

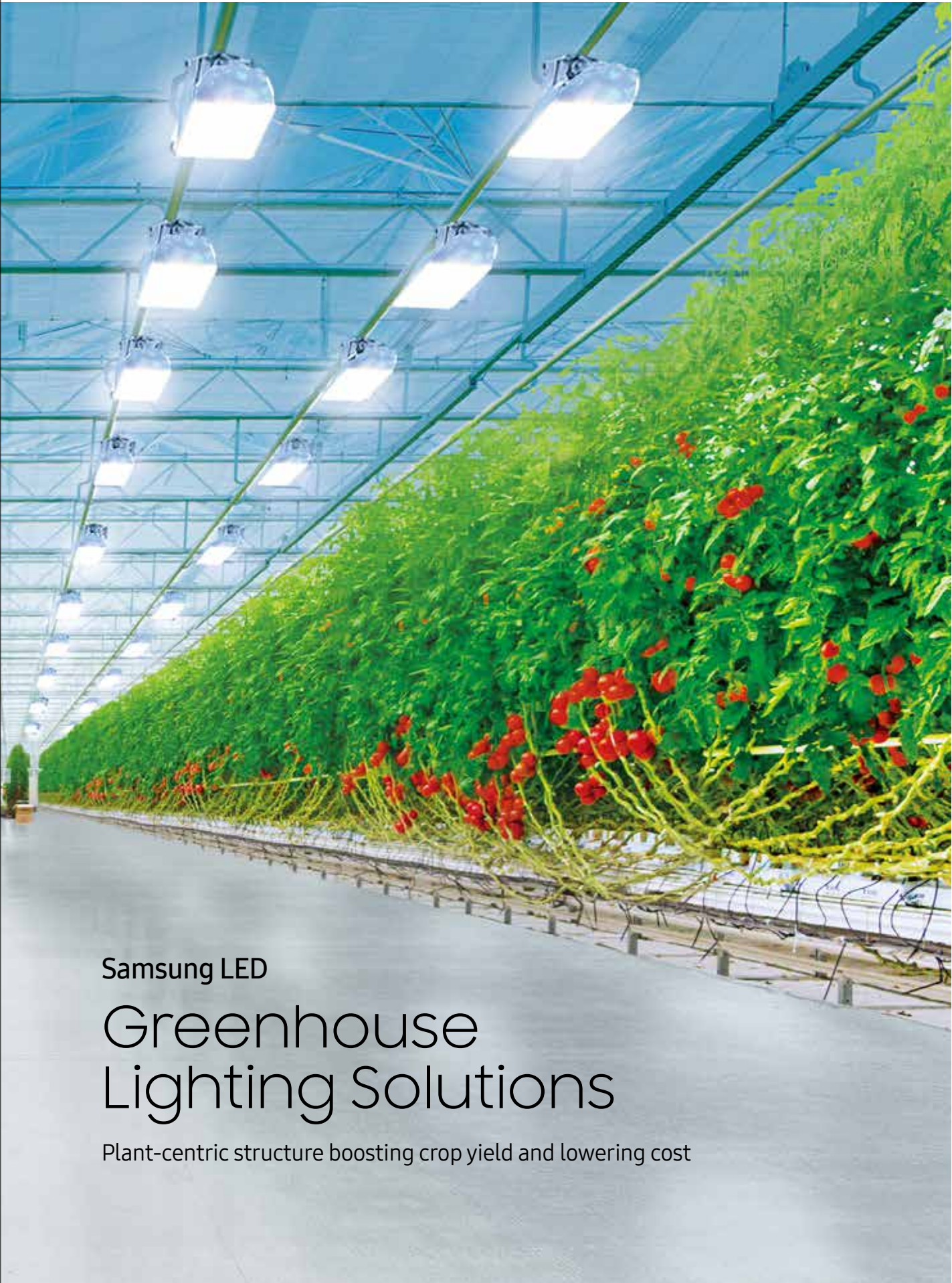
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Samsung LED  
Greenhouse  
Lighting Solutions  
Plant-centric structure boosting crop yield and lowering cost

