



Environmental Energy Technologies Division Lawrence Berkeley National Laboratory

EnergyPlus and fenestration routines

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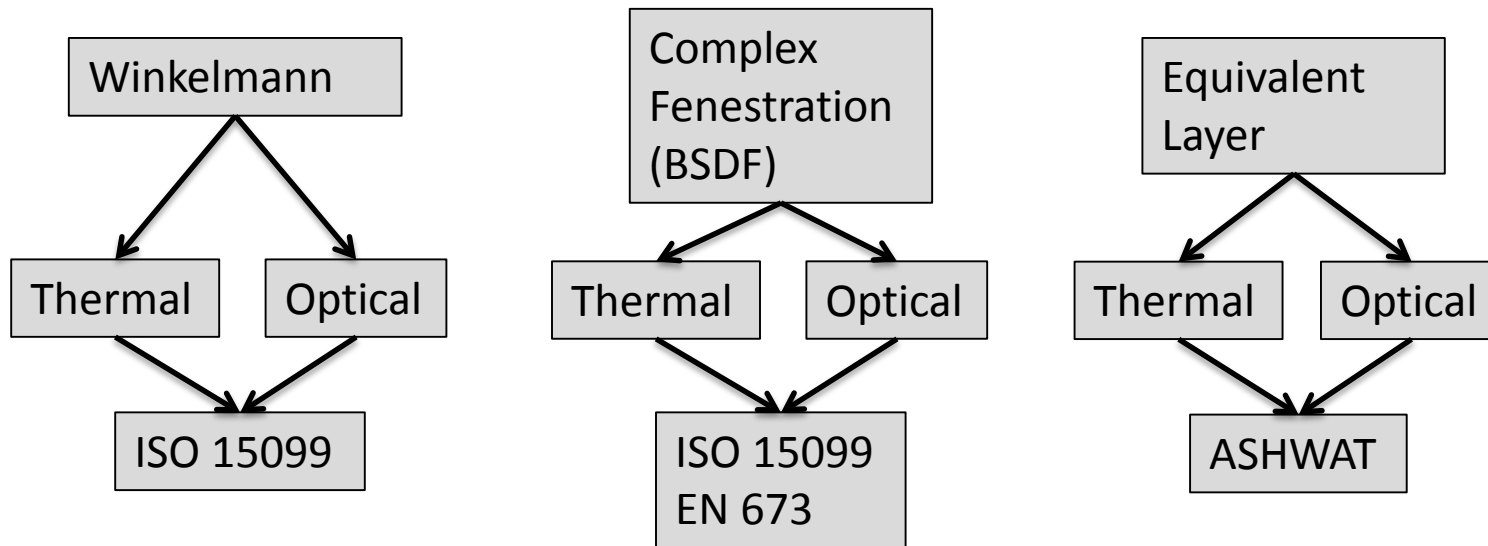
Three different models in E+:

- Winkelmann (ISO 15099)
 - Layer by layer calculations (most commonly used)
 - Conversion to single equivalent layer (does not work for shading devices)
- Complex fenestration BSDF (ISO 15099 and EN673 standards with BSDF solar/optical distribution)
- Equivalent layer (ASHWAT)

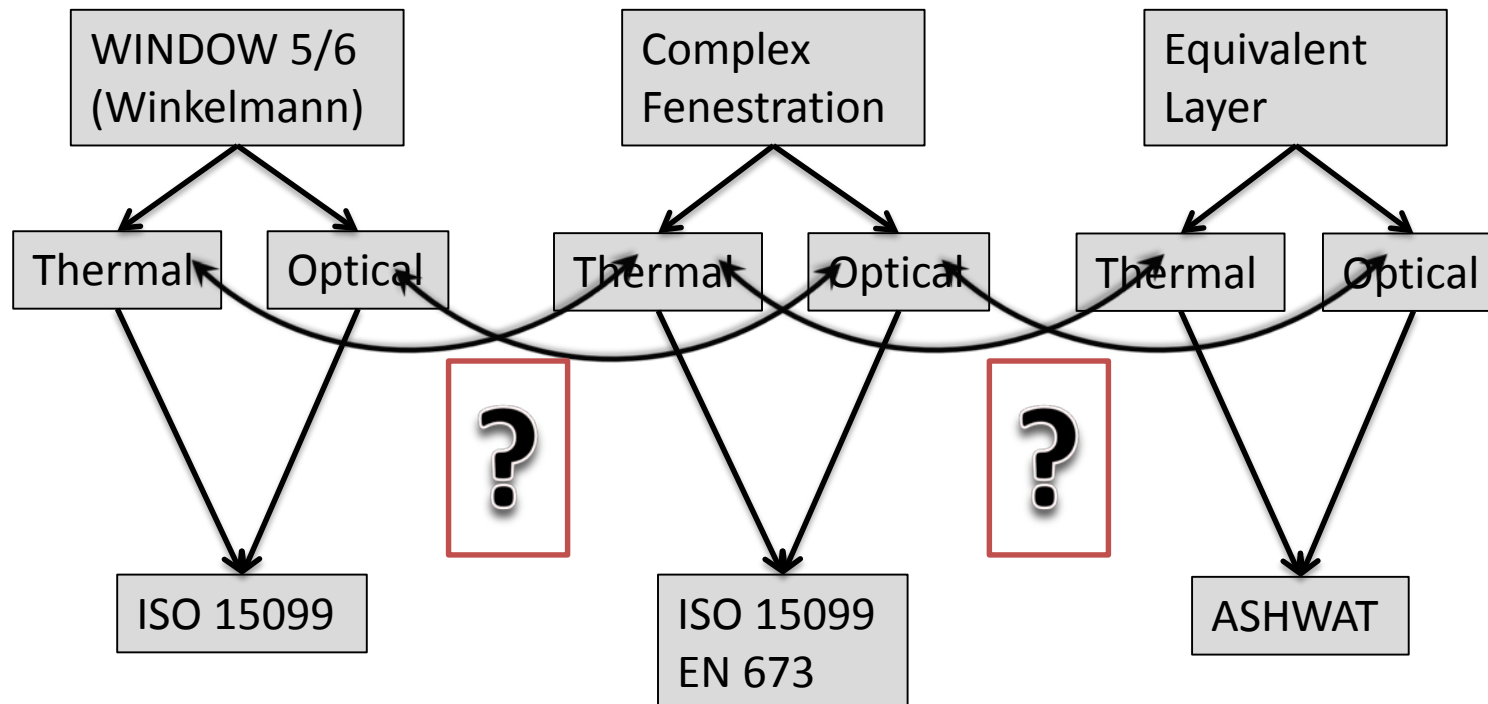
Fenestration routines are divided into two parts:

