## CHAPTER 4. SCREENING ANALYSIS

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# CHAPTER 4. SCREENING ANALYSIS

## 4.1 INTRODUCTION

This chapter discusses the U.S. Department of Energy's (DOE) screening analysis of the technology options identified for general service fluorescent lamps (GSFL) and incandescent reflector lamps (IRL). As discussed in Chapter 3, Market and Technology Assessment, DOE consults with industry, technical experts, and other interested parties in developing a list of technology options for consideration. The purpose of the screening analysis is to evaluate the list of options to determine which to consider further and which to screen out.

Section 325(o)(2) of EPCA provides that any new or revised standard must be designed to achieve the maximum improvement in energy efficiency that is determined to be technologically feasible and economically justified. (42 U.S.C. 6295(o)(2)) In view of the EPCA requirements for determining whether a standard is technologically feasible and economically justified, Appendix A to Subpart C of Title 10, Code of Federal Regulations, Part 430 (10 CFR Part 430), "Procedures, Interpretations, and Policies for Consideration of New or Revised Energy Conservation Standards for Consumer Products" (the Process Rule) sets forth procedures to guide DOE in its consideration and promulgation of new or revised efficiency standards. These procedures elaborate on the statutory criteria provided in 42 U.S.C. 6295(o) and, in part, eliminate problematic technologies early in the process of prescribing or amending an energy efficiency standard. In particular, sections 4(b)(4) and 5(b) of the Process Rule provide guidance to DOE for determining which design options are unsuitable for further consideration:

1. **Technological feasibility.** DOE will consider technologies incorporated in commercial products or in working prototypes to be technologically feasible.

2. **Practicability to manufacture, install, and service.** If mass production and reliable installation and servicing of a technology in commercial products could be achieved on the scale necessary to serve the relevant market at the time the standard comes into effect, then DOE will consider that technology practicable to manufacture, install, and service.

3. **Adverse impacts on product utility or product availability.** If DOE determines a technology would have significant adverse impact on the utility of the product to significant subgroups of consumers, or would result in the unavailability of any covered product type with performance characteristics (including reliability), features, sizes, capacities, and volumes that are substantially the same as products generally available in the United States at the time, it will not consider this technology further.

4. **Adverse impacts on health or safety.** If DOE determines that a technology will have significant adverse impacts on health or safety, it will not consider this technology further.

Section 4.2 discusses the technology options DOE screened out from further consideration. Section 4.3 summarizes those options. Section 4.4 lists the remaining design options DOE considered in its analyses.

## 4.2 SCREENED-OUT TECHNOLGIES

This section addresses the technologies that DOE screened out, having considered the following four factors: (1) technological feasibility; (2) practicability to manufacture, install, and service; (3) adverse impacts on product utility to consumers; and (4) adverse impacts on health or safety.

### 4.2.1 General Service Fluorescent Lamp Screened-Out Technologies

DOE has screened out the following technologies in its analyses of GSFL. Although these technologies were not considered in the subsequent analyses, DOE does not discourage their use by manufacturers. These technologies may be capable of reducing energy consumption or providing additional benefits to consumers, even though they do not currently meet the requirements for DOE's consideration.

#### 4.2.1.1 Multi-Photon Phosphors

Theoretically, the use of multi-photon phosphors, or quantum-splitting phosphors, could significantly improve lamp efficacy. By emitting more than one visible photon for each ultraviolet photon, a lamp would be able to emit more light for the same amount of power. However, development of this technology remains in the research phase and DOE is unaware of any prototypes or commercialized products that incorporate multi-photon phosphors.[1] Thus, DOE screened out this technology option based on the first criterion, technological feasibility. Additionally, because this technology is still in the research phase, DOE believes that it would not be practicable, or even possible, to manufacture, install, and service this technology on the scale necessary to serve the relevant market at the time of the effective date of an amended standard. It is not possible to assess whether the technology will have adverse impacts on utility to consumers, availability, or consumer health or safety. Therefore, DOE will not consider multi-photon phosphors as a design option for improving the efficacy of GSFL.

### 4.2.2 Incandescent Reflector Lamp Screened-Out Technologies

DOE screened out the following technologies for IRL. Although DOE did not consider the following technologies, DOE does not discourage their use since they may reduce energy consumption or provide other benefits to consumers.

#### 4.2.2.1 Microcavity Filaments

By fabricating microcavities on the incandescent lamp filament, it is theoretically possible to increase a lamp's emissivity, and therefore its efficacy. The market and technology assessment (Chapter 3) notes that Sandia National Laboratories researchers examined microcavity resonance in a tungsten photonic lattice and found multiple patents referencing this technology. Since research prototypes of microcavity filaments do exist, DOE determined that this technology option is technologically feasible. However, research indicates that materials patterned at the submicron level may experience problems with stability.[2] Because such instability could negatively affect lamp lifetime, DOE believes the technology is not yet practical to implement on a wide scale. For this reason, DOE screened out this technology option based on the third criterion, impacts on product utility to consumers. DOE is also unaware of any commercialized lamps that incorporate microcavity filaments, and is concerned that mass-manufacturing techniques for this technology would be problematic. For this reason, DOE does not believe that this technology would be practicable to manufacture, install, and service. Therefore, DOE will not consider filaments with microcavities as a design option for improving the efficacy of IRL. DOE does not have enough information to assess whether implementation of this technology will have adverse impacts on consumer health or safety.

