



Center for Sustainable Engineering

# Life Cycle Assessment

Cliff I. Davidson

H. Scott Matthews

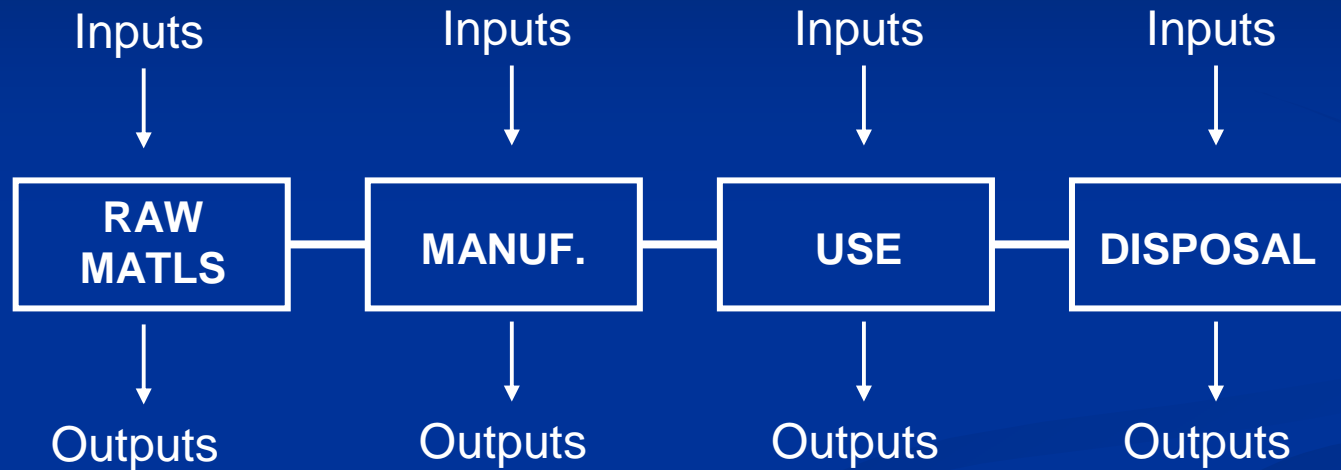
Carnegie Mellon University

**“Sustainable Engineering in Green Buildings”**

**Tel Aviv, June 29, 2009**

- **Models of Life Cycle Assessment**
- **Solid State Lighting as a Case Study**

# Life Cycle Assessment



Inputs: Chemicals, materials, energy, water, etc.

Outputs: Desired products, wastes

## Models of LCA

- **Process-based LCA, developed by SETAC and EPA**
- **Economic input-output LCA (EIO-LCA)**
- **Hybrid LCA: a combination of the Process-based and Economic input-output methods**