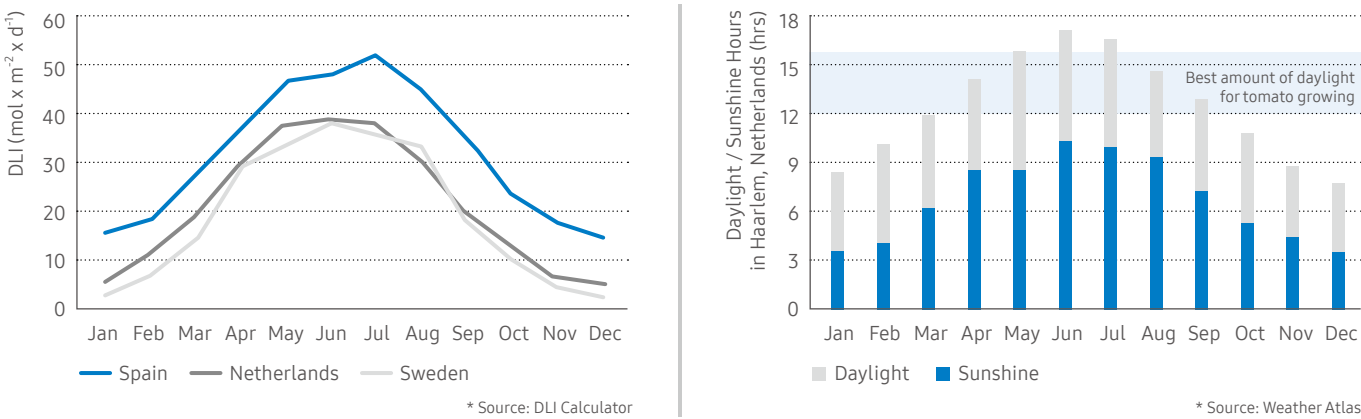




# The Importance of Greenhouse Lighting

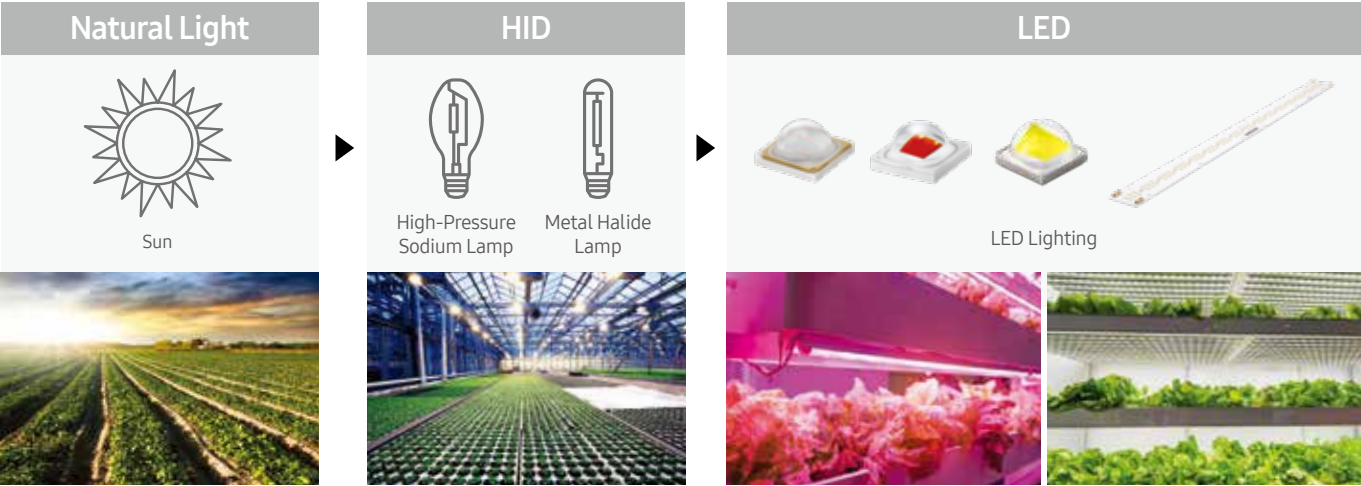
## The Need for Supplemental Lighting in Greenhouse

High latitude regions lack sufficient daylight, or DLI (Daylight Integral) for farming. Plentiful light supply is critical for most crops, such as tomatoes, which require at least 12 hours of daylight per day.



## Evolution of Horticulture Lighting

Growers are switching to LEDs, which produce higher crop yield and reduce the total cost of lighting system ownership and operation.



