Circadian Lighting and You

Learn what circadian lighting is and how to apply it in your home.

Powering forward.
Together.

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Commitment to our customers

As a community-owned, not-for-profit electric service for over 70 years, SMUD exists to serve you, our customer. This means we're able to make decisions that focus on the best interests of our community. We make every effort to provide you with affordable, reliable electricity and offer services that can increase energy-efficiency, reduce your energy costs and protect our environment. We're always looking for the latest innovations in electricity that can help our customers. You are at the heart of all we do.

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Introduction

New technology has changed the way we light spaces, including our homes. Light Emitting Diodes (LEDs) have transformed the lighting market and are able to illuminate spaces with many colors, dim nicely with modern controls and are energy efficient.

LEDs are being used to illuminate spaces differently than ever before. One way is with circadian lighting which changes the color of light inside to mimic the daylight patterns outside. The changing colors throughout the day can stimulate our bodies and minds and help keep us stay alert and awake. It can also help us unwind and become more relaxed in the evening as we get ready for bed.

The key is knowing what color of light to use and when.
This booklet will help guide you on a circadian journey to help enhance your every-day interactions with lighting. Get ready to experience an amazing transformation in how you see and use lighting in the comfort of your own home.

How we got here

A lot of research has been conducted on how lighting affects seniors, office workers, hospital patients/nurses, sports players, school children and much more.

The Lighting Research Center[1] has been instrumental in providing applicable research towards lighting and its effects on several different people groups.

An article by Dr. Satchin Panda, professor at the Salk Institute in La Jolla, CA, mentions some effects of good and bad lighting especially linked with the importance of sleep.

> *Research scientists uncovered the role that blue or orange light plays in regulating our sleep cycles. Too little bright light during the day, or too much blue light in the evening, directly disrupts the secretion of melatonin, a sleep-inducing hormone.*
> *Just a few sleepless nights can negatively impact metabolism, increasing diabetes risk. But if it continues for weeks, months, or years, then disrupted sleep can lead to over 100 different chronic diseases, including depression, metabolic disorders, cognitive issues and inflammation—the killers of our modern age.*
> *Thanks to circadian medicine, we now know that "lighting for health is not lighting for vision," said Panda.*[2]

Research in how lighting affects human behavior as well as health is continuing to grow. However, we do know that modern-day lighting design can affect us in a positive way. Let's get started by looking at some basics about lighting.

Additional Resources

[1] Learn more at the Lighting Research Center website at http://www.lrc.rip.edu/

[2] Clocking the Drugs, Drugging the Clock: The Health Impact of Circadian Medicine https://apple.news/A6wyrUZdhQ_25qmoPlA7ywQ

Proper lighting design


Photo by Shannon Demma

Proper lighting in our homes has a huge impact on how we interact with our environment. When we live and function in good lighting, most of the time we don't pay attention to it. However, if the lighting is bad we tend to notice. Dimly lit areas, excessive brightness (glare), wrong placement or color and other factors can affect our health and daily lives. The key is to have the right amount of high quality light when and where we need it. A technique for accomplishing this objective is called **light layering.** Light layering is a great tool to use when lighting different spaces in our home. As the name implies, this technique involves designing lighting for three layers.

1. **Ambient lighting** is general lighting in the space such as surface mounted lighting or recessed downlights.
2. **Task lighting** is used for specific task being done in the space. i.e. the kitchen may use undercabinet lighting to help brighten the area for recipe reading or preparing food while the living room may have table lamps used for reading.
3. **Accent lighting** is for highlighting a specific area to call attention to it such as a piece of art, glass cabinetry or toe-kick lighting in a kitchen.

Other factors to consider are the finishes and paint colors used on the walls and ceilings in a home. When lighter finishes are used, most spaces appear bigger and brighter. When darker finishes are used, spaces may appear smaller and cozier.

You can easily transform your home with the right lighting placed in strategic locations. Adding the proper color of light during the right time of day can transform it even more while adding circadian benefits. Let's start by reviewing some basic lighting terms.

Lighting basics

The amount of light radiating from a light source in all directions is called lumens. We need light bulbs and light fixtures to have the proper amount of lumens to help provide the right amount of light in an area for us to function well in our homes. The chart below provides a comparison of some common light sources used in homes.

Lumens. The new measure of light.