- Thermal
- Solar/Optical

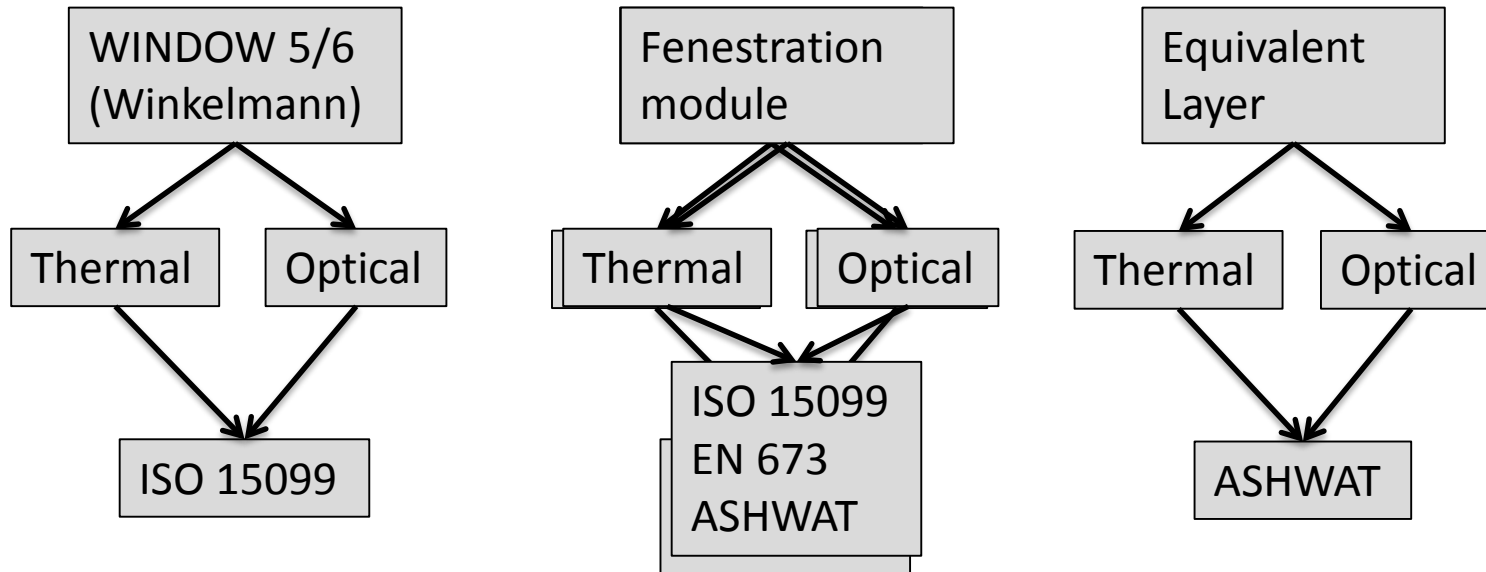
Current State - Diagram



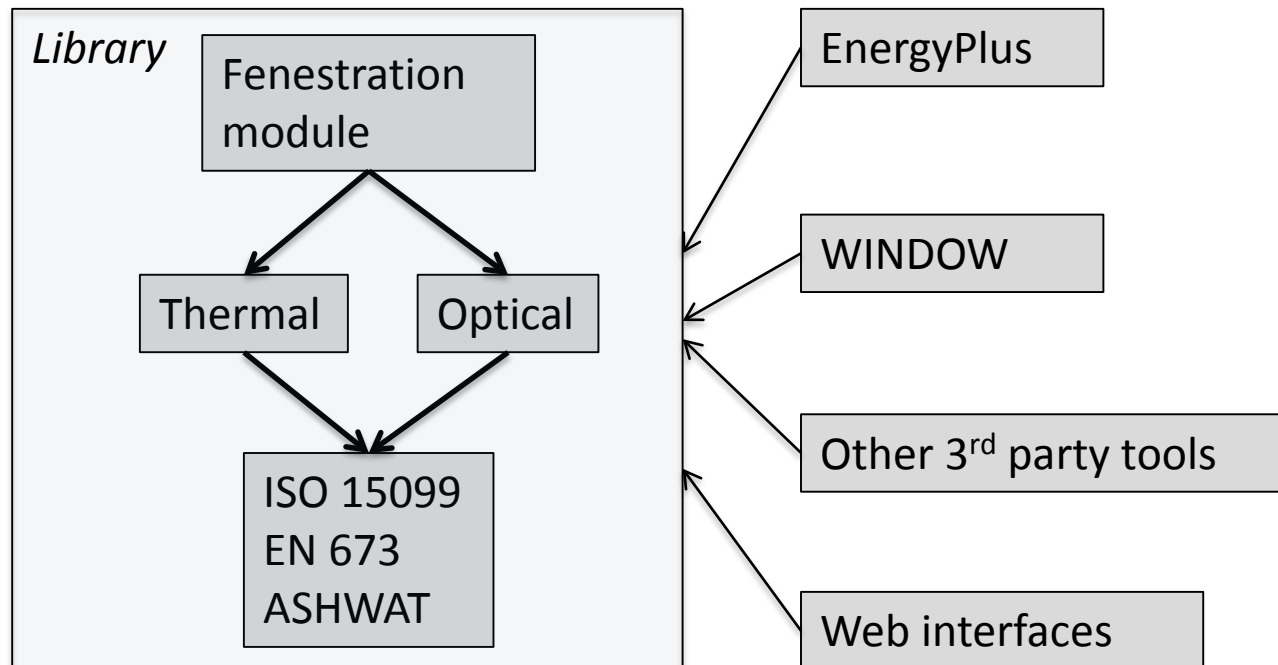
- Some of the routines that use same standard are NOT shared between models.
 - Bug fixes in multiple places with inconsistent implementation
 - New feature implementation across different routines – extra effort
 - Discrepancy between established fenestration software tools and E+
- Harder to perform tests.



- Implementation of single set of modules, shared between WINDOW and E+
- Single set of modules for fenestration components in EnergyPlus, with option to select different calculation algorithm through input data. Same set of modules will also be available in WINDOW.
- Benefits:
 - Easier to maintain and develop new features across different modules (fixing bugs, new features, unit tests)
 - Introduction of unit tests for certain routines, which improves accuracy and consistency
 - Single, consistent set of fenestration routines in EnergyPlus
 - Validation of fenestration algorithms are more extensively performed in WINDOW world
 - Additional unit tests are being added to the test suite



- Separate modules into the library
- Fenestration module will share variables (constants) in EnergyPlus
- Fenestration module will share interface between EnergyPlus and WINDOW
- Develop documented API that can be used by other programs and web interfaces



- More importantly, bug fixes and new features developed as part of WINDOW or OPTICS will become part of EnergyPlus world