	Conventional			LED	
	Fluorescent	MH	HPS	Narrow Spectrum	Full Spectrum
Efficacy (μmol/J)	1	1.4	1.8	> 2.5	> 2.5
Heat	Low	High	High	Low	Low
Lifetime (hrs)	< 20,000	< 20,000	< 20,000	> 50,000	> 50,000
Lighting System Cost	Low	Low	Low	High	Mid
Spectrum Controllability	n/a	n/a	n/a	Low	High
Visibility (Human Eye)	Good	Good	Good	Bad	Good
Warm-up Time	Short	Long	Long	Short	Short
Design Flexibility	Low	Low	Low	High	High



# Samsung White-based Full Spectrum LEDs for Greenhouse Lighting



### Low Cost

Low initial lighting system cost to minimize investment



### Saving Energy

Highly efficient light sources to reduce power consumption



### Balanced Growth

Light optimized for plant growth to increase crop yield



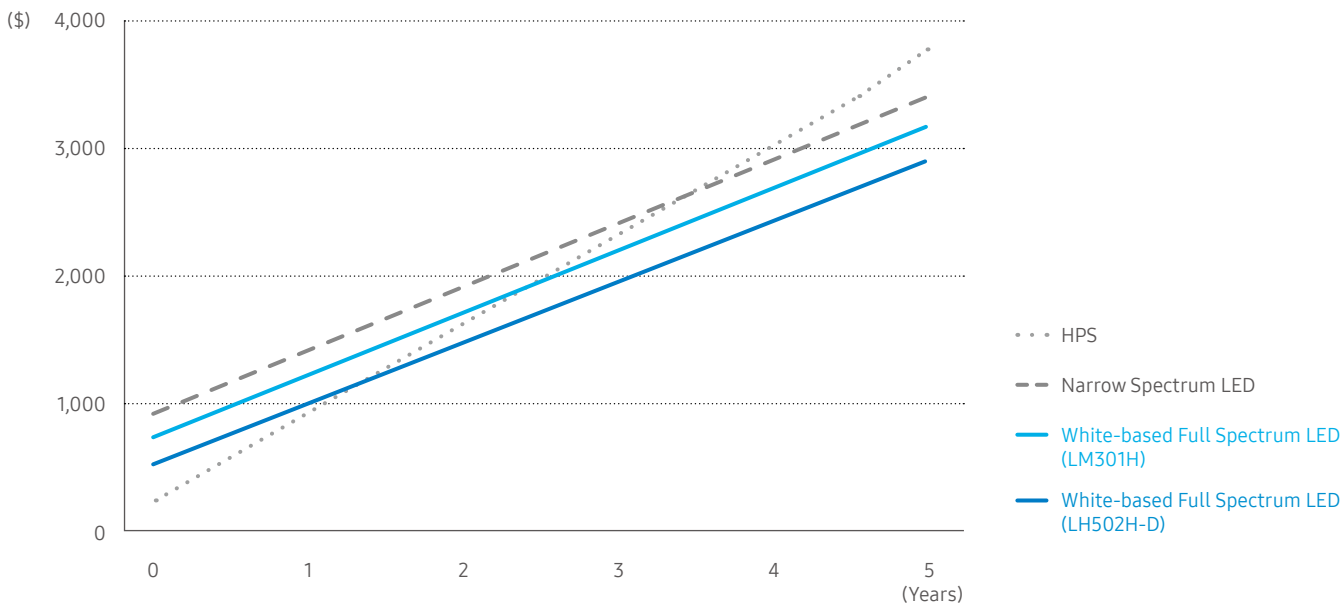
### Robustness

Durable in high temperatures and humidity with strong sulfur resistance

## Cost-effectiveness

### Lower Initial Investment

The initial investment for cost-effective full spectrum LEDs is lower than HPS lighting, narrow spectrum LEDs, and conventional full spectrum LEDs.

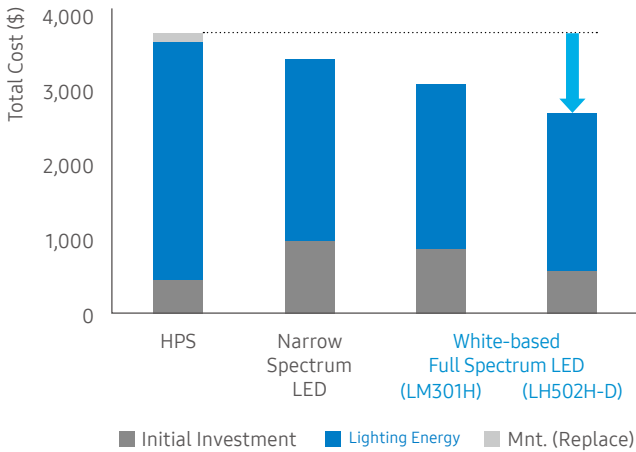


\* Unit Price: HPS 1000W (\$400), Narrow 720W (\$1000), Full 700W (\$850), Cost Full 700W (\$600) / Lifetime: HPS (20k hrs.), Narrow (60k hrs), Full (60k hrs.), Cost Full (60Khrs) / Electricity Rate : \$0.15 per kWh / 12hrs a day