Less Bright → Brightest

Rated Life	Brightness	450 Lumens	800 Lumens	1100 Lumens	1600 Lumens
1 year	Standard Incandescents	40W	60W	75W	100W
2 years	New Halogen Incandescents *Save up to 28%*	29W	43W	53W	72W
6 years	CFLs • *Save up to 75%*	10W	14W	19W	23W
20+ yrs	LEDs • *Save up to 80%*	6-8W	9-13W	14-17W	18-22W

Learn more at smud.org/lighting SMUD®

Another important term is **Correlated Color Temperature** or CCT. Basically, this describes the color emitted from the light measured in Kelvin (K). Lights with CCTs of 2700K produce light that appears to be very "warm" whereas lights with a CCT of 6500K appear much "cooler", like daylight. The CCT of the light source is an important factor for circadian lighting. We'll talk more about this in the circadian lighting section of this guide. For now, please refer to the diagram below regarding CCT.

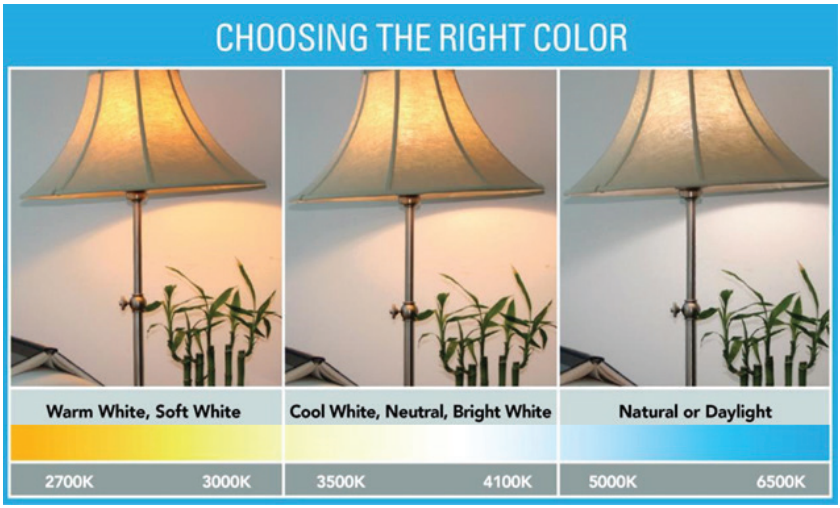
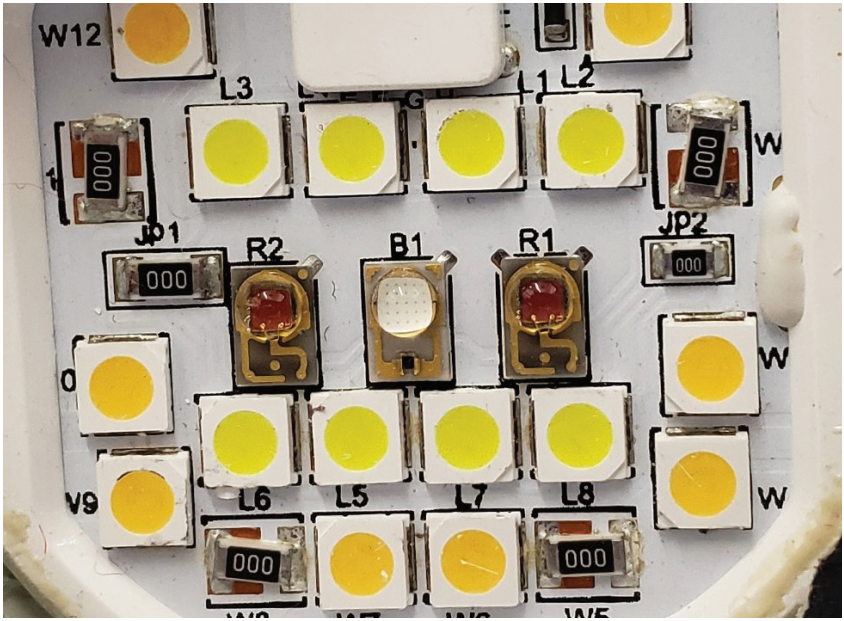


Photo by Energy Star

Tunable-white is a term describing the ability for a light bulb or light fixture to change CCT from warm to cool. Color-tuning is the ability for a light bulb or light fixture to produce any color including different colors of white light (CCT).

One of the key metrics for light sources is called the **Color Rendering Index (CRI).** This metric describes how true colors or objects look under a given light source. As shown in the picture, CRI has a dramatic impact on lighting quality. A CRI value of 90 or above is considered good.

Photo by Energy Star



Light Emitting Diodes (LED)s are tiny little devices that emit visible light when electric current is applied. Because of their high efficacy, small size and long life, LEDs are rapidly increasing in popularity and are used in most modern light bulbs.