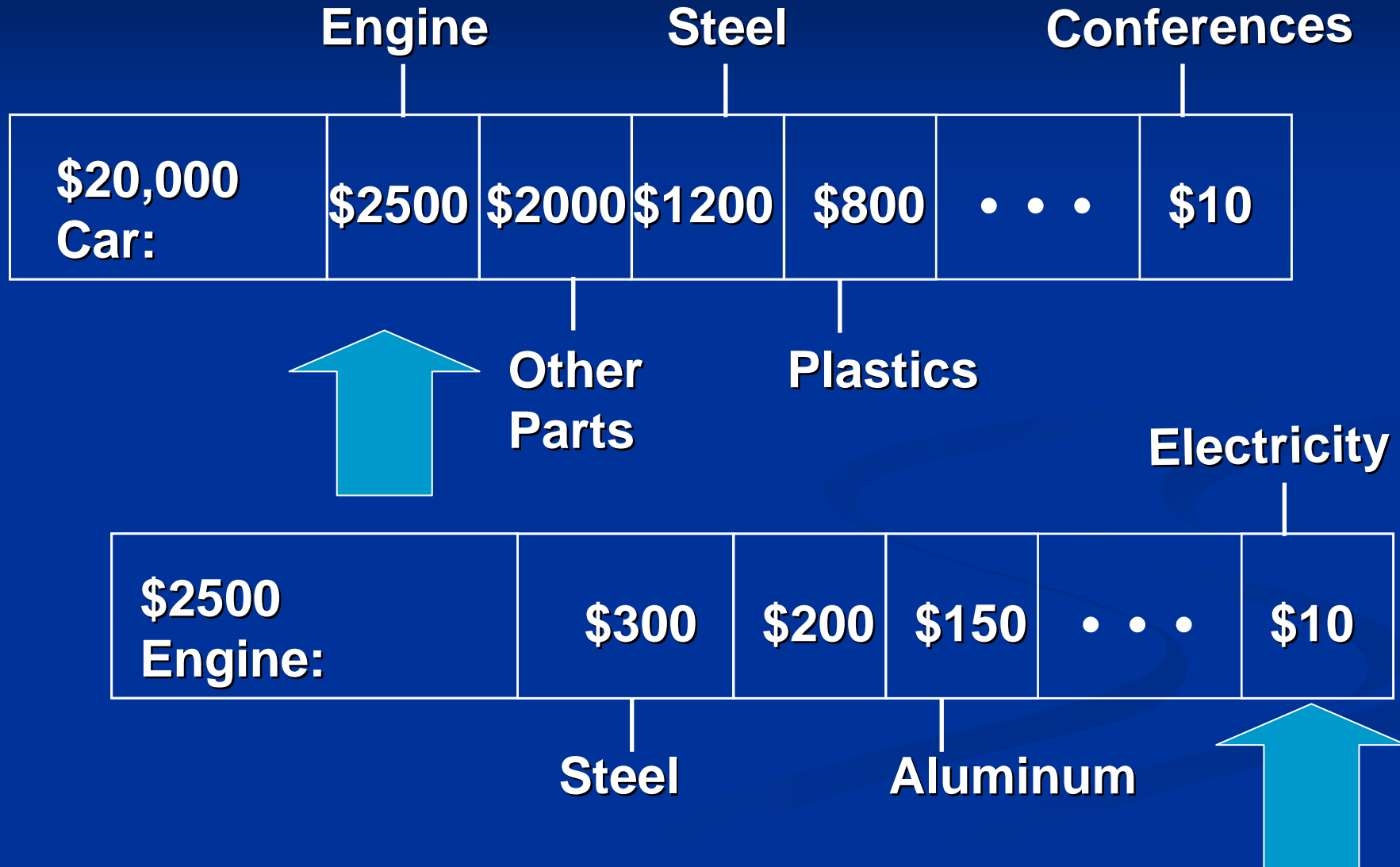
# Environmental Assessment Inputs and Outputs

- **Raw materials**
  - minerals, ores, chemicals, fertilizers, etc.
- **Energy**
  - electricity, biomass fuels, fossil fuels
- **Greenhouse Gases**
- **Other Wastes**

# Economic Input-Output Analysis

- **Developed by Wassily Leontief (Nobel Prize in 1973)**
- **Quantifies interrelationships among sectors of an economy**
- **Identifies direct & indirect economic inputs**
- **Extended to environmental and energy analysis**

# I-O and Supply Chains



# Effects Specified

- **Direct**
  - **Inputs needed for final production of product (energy, water, etc.)**
- **Indirect**
  - **ALL inputs needed in supply chain**
  - **e.g. Metal, belts, wiring for engine**
  - **e.g. Copper, plastic to produce wires**
  - **Calculation yields every \$ input needed**



## EIO-LCA Software

- Internet version <http://www.eiolca.net/>
- ~1 million “uses” to date
- About 1,500 registered users
  - update notices
  - other benefits
- First LCA tool completely free on Internet
- A “first step” screening tool

## Case Study: Solid State (LED) Lighting

- **New technology that will leapfrog CFL bulbs**
- **Very high-tech process (like IC chips)**
- **Current generation replacement bulb**
- **Luminaire efficacy of 60 lm/w**
- **Luminaire lifetime of 25,000 hours**