#### 4.2.2.2 Novel Filament Materials

Novel filament materials such as nitrides and carbides have the potential to improve lamp efficacy by emitting more light in the visible spectrum at a given temperature than traditional tungsten filaments. Because several patents on such filaments exist, DOE believes that this technology option is technologically feasible. However, DOE is unaware of any lamps available today that use such filaments. Furthermore, DOE understands that technological barriers, such as prohibitive brittleness of the filament, limit implementation of this technology. Finding a practical way to incorporate novel filament materials into incandescent reflector lamps would require further research, as would making such lamps practical for general service applications. DOE believes that it would not be practicable to manufacture this technology on the scale necessary to serve the relevant market at the time of the effective date of an amended standard. Therefore, DOE will not consider novel filament materials as a design option for improving the efficacy of IRL. DOE is unaware of any research on the potential impact of this technology on consumer health or safety.

#### 4.2.2.3 Crystallite Filament Coatings

DOE screened out crystallite filament coatings, which are oxide-covered micron or sub-micron crystallites comprised of thorium, tantalum, or niobium. These coatings can be used to increase the light emissivity of a lamp's filament. Because several patents on such filament coatings exist, DOE believes that this technology option is technologically feasible. However, DOE was unable to locate any data on the incorporation of crystallite filament coatings into prototype or commercially available products. Using crystallite filament coatings may require additional manufacturing techniques, such as chemical vapor deposition. DOE understands that these techniques are not in use in the mass-production of incandescent reflector lamps. DOE believes that it would not be practicable to manufacture this technology on the scale necessary to serve the relevant market of IRL at the time of the effective date of an amended standard. DOE screened out this option based on the second criterion. It is also not possible to assess whether this technology will have adverse impacts on utility to consumers, availability, or consumer health or safety. Therefore, DOE will not consider crystallite filament coatings as a design option for improving the efficacy of IRL.

#### 4.2.2.4 Luminescent Gas

Luminescent gases encompass gaseous fills for incandescent lamps that react with certain wavelengths of the filament emission and generate visible light. DOE is unaware of any existing commercially available products or prototypes of incandescent lamps incorporating luminescent gases. DOE screened out luminescent gases based on technological feasibility. To the best of DOE's knowledge, luminescent gas fills also have not been incorporated into residential, commercial, or industrial products, so DOE cannot assess the practicability to manufacture, install, and service this technology on the scale necessary to serve the relevant market at the time of the effective date of an amended standard. It is not possible to assess whether this technology will have adverse impacts on utility to consumers, availability, or consumer health or safety. Therefore, DOE will not consider luminescent gas fills as a design option for improving the efficacy of IRL.

#### 4.2.2.5 Non-Tungsten-Halogen Regenerative Cycles

The regenerative cycle of filament evaporation and redeposition can be used to greatly increase the life of an incandescent lamp and improve lumen maintenance. The filament can burn at a higher temperature than conventional incandescent lamps while maintaining a useful service life. The market and technology assessment (Chapter 3) discusses the use of a regenerative cycle for tungsten-halogen lamps. DOE understands that other regenerative cycles also may be possible for other filament materials and are considered technologically feasible. However, as noted above, DOE has screened out the use of novel filament materials on the basis of the second and third screening criteria. Because use of the non-tungsten-halogen regenerative cycles would depend on incorporating a non-tungsten filament, DOE is screening out such cycles from consideration based on the same two criteria. DOE believes that it would not be practicable, and maybe not even possible, to manufacture novel filament materials lamps with associated regenerative cycles on the scale necessary to serve the relevant market at the time of the effective date of an amended standard. Also, the use of other filament materials, and therefore their associated regenerative cycles, may have an adverse impact on utility. In addition, because this technology has not been incorporated into commercially available products, DOE is unable to assess whether it will have adverse impacts on consumer health or safety. Therefore, DOE will not consider non-tungsten-halogen regenerative cycles as a design option for improving the efficacy of IRL.

#### 4.2.2.6 Infrared Phosphor Glass Coating

When used as a coating on the bulb surface, infrared phosphors harvest the emitted infrared energy and convert it to visible light, potentially increasing lamp efficacy. Because patents on such infrared phosphor coatings exist, DOE believes that this technology option is technologically feasible. However, DOE was unable to locate any data on the incorporation of infrared phosphor coatings into commercially available products. Because using infrared phosphor coatings in incandescent reflector lamps may require retooling of the manufacturing process, DOE believes that it would not be practicable to manufacture this technology on the scale necessary to serve the relevant market at the time of the effective date of an amended standard. Therefore, DOE screened out this option based on the second criterion. It is also impossible to assess whether the technology will have adverse impacts on utility to consumers, availability, or consumer health or safety. Therefore, DOE will not consider infrared phosphor coatings as a design option for improving the efficacy of IRL.

