Re: Calculation of peak reduction from an efficiency measure
Submitted to: TWG on IRP
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We were asked to provide clarification on the following equation from the slide deck presented on July 19, 2022:

$$PeakSavings_{ES} = (BaseConsump - UpConsump)\,x\;PeakFactor \qquad (1)$$

Where:

$PeakSavings_{EC}$ is the peak savings for the energy savings measure for this fuel, region, segment, existence category, and end use.
$BaseConsump$ is the base energy consumption for the energy consumption measure for this fuel, region, segment, existence category, and end use.
$UpConsump$ is the upgrade energy consumption for the energy consumption measure for this fuel, region, segment, existence category and end use, as specified in the Measure input file.
$PeakFactor$ is the ratio of peak reduction to annual savings appropriate to this measure. In many cases it will be the hours-use peak factor for the end use affected, but **some measures have savings with a different load shape than the underlying end use and therefore have their own factor**. (emphasis added)

During the meeting, it was suggested by Jay Sheppard the following equation should be used instead:

$$PeakSavings_{ES} = BaseConsump * PeakFactor_{Base} - UpConsump * PeakFactor_{Up} \qquad (2)$$

Where:

$PeakSavings_{ES}$ is the peak savings for the energy savings measure
$BaseConsump$ is the base energy consumption
$UpConsump$ is the upgrade energy consumption
$PeakFactor_{Base}$ is the baseline hours-use peak factor, or the ratio of peak hour use to base energy consumption
$PeakFactor_{Up}$ is the hours-use peak factor after measures have been applied, or the ratio of upgrade peak hour use to upgrade energy consumption

1.1 Worked Example

A worked example may be the most helpful approach to answering this question. We will provide the algebra at the end, to show that this approach can be generalized.

Consider the following situation:

- We have an extremely simple Navigator model with only one house that uses natural gas for space heating. In the reference case, it uses 1000 m^3/year ($BaseConsump$), of which 1 m^3 occurs during the peak hour. The $PeakFactor_{Base}$ for space heating for this house is therefore 0.001 ($PeakFactor_{Base}$ = base peak hour use/BaseConsump = 1/1000 = 0.001).

- We apply an energy efficiency measure to this house that will reduce the annual consumption to 900 m³/year (UpConsump). Some of this reduction occurs on peak, reducing space heating consumption during the peak hour to 0.8 m³. The *PeakFactor*$_{Up}$ for space heating for this house is therefore 0.0008888 (*PeakFactor*$_{Up}$ = upgrade peak hour use/UpConsump = 0.8/900 = 0.0008888).
- The *PeakFactor* is therefore 0.002 (*PeakFactor* = peak savings/annual savings = 0.2/100 = 0.002)
- The peak savings is 0.2 m³, so whatever approach we use should produce this answer.

There are two ways to perform this calculation, using equations 1 and 2, defined above.

Using equation 2 and the values defined in the example above:

$$PeakSavings_{ES} = BaseConsump * PeakFactor_{Base} - UpConsump * PeakFactor_{Up}$$

$$PeakSavings_{ES} = 1000 * 0.001 - 900 * 0.0008888 = 1 - 0.8 = 0.2 \ m^3$$

This method works.

Using equation 1 and the values defined in the example above:

$$PeakSavings_{ES} = (BaseConsump - UpConsump)x \ PeakFactor$$

$$PeakSavings_{ES} = (1000 - 900) * 0.002 = 100 * 0.002 = 0.2 \ m^3$$

This method also works. In this case, the hypothetical measure has savings that are peakier than the underlying end use. It reduces the peak by 20% even though it reduces annual consumption by only 10%.

1.2 Why Use the First Method?

The two methods both work fine in this simple case, but we have several reasons for choosing the first one.

- PG often relies on the expertise of Joe Lopes of DNV for advice on peak load analysis. We presented these two alternative approaches to Mr. Lopes when we were writing the peak load module for Navigator. He indicated that either method would work, but it was often easier to find sources for the load shape of a measure's savings than for the load shape of the end use after the measure is applied.

- The above example involves just a single measure, but Navigator is often applying several measures to the same end use. Some of them may change the underlying load shape and some may not. It would be very difficult to find PeakFactor$_{Up}$ for the load shape after a basket of measures had been applied. It is much easier to subtract the peak savings for each measure, based on the load shape of each measure's savings.

- In the Navigator model measures are typically applied across many types of houses (or commercial buildings or industrial plants), in a variety of climate zones. Depending on applicability and economics that vary by house type and region, some measures will pass for some houses and not for others. That means a different PeakFactor$_{Up}$ would be needed

for potentially thousands of different cases. The PeakFactor of each measure's savings, on the other hand, tends to be consistent from one house type and region to another. This is another reason it is easier to use equation 1.

The Navigator model reports on the peak value after subtracting the peak savings of all the measures that are applied. The user can divide the post-DSM peak consumption by the post-DSM annual consumption to find the value of post-DSM PeakFactor$_{Up}$. In fact, it is straightforward to produce a table of how the peak factor changes with time in different regions and building types, both before and after the application of DSM.

1.3 Algebra

We will show the general case, to demonstrate the math works.

Consider the following equations:

$$SvgsConsump = BaseConsump - UpConsump \tag{3}$$

$$SvgsPeak = BasePeak - UpPeak \tag{4}$$

$$BasePeak = BaseConsump * BaseFactor \tag{5}$$

$$UpPeak = UpConsump * UpFactor \tag{6}$$

$$SvgsPeak = SvgsConsump * SvgsFactor \tag{7}$$

Where:

BaseConsump is the base energy consumption
UpConsump is the upgrade energy consumption
SvgsConsump is the annual consumption savings
BasePeak is the peak consumption before the measure
UpPeak is the peak consumption after the measure
SvgsPeak is the peak savings
BaseFactor is the peak factor for the pre-measure situation
UpFactor is the peak factor for the post-measure situation
SvgsFactor is the peak factor for the measure savings

Equations 4 and 7 are both ways of calculating the peak savings. If we substitute equations 5 and 6 into equation 4, we get:

$$SvsgPeak = BaseConsump * BaseFactor - UpConsump * UpFactor$$

This equation is equivalent to equation 2, which is Jay Sheppard's suggested method.

If we substitute equation 3 into equation 7, we get:

$$SvgsPeak = (BaseConsump - UpConsump) * SvgsFactor$$

This equation is equivalent to equation 1 and is the method used in the Navigator model.