### Lower Operation Cost

Samsung's white-based full spectrum LEDs bring down operation cost by reducing energy consumption with its industry-leading performances and high efficacy LEDs

	Mid Power White 65mA, 5000K, 25°C	High Power White 180mA, 5000K, 25°C
Samsung White-based Full Spectrum	3.14 umol/J	2.90 umol/J
Normal Full Spectrum	3.08 umol/J	2.76 umol/J
Remark	+ 2%	+ 5%

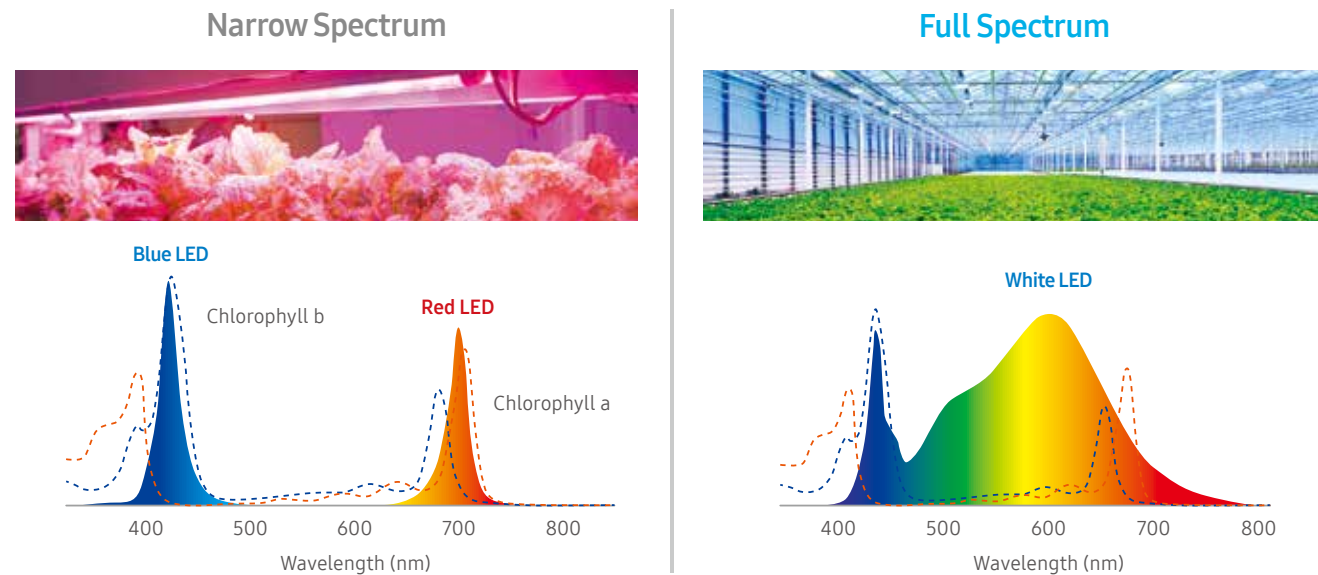




# Balanced Growth

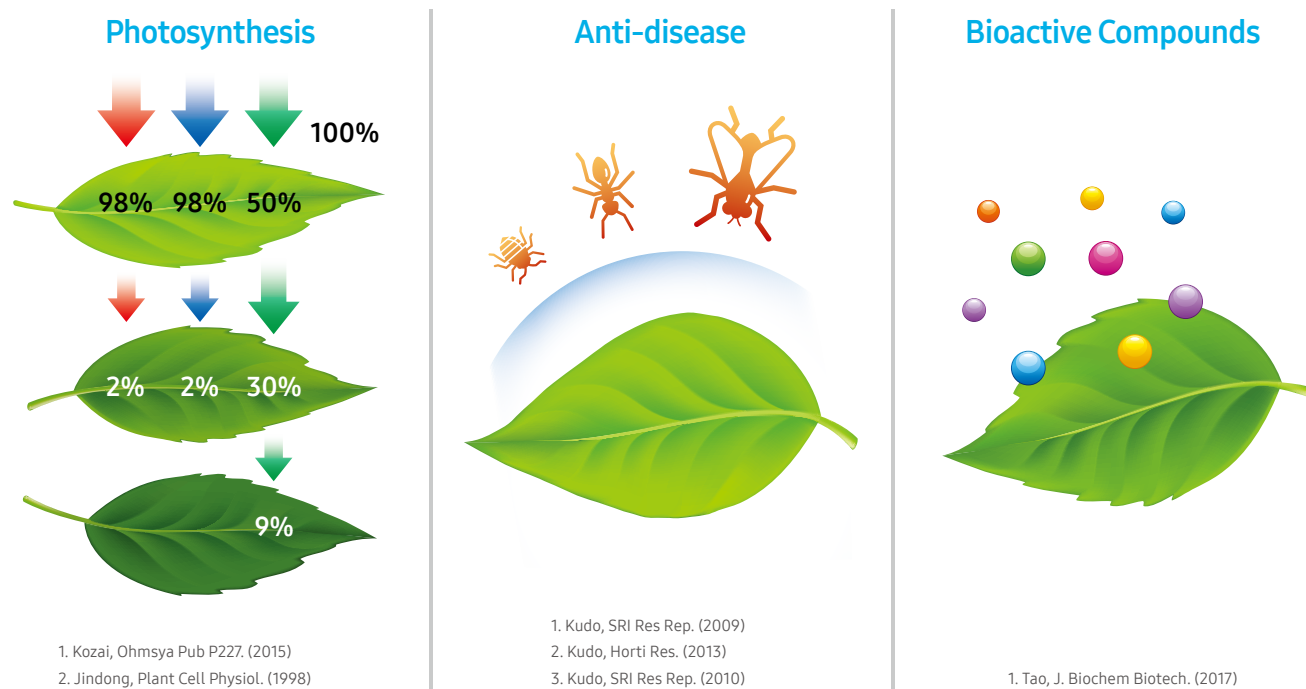
## I White-based Full Spectrum LED

Full spectrum is recent trend with more cost-effective, productive, and favorable solution



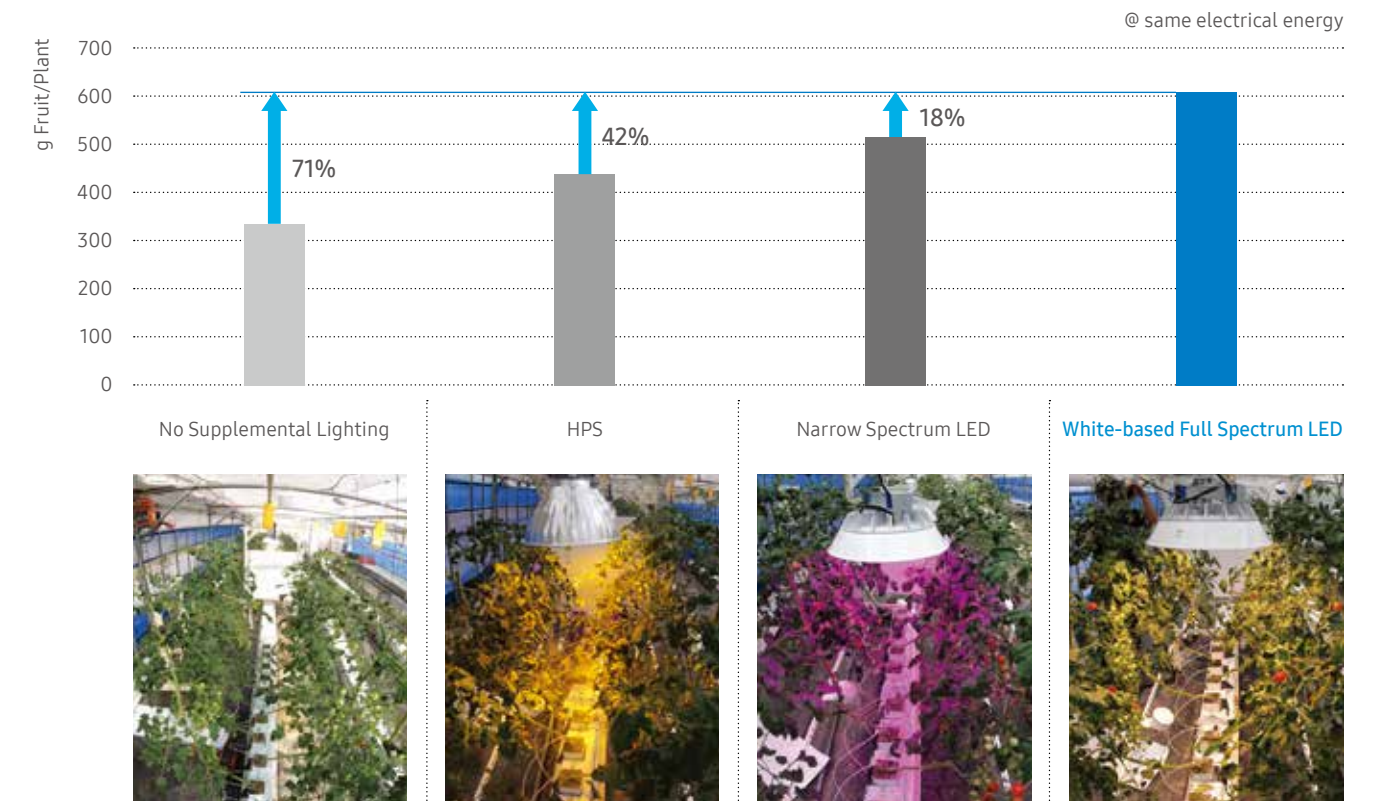
## I Healthier Crops under Full Spectrum