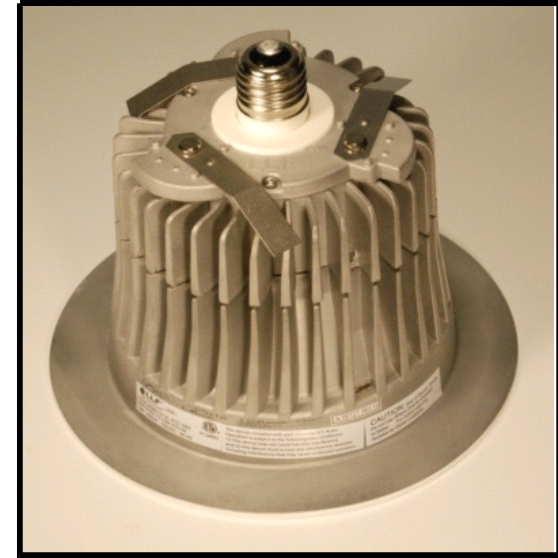
# SSL Product Components



**Chip**



**Device**



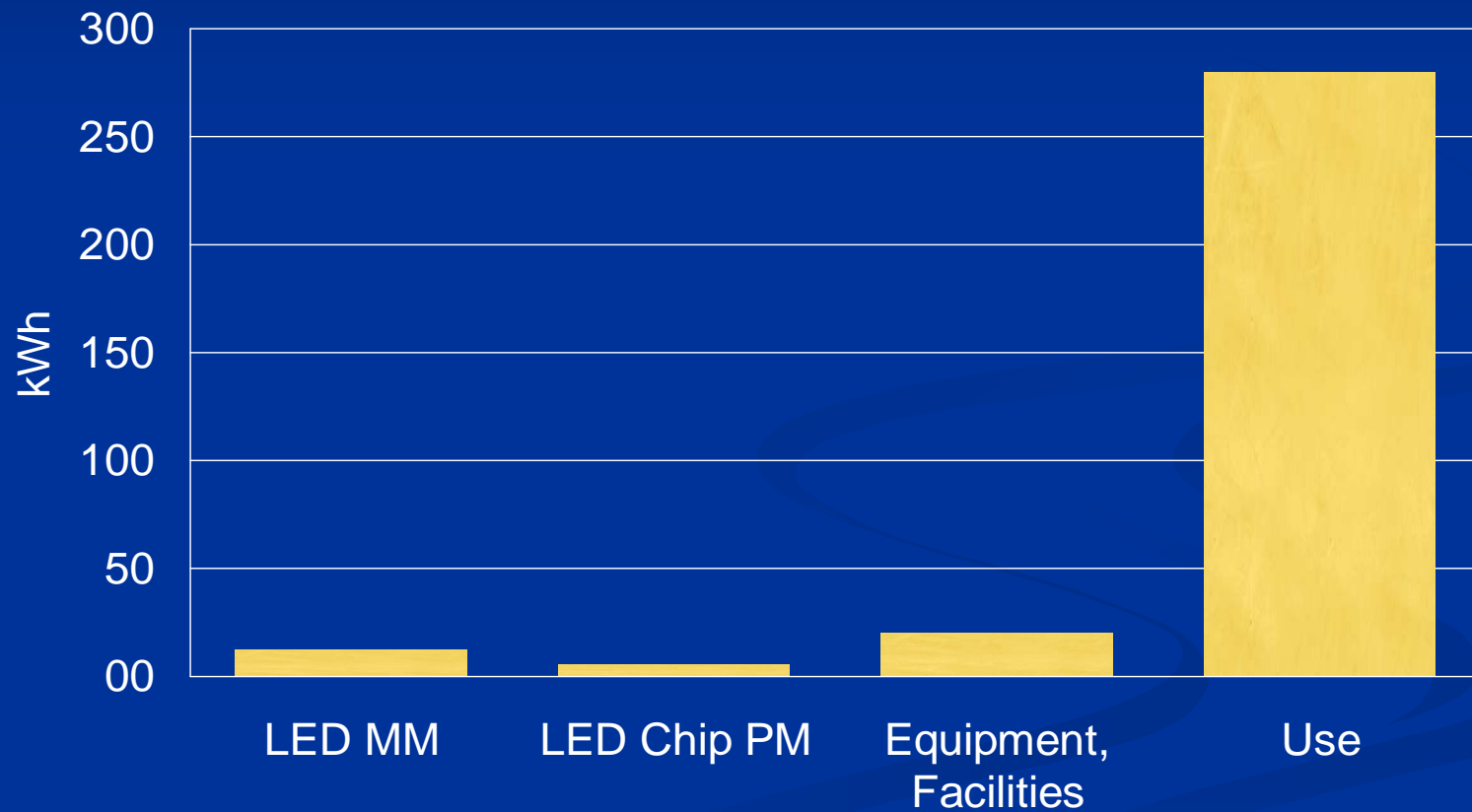
