5000 plus maintenance. Training material includes good content on Frontline’s website and Excel’s Help section, plus assorted YouTube videos and miscellaneous content on the Internet.

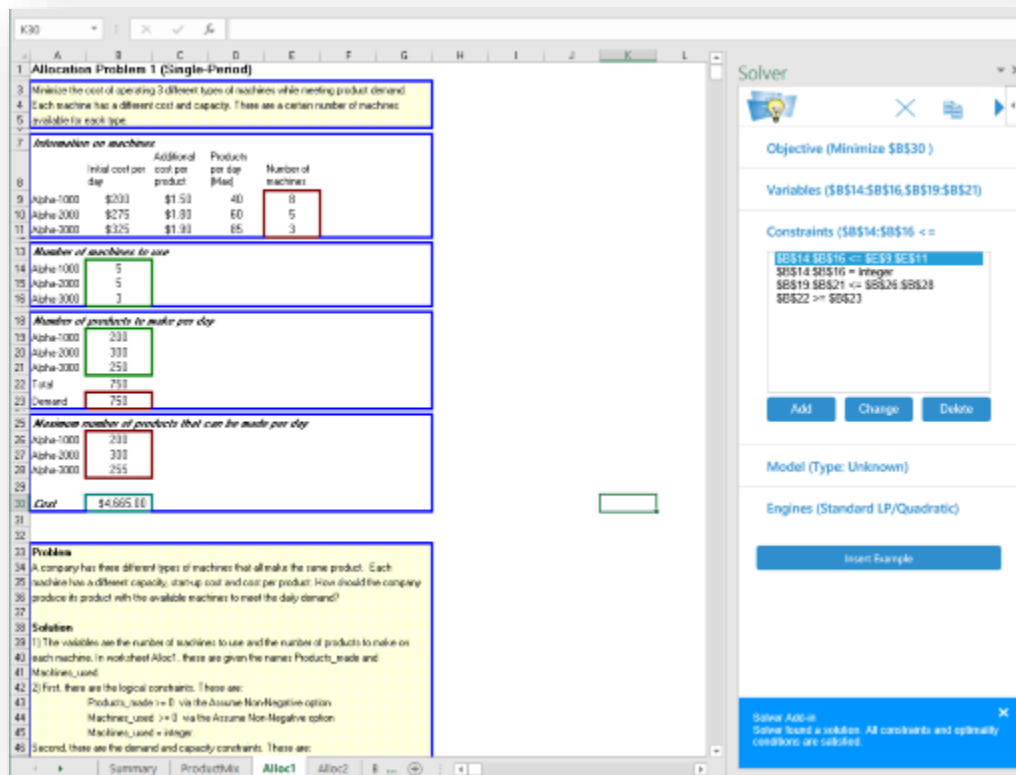


## What is a Solver model?

A significant benefit is that the Solver add-in only requires learning to use the Solver Parameters dialog. Before starting, you will need a basic understanding of the optimization solving method that you intend to use. Solver supports three methods: GRG Nonlinear (smooth nonlinear), Simplex LP (linear) and Evolutionary (non-smooth). If in doubt, you will most likely want Simplex LP.

With good working knowledge of Excel, accurately defining a Solver-based model is a relatively simple process: data must be arranged so the Solver can accurately interpret the objective function choice (e.g., — minimize or maximize) and constraints. Once complete, you click the Solve button.

Below is a screenshot from the Microsoft store which shows a simple allocation problem. Each highlighted rectangle includes objective function coefficients and constraints. The entire model definition is contained in the Solver window on the right side. (Note, this version appears to be outdated.)



**Allocation Problem 1 (Single-Period)**

Minimize the cost of operating 3 different types of machines while meeting product demand. Each machine has a different cost and capacity. There are a certain number of machines available for each type.

	Initial cost per day	Additional cost per product	Products per day (fixed)	Number of machines
Alpha-1000	\$200	\$1.50	40	8
Alpha-2000	\$275	\$1.30	60	5
Alpha-3000	\$325	\$1.30	85	3

**Number of machines to use**

Alpha-1000	5
Alpha-2000	5
Alpha-3000	3

**Number of products to make per day**

Alpha-1000	233
Alpha-2000	333
Alpha-3000	253
Total	753
Demand	753

**Maximum number of products that can be made per day**

Alpha-1000	233
Alpha-2000	333
Alpha-3000	253

**Cost** \$4,695.00

**Problem**  
A company has three different types of machines that all make the same product. Each machine has a different capacity, startup cost and cost per product. How should the company produce its product with the available machines to meet the daily demand?