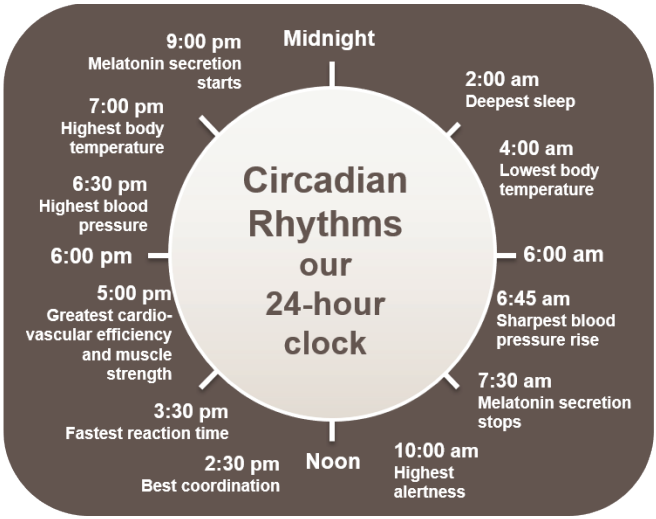
Although many LEDs look yellow, they are blue with a yellow phosphor coating which allows them to produce white light. These little devices are placed inside light bulbs and light fixtures to provide great white light and save a lot of energy compared to traditional light sources such as incandescent or compact fluorescent lamps (CFL). Many LED light bulbs are also dimmable, but it is important to use dimmers that are compatible.

Since LEDs have become mainstream, some products can change their color of light with an App. These light bulbs or light fixtures are called tunable-white or color-tunable products.

Now that we have covered the basics, let's explore circadian lighting.

Circadian lighting

Every human has a circadian cycle (also known as our sleep/ wake cycle which is roughly 24-hours). Many natural occurrences happen within our bodies throughout the day as shown by the illustration below. Please note that each person is different so the exact times these occurrences happen may vary.



Something to pay close attention to is our natural hormone production of melatonin and seratonin. These hormones regulate our sleep, moods, appetite, digestion, memory and much more.

Melatonin is our sleep hormone and seratonin is our daytime hormone. If our melatonin production is suppressed, we may not get as much sleep or high quality sleep which can affect us if we continue in this pattern. **Lack of sleep or poor sleep quality can lead to:**

1. Memory deficits
2. Limited attention spans
3. Poor balance
4. Higher rates of depression and anxiety

Basically, better sleep is associated with better health and faster recovery times. A quote from the Lighting Research Center says it well,

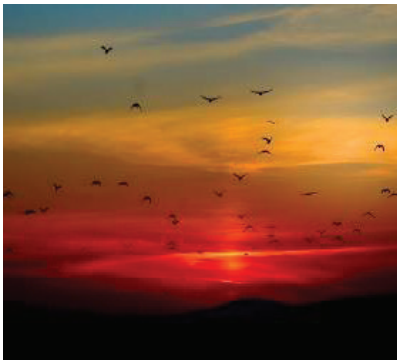
> *"A good night's sleep 'reboots' our brain."*

Circadian lighting is lighting that coincides with our circadian system for the entire day. Outdoor lighting changes color throughout the day from a warm light color to a cool daylight color and again to a warm color.

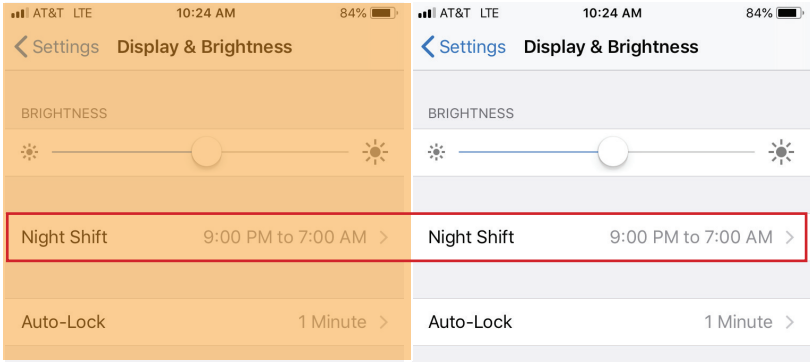
Research conducted by the Lighting Research Center (LRC) and others has shown that a higher color temperature (blue/white light color, i.e. daylight) in the morning may suppress our melatonin and help wake us up.[3] A white light in the afternoon helps keep us awake and warmer light at night does not suppress our melatonin and can help our bodies relax and fall asleep faster. Thanks to modern lighting technologies, we're now able to easily change the color of the lights throughout the day. It's important to note that circadian lighting isn't limited to light bulbs and fixtures, it includes electronic devices as well.