Full spectrum LEDs are better at stimulating photosynthesis, preventing disease, and making more bioactive compounds



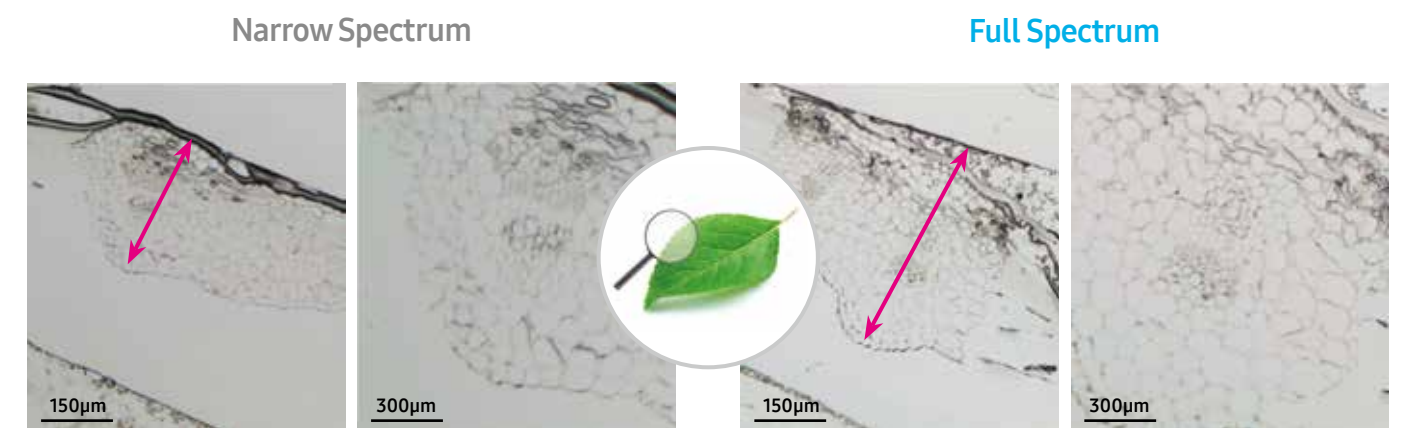
## I Spectrum Comparison Experiment

- Plants: Cherry Tomato
- Environment: 28.8 ±14°C, RH 76±20%, On/Off=8hrs/day
- Test Period: 49 days
- Variable: Light Spectrum



Acknowledgement: Prof. Son at Gyeongsang National Univ.

- Examined cross sections of leaves under narrow spectrum vs. full spectrum
- Leaves under full spectrum grew thicker and more well-formed in structure (xylem, phloem, etc)



Acknowledgement: Prof. Chun at Seoul National Univ.

# Favorable Environment

## I Improved Working Environment

White-based full spectrum LEDs enable quicker disease detection and create a more pleasant work environment



Narrow Spectrum



Full Spectrum

## I Preventing Light Pollution

White-based full spectrum LEDs prevent “Purple Sky,” a type of light pollution that harms the environment