**Solution:**  
(1) The variables are the number of machines to use and the number of products to make on each machine. In worksheet 'Alloc1', these are given the names Products\_made and Machines\_used.  
(2) First, there are the logical constraints. These are:  
Products\_made >= 0 via the Assume Non-Negative option  
Machines\_used >= 0 via the Assume Non-Negative option  
Machines\_used = integer  
(3) Second, there are the demand and capacity constraints. These are:

Source: store.office.com

There is value in using Solver. The time to setup, cost (anywhere from free to €5000, plus maintenance), relative ease of learning and tight integration inside Excel makes it attractive, especially to students with little modeling experience or companies on a tight budget.

But, like the old cliché, you get what you pay for. Although the Solver add-in is an understandable choice, its limitations can be a *significant* drawback. If you're considering it, I urge you to read carefully the following list.

## Limitations and Drawbacks of Excel Solver

### 1. Does Not Scale for Business-sized Problems

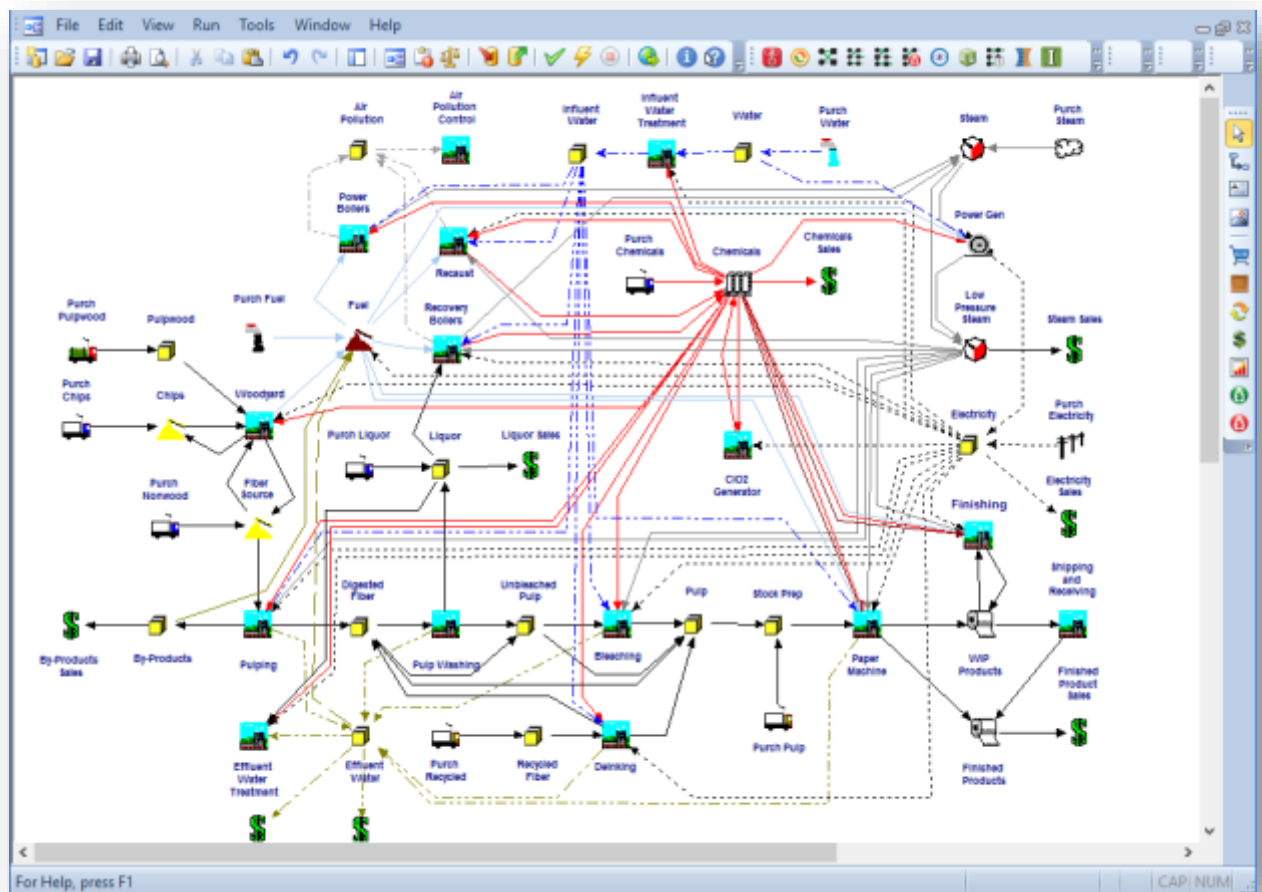
What if your business problem to be modeled requires a 12-month period planning horizon; many factories, DCs, and retail outlets; thousands of products, etc.? What if you expect this will result in a model with millions of decision variables and constraints?

Can Solver scale from textbook-sized simple to a very large and complex business problem?

*No, the free Solver version solves only very small problems — 200 decision variables by approximately 200 constraints.* The example above is a small, textbook-sized problem because it fits within the add-in's

restrictions. Very large models are also not possible in Frontline's advanced Analytic Solver versions, which are limited to 8,000 variables by approximately 8,000 constraints.