- Some of the features are already part of EnergyPlus code (available only for complex fenestration):
 - Deflection
 - Vacuum glazing
 - Support pillars
 - EN 673 standard
- Some features that are part of WINDOW (and OPTICS) are still not in EnergyPlus:
 - Creation of optical properties in BSDF format.
 - Venetian blind
 - Woven shade
 - Perforated screens

- Some of the code in WINDOW and OPTICS is written in FORTRAN and Visual Basic. New code is converted to C++
- Introduction of object oriented modeling (classes, records, enumerators).
- Use of libraries for common mathematical operations (mainly matrix operations). Implementation of efficient solver for system of non-linear equations
- Use of Objexx library is being removed from fenestration modules. Pure C++ code is implemented without translation
- Usage of common modules. Some modules will be shared between EnergyPlus and fenestration library (good example is “DataGlobals” module from EnergyPlus)

- Explore usage of Modelica and FMI in EnergyPlus, WINDOW and OPTICS.
- Fixes of some of the other issues related to fenestration calculations in EnergyPlus:
 - Inconsistent frame heat transfer calculations (inability to model highly conductive frames and inaccuracy in translating WINDOW frame performance data in EnergyPlus)
 - Use of conductance area weighting as opposed to U-factor area weighting
 - Scheduling of automated shading operations
 - Inconsistent modeling of dynamic glazing (EC, TC, etc.)
- OpenStudio implications?