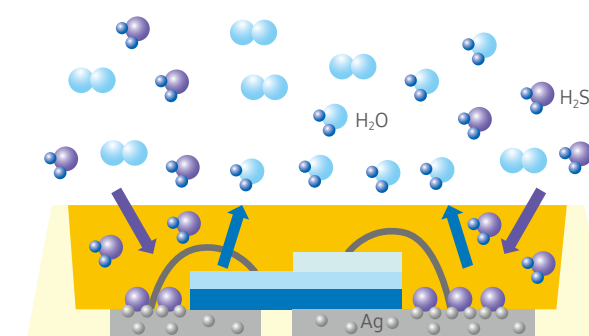
Narrow Spectrum



Full Spectrum

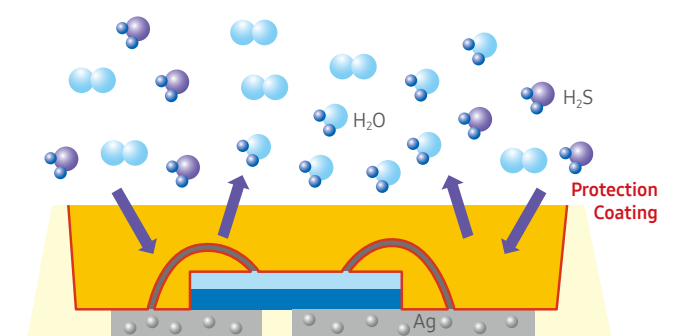
# Robust Performance

## I Superior Device Architecture for Durability



Conventional LED

- Ag in wire or electrodes can be tarnished when exposed to  $H_2S$
- $2Ag + H_2S + 1/2O_2 \rightarrow Ag_2S + H_2O$  ( $Ag_2S$  causes PPF degradation)



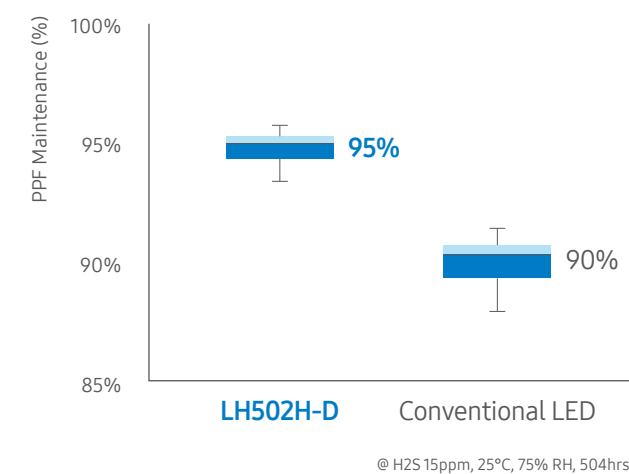
LH502H-D

- LH502H-D: Protection coating to prevent Ag exposure

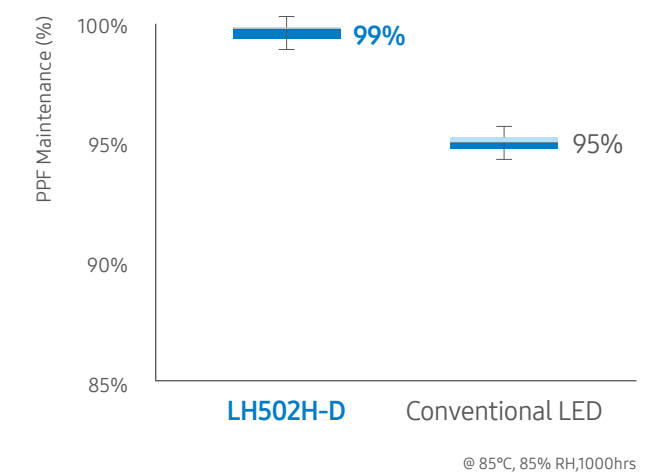
## I No Degradation in Horticulture Environment

With a protection coating, Samsung's horticulture LEDs can present superior performance maintenance in greenhouse conditions.

### Sulfur Resistance Test



### High Temp/Humidity Operating Test





# Maximum Plant Growth at Minimum Cost

Plant-centric Structure Boosting Crop Yield and Lowering Cost for Greenhouse Lighting Solutions



## Product Line-up

### White Mid Power LEDs

Samsung's mid-power white LEDs deliver the highest efficacy and excellent reliability

#### LM301H



- Optimized light spectrum for leafy greens
  - Anti-sulfurization (with flip-chip technology)
- @65mA, 25°C, 5000K, CRI80+

Rank	Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm²)
SL	White	0.54	3.08	3.0 × 3.0

#### LM301H ONE



- Optimized light spectrum for leafy greens
  - Anti-sulfurization (with flip-chip technology)
- @65mA, 25°C, 3500K, CRI70+

Rank	Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm²)
S0	White	0.49	2.75	3.0 × 3.0

#### LM301H EVO



- Plant-centric light spectrum for better growth
  - World's best efficacy
  - Anti-sulfurization (with flip-chip technology)
- @65mA, 25°C, 5000K, CRI70+