#### 4.2.2.7 Integrally Ballasted Low Voltage Lamps

Incandescent filaments that are designed to operate at a lower voltage are both shorter in length and thicker in cross-sectional area than incandescent filaments designed to operate at a line voltage from 115 to 130V. Increasing the thickness of the filament can improve its efficacy by allowing the lamp to operate at higher temperatures. Therefore, using an integral ballast allows the efficacy of a lamp to increase by operating its filament at a lower voltage (e.g., 12 volts) than standard U.S. household line voltage (i.e., 120 volts). Although this technology is commercially available in Europe[1] and elsewhere in the world where the standard household line voltage is 220-240 volts, DOE is unaware of any commercially available products or prototypes of this technology option that operate on U.S. household line voltage of 120 volts. Accordingly, DOE is screening out integrally ballasted low voltage lamps based on the first criterion, technological feasibility. Therefore, DOE will not consider integrally ballasted low voltage lamps as a design option for improving the efficacy of IRL.

#### 4.2.2.8 Trihedral Corner Reflectors

Trihedral corner reflectors incorporated into the cover glass of IRL have the potential to increase lamp efficacy by redirecting infrared radiation back onto the filament. Because patents on trihedral corner reflectors exist, DOE believes that this technology option is technologically feasible. However, DOE was unable to locate any data on the incorporation of this technology into commercially available products. Using trihedral corner reflectors, which entail an additional disc requiring external fabrication and installation in the lamp, may necessitate manufacturing techniques not currently available for mass production. For this reason, DOE believes that it would not be

[1] Philips Electronics Press Release (2007). Available at http://www.lighting.philips.com/gl_en/news/press/product_innovations/archive_2007/press_new_masterclassic_lamp.php.

practicable to implement the new manufacturing technique for this technology on the scale necessary to serve the relevant market of IRL at the time of the effective date of an amended standard. Therefore, DOE screened out this option based on the second criterion. It is not possible to assess whether the technology will have adverse impacts on utility to consumers, availability, or consumer health or safety. Therefore, DOE will not consider trihedral corner reflectors as a design option for improving the efficacy of IRL.

## 4.3 SUMMARY OF TECHNOLOGY OPTIONS SCREENED OUT

The following tables summarize the technology options DOE screened out from further consideration and note the screening criteria.

**Table 4.3.1 GSFL Technology Options Screened Out of the Analysis**

| Design Option Excluded | Screening Criteria |
|---|---|
| Multi-Photon Phosphors | Technological feasibility<br>Practicability to manufacture, install, and service |

**Table 4.3.2 IRL Technology Options Screened Out of the Analysis**

| Design Option Excluded | Screening Criteria |
|---|---|
| Microcavity Filaments | Product utility to consumers<br>Practicability to manufacture, install, and service |
| Novel Filament Materials | Practicability to manufacture, install, and service; product utility to consumers |
| Crystallite Filament Coatings | Practicability to manufacture, install, and service |
| Luminescent Gas | Technological feasibility |
| Non-Tungsten-Halogen Regenerative Cycles | Practicability to manufacture, install, and service<br>Product utility to consumers |
| Infrared Phosphor Glass Coating | Practicability to manufacture, install, and service |
| Integrally Ballasted Low Voltage Halogen | Technological feasibility |
| Trihedral Corner Reflectors | Practicability to manufacture, install, and service |

## 4.4 REMAINING TECHNOLOGIES

After screening out those technologies in accordance with the policies set forth in 10 CFR Part 430, Subpart C, Appendix A, (4)(a)(4) and 5(b), DOE is considering the design options in the following list as viable means for improving efficacy. The market and technology assessment (Chapter 3) provides a detailed description of these design options.

### 4.4.1 General Service Fluorescent Lamps Design Options

- Highly Emissive Electrode Coatings
- Higher-Efficiency Lamp Fill Gas Composition
- Higher-Efficiency Phosphors
- Glass Coatings
- Higher-Efficiency Lamp Diameter

### 4.4.2 Incandescent Reflector Lamps Design Options

- Higher-Temperature Operation
- Thinner Filaments
- Efficient Filament Coiling
- Efficient Filament Orientation
- Higher-Efficiency Inert Fill Gas
- Tungsten-Halogen Lamps
- Higher-Pressure Tungsten Halogen Lamps
- Infrared Glass Coatings (thin-film)
- Higher-Efficiency Reflector Coatings
- Efficient Filament Placement

DOE will consider these options in the engineering analysis. As discussed in Chapter 5, DOE based its engineering analysis to the greatest extent possible on commercially available products, which incorporate one or more of these design options. By doing this, DOE uses catalog data to determine both prices and performance attributes more efficacious lamps.

## REFERENCES


[1] U.S. Department of Energy○Office of Building Technologies. U.S. Lighting Market Characterization, Volume II: Energy Efficient Lighting Technology Options. September, 2005. Washington, D.C. < www.eere.energy.gov/buildings/info/documents/pdfs/ee_lightingvolII.pdf>

[2] *Ibid.*