I've created more than one hundred industrial-size models in my career. I cannot recall any customer ever making business decisions using a model that small. Even my very first model, built in 1991 for a forest products company in Idaho, had over 50k variables and constraints. Real problems tend to look more like the pulp and paper model shown below, which I built many years ago using my company's modeling platform. It uses a visual modeling approach to describe large, complex business functions and processes. Depending on the data configuration, it can easily solve *4-5 million variables or more at one time*.



To be fair, Frontline never designed their Excel add-in products to solve for these kinds of industrial-sized business problems. Instead, very large problems can be solved in Excel using their Premium Solver Platform product.

However, using this product means the problem itself can no longer be explicitly defined inside worksheet cells (as displayed in the screenshot above.) Someone with highly specialized Operations Research (OR) skills must write VBA code to generate the matrix; then call an advanced solver like Gurobi and Express; and then be able to debug formulation issues and infeasibilities using the limited output provided. (I will cover the positives and negatives of this approach in a future blog.)

## 2. Has Difficulty Modeling Key Constraints

A few years back, I was doing work for a Canadian customer, a manufacturer of aluminum auto parts blended from many different sources like scrap metal (e.g., home gutters). A key project was to replace their old Excel-based model with my company's technology. During a management meeting, it was revealed that for several years they desperately needed to add a critical blending constraint to their model – the ratio of manganese (Mn) to magnesium (Mg) must be within certain limits. The customer's original model author had departed and those tasked with maintaining the model were never able to add this key constraint.

In the middle of the meeting, in front of the plant's management, I added this ratio constraint to the prototype model I was building. It took me about one minute and the next solution found was properly constrained.

To be honest, sometimes those kind of ad-hoc trials backfire, but having technology that can enable this counts for a lot. Depending on a product designed for one primary purpose — to store, calculate and analyze data — for another purpose — solving Prescriptive Analytics models — won't always work out as intended. In this case, the inability to apply a key constraint in the Excel model was quite serious, since it meant the solution might be out of tolerance, which was unacceptable to their customers.

## 3. Creates a "Black Box" Syndrome

Managers beware: if a Solver-based optimization model becomes an integral part of your company's critical decision making process, ensure that multiple people have a complete working knowledge, including adding constraints, debugging problems, etc.

I have been in customer situations where Excel-based models have been discarded and replaced only because there was no one to support it. Management had succeeded in integrating the model into their planning process — which was great — but that dependency also created a crisis that in hindsight should have been avoided.

*The only surefire way to remove the risk of a "black box" no one understands? Adopt a technology that creates a visual map to represent the company's reality.* If the company makes semiconductors, then the model diagram should visually display that process — something that is hard to do in an Excel model.

#### 4. There are No Out-of-the-box Financials

Smart and motivated Excel jockeys, especially those with MBAs and knowledge of finance and accounting, can likely create a simplified (and hard-coded) P&L based on the solution found with Solver. Sometimes, that's all that is needed.

However, most managers want more information than just a simple P&L. Other financial statements, like balance sheets and cash flow statements, along with activity-based summary and detailed unit costs, are very difficult to produce within the confines of a Solver-based Excel model.

If basing decisions on complete financial information is important, consider a modeling technology that includes a default chart of account with built-in financials in every model. It should allow for a customized chart of accounts (to match the company's accounts) and support data inputs for allocations, currency exchange rates, transfer prices and other important financial inputs. The software should also be able to optimize on Net Present Value and apply financial ratio constraints.

#### 5. Excel Solver is NOT a Collaborative Platform

*Companies adopting modeling technology that is not web-based and collaborative will soon find it limiting and outdated.* Microsoft Excel is a desktop Windows program with the ability to run in the cloud. Frontline even advertises they have now surpassed 200,000 cloud analytic users. This is an impressive number, but solving a model in Excel in the cloud is not much different than on a desktop PC. While more people can easily access the model, either as a modeler, contributor or reader, *it does not make it truly collaborative.* Newer technologies are designed to allow these different user roles to manage and analyze scenarios while incorporating important features like single sign-on, workflow, approvals, etc.

### Summary

Can the Solver add-in be used to solve real business-sized problems? Given the significant size limitations for the free and paid Analytic Solver versions, only if the problem is small, or the task is simply to learn how to model textbook-like problems, does using these products makes sense. The Premium Solver Platform can solve for problems of unlimited size, but this requires OR experts to create and maintain.

But anyone considering Solver for typical business-sized problems should consider it carefully. At some point, a showstopper will appear. It might be the need to expand the model from a one period to 12 months, 52 weeks, or 365 days. It might be the need to add in a key constraint, like batch processing with changeovers, a constraint set or sole sourcing. It might be due to key personnel leaving the company and taking their domain knowledge with them. *Or, Excel itself might just not fit anymore into the need for a more inclusive and collaborative planning process.*