Rank	Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm²)
PR	White	0.56	3.14	3.0 × 3.0

#### LM301H EVO Mint White



- Plant-centric light spectrum for better growth
  - World's best efficacy
  - Anti-sulfurization (with flip-chip technology)
- @65mA, 25°C, 5000K, CRI70+

Rank	Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm²)
PM	White	0.57	3.17	3.0 × 3.0

### White High Power LEDs

Full line-up of high power white LEDs with industry-proven performance for various horticulture applications

#### LH241H



- Compact design for small LES module
  - Viewing angle: 120°
  - Thermal resistance: 2.0K/W
- @350mA, 25°C, 5000K, CRI70+

Rank	Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm²)
R1	White	2.51	2.52	2.4 x 2.4

#### LH281H



- Compact design for small LES module
  - Viewing angle: 120°
  - Thermal resistance: 2.0K/W
- @350mA, 25°C, 5000K, CRI70+

Rank	Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm²)
SB	White	2.59	2.65	2.8 x 2.8



# Product Line-up

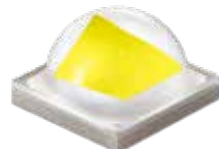
## LH351H-B



- Viewing angle: 120°
  - Thermal resistance: 4.2K/W
- @350mA, 25°C, 5000K, CRI70+

Rank	Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm²)
Q1	White	2.48	2.51	3.5 × 3.5

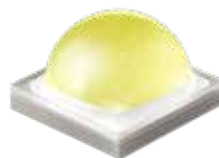
## LH351H-C



- Viewing angle: 130°
  - Thermal resistance: 3.0K/W
- @350mA, 25°C, 5000K, CRI70+

Rank	Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm²)
RB	White	2.56	2.60	3.5 × 3.5

## LH351H-D



- Viewing angle: 130°
  - Thermal resistance: 2.2K/W
- @350mA, 25°C, 5000K, CRI70+

Rank	Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm²)
Y2	White	2.58	2.69	3.5 × 3.5

## LH502H-D



- Anti sulfurization
  - Viewing angle: 120°C
- @180mA, 25°C

Rank	Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm²)
Y2	White	2.84	2.90	5.0 × 5.0

\* Subject to change without notice

## I Color High Power LEDs

Full line-up of high power color LEDs with industry-proven performance for various horticulture applications

## LH351H Blue (450nm)



- Viewing angle: 130°
  - Thermal resistance: 4.0K/W
- @350mA, 25°C

Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm²)
Blue	2.80	2.80	3.5 × 3.5

## LH351H Red (630nm)



- Viewing angle: 120°
  - Thermal resistance: 4.0K/W
- @350mA, 25°C

Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm²)
Red	1.82	2.41	3.5 × 3.5

## LH351H Deep Red (660nm)



- Viewing angle: 120°
  - Thermal resistance: 2.5K/W
- @350mA, 25°C

Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm²)
Deep Red	2.4	3.22	3.5 × 3.5

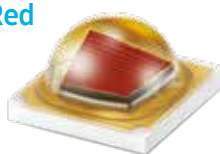
## LH351H Deep Red (660nm) V2



- Viewing angle: 130°
  - Thermal resistance: 3.0K/W
- @700mA, 25°C

Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm²)
Deep Red	5.54	3.75	3.5 × 3.5

## LH351H Deep Red (660nm) V2+



- Viewing angle: 130°
  - Thermal resistance: 3.0K/W
- @700mA, 25°C

Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm²)
Deep Red	5.6	3.8	3.5 × 3.5

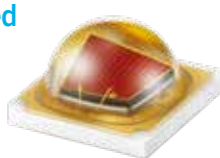
## LH351H Deep Red (660nm) V3



- Viewing angle: 130°
  - Thermal resistance: 3.0K/W
- @700mA, 25°C

Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm²)
Deep Red	5.65	3.9	3.5 × 3.5

## LH351H Far Red (730nm)



- Viewing angle: 120°
  - Thermal resistance: 3.9K/W
- @350mA, 25°C

Color	* BPF (μmol/s)	* BPF/W (μmol/J)	Footprint (mm²)
Far Red	2.07	3.1	3.5 × 3.5

\* Biologically-active Photon Flux

## I Module

Customized designs are also available per customer request

## Horticulture LED Module Gen2



Color	PPF (μmol/s)	PPF/W (μmol/J)	Luminous Flux (lm)	Watt (W)	Vf (V)	IF (mA)	Efficacy (lm/W)	Tp (°C)
White + Red	154.2	3.06	8,960	50.4	42	1,200	178	25

\* Subject to change without notice