**Luminaire**

Source: SSL Multi-year Program Plan

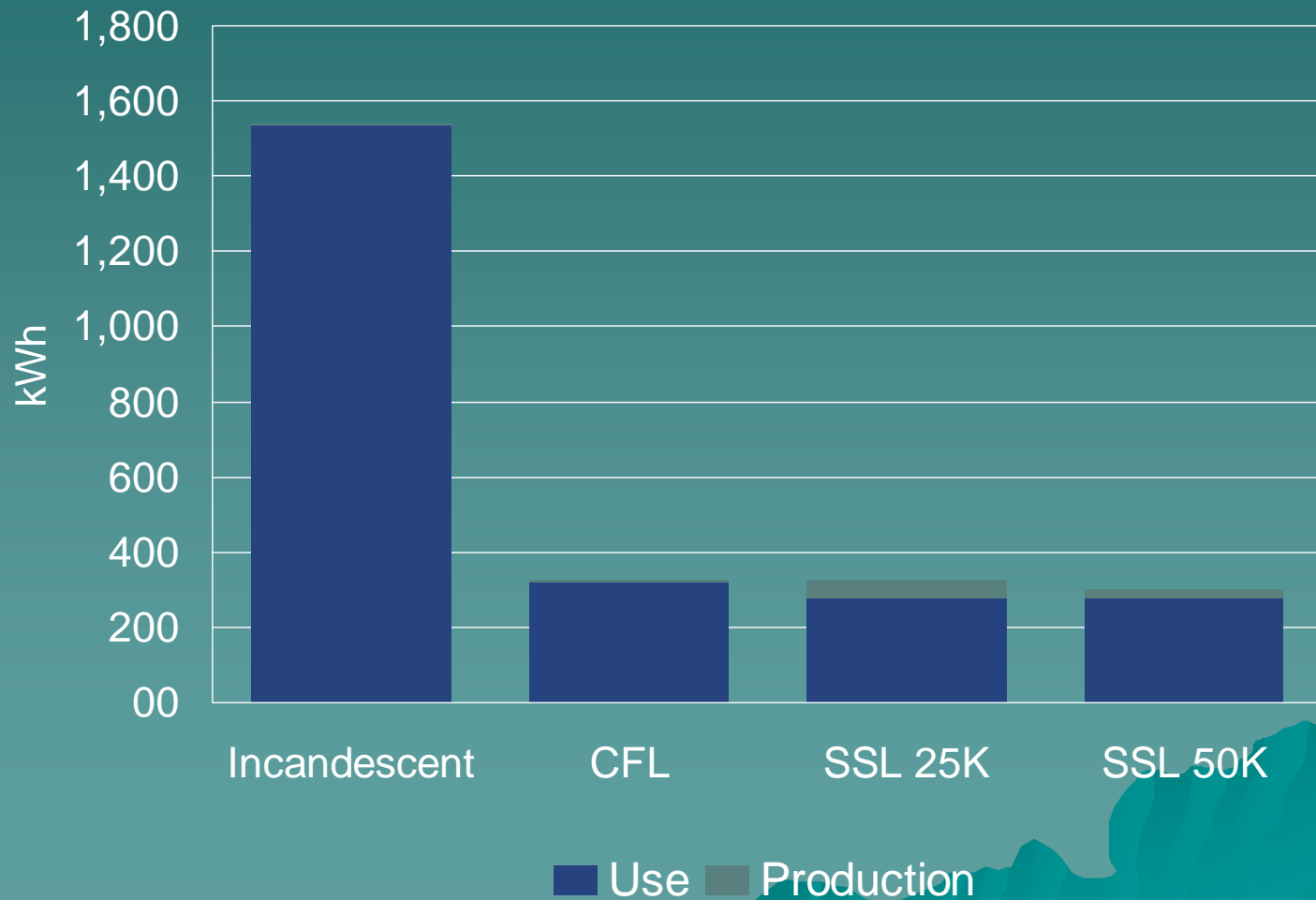
**To date, focus has currently been ONLY on the chip materials and production steps.**

# Preliminary LC Energy of SSL Product 25,000 hour lifetime

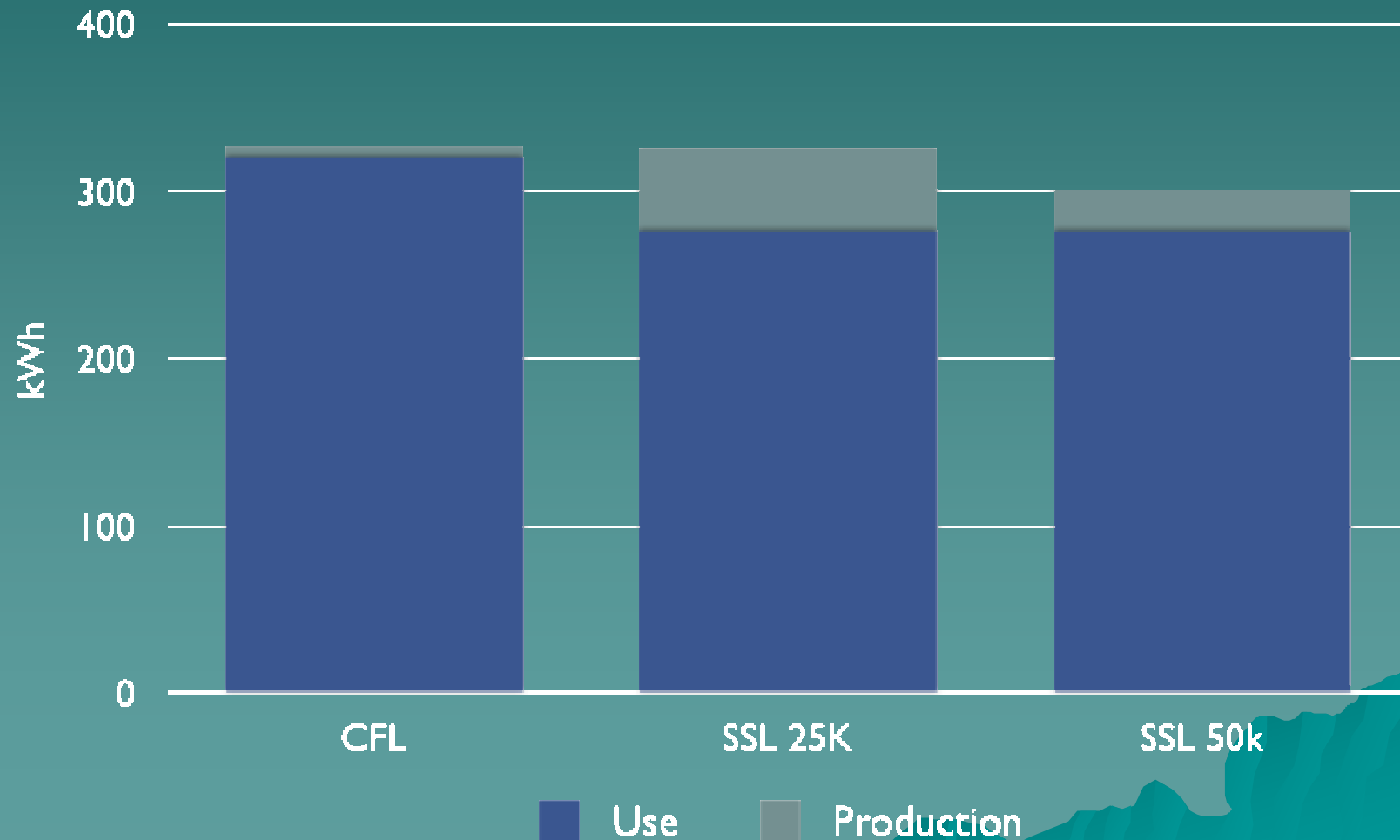
**LED Manufacturing total: 15-50 kWh**



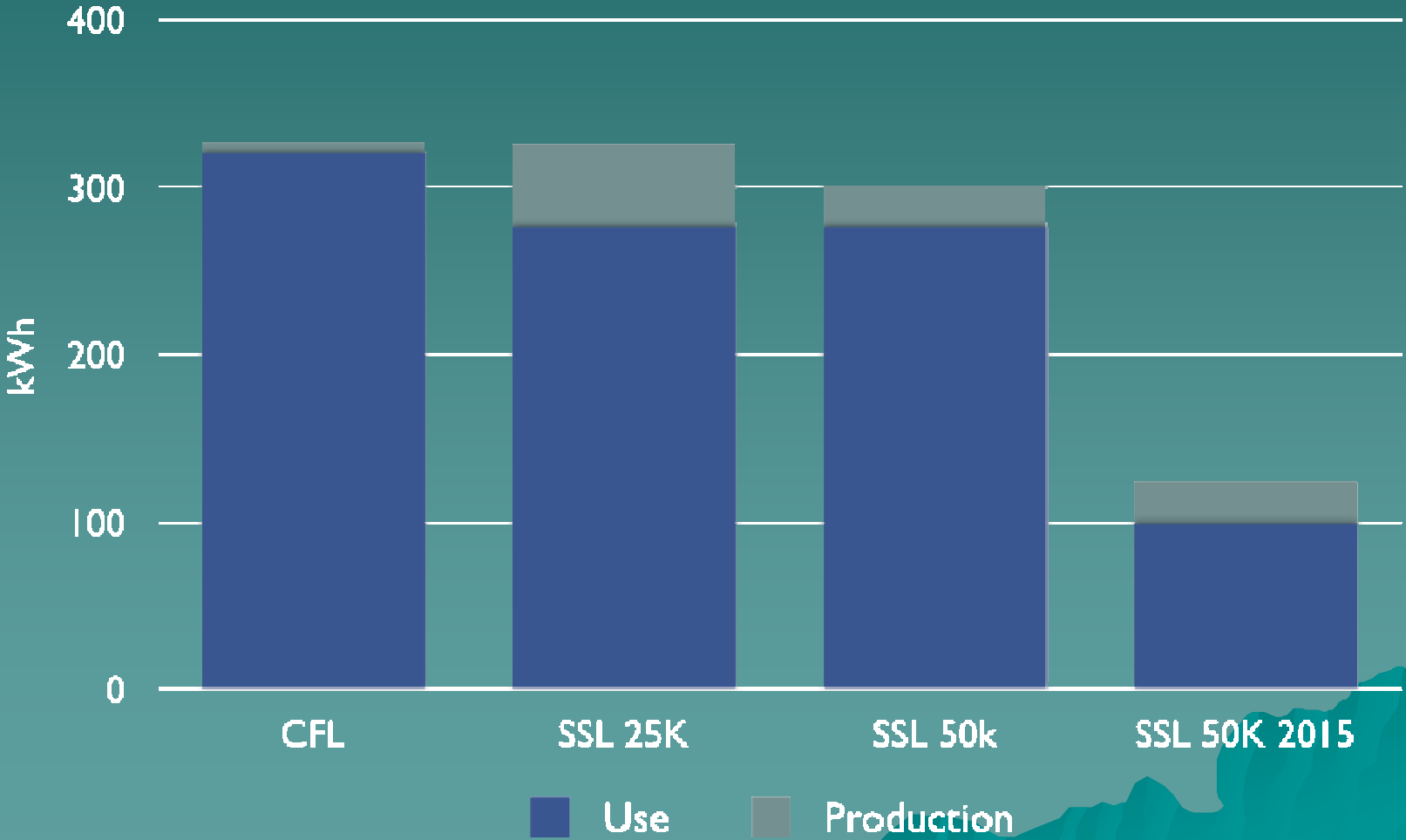
# Life Cycle Energy Comparison of Lighting Technologies



# Life Cycle Energy Comparison of Lighting Technologies



# Life Cycle Energy Comparison of Lighting Technologies



# Summary

- ◆ Life-cycle assessment is an important tool for pollution prevention and environmental decision-making
- ◆ Two models: Process-based and EIO-LCA
- ◆ Both have merits and limitations
- ◆ Credible LCA studies are difficult to do