Additional Resources

[3]Learn more at the Lighting Research Center website at http://www.lrc.rip.edu/

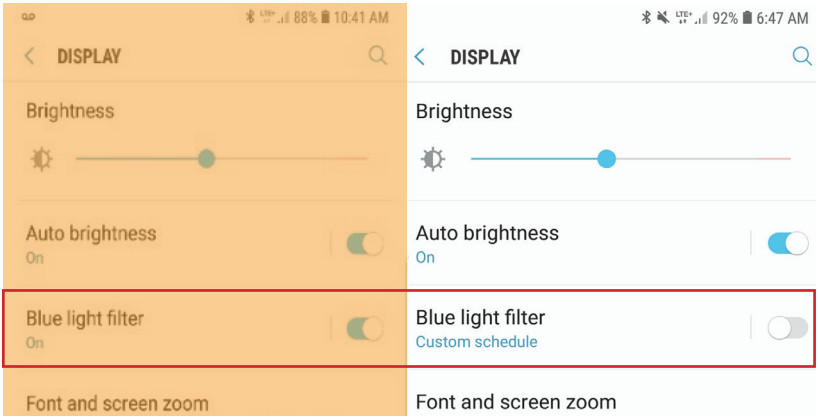


The screens for smart back-lit devices (cell phones, tablets, iPads and computers) contain a lot of blue light and tend to be used near our eyes. This blue light can stimulate our systems keeping us awake—especially if they are used at night. If you use these devices close to bedtime, we recommend using a blue light filter to shift the display to an amber color, to minimize disruption to your melatonin production.



Night Shift setting for Apple products

Fortunately, Apple products include a feature known as Night Shift. This feature has been around for a long time and can be activated via the Settings menu on your device. Android products use a similar approach and may call it a Blue Light Filter. These settings are easy to use and may be customized to fit your daily schedule.



Blue light filter for Android products

One final aspect of circadian lighting is known as **nighttime navigation.** Essentially, this involves using lights at low illumination levels and warm color temperatures (CCTs) for those late-night wake up calls. Providing just enough light to safely navigate through your home at night can reduce falls and minimize disruption to your circadian system.

In summary, good circadian lighting design includes:

1. Changing the CCT and intensity of the lighting throughout the day to mimic the sun.
2. Using blue light filters for all backlit electronic devices (phones, tablets, iPads, computers, etc.) that are being used during evening hours.
3. Using low light levels and warmer CCTs to provide nighttime navigation.

The good news is that all of this in now possible by using connected lighting systems!

Connected lighting systems

Connected lighting systems are light bulbs and light fixtures that can be controlled via a smart phone, iPad, tablet, computer and/or other wireless devices. Things to consider:

- Most systems include LED light bulbs and fixtures.
- Some can be controlled outside of house, while others cannot.
- Many require downloading Apps from the manufacturer.
- Most require "hubs," "gateways" and computer network routers.
- Some systems can be controlled via home automation platforms such as Amazon Alexa, Google Assistant, Apple HomeKit and others.

As shown below, connected lighting systems include tunable-white light bulbs, color-tuning light bulbs, wireless dimmer switches, remote controls, LED strip lights, LED table lamps and recessed downlight kits.

Product photos by Amazon.com

Lighting strategies

Connected lighting systems offer tremendous capabilities but can be rather expensive. With this in mind, let's look at some potential strategies for your home.

Below are recommended color temperatures throughout the day derived from previous research. Program a slow transition time from one color to the next.

Time of Day	Color Temperature
Wake up - noon	5000K
Noon - 2 p.m.	4500K
2 p.m. - 4 p.m.	4000K
4 p.m. - 6 p.m.	3500K
6 p.m. - 7 p.m.	3000K
7 p.m. - 9 p.m.	2700K
9 p.m. - 6 a.m.	2200K-2400K

If the lighting is too bright for you or your family member, please dim the intensity to an acceptable level.

Approximate color of light at different color temperature settings.

Lighting strategies for your home

- **Starter kits** are a great way to introduce your household to smart lighting. These kits include light bulbs, a dimmer switch and a bridge to help you get started. An App will need to be downloaded on a smart device to program the system.

- **Wireless motion sensors** are a great way to automatically turn lights on without having to use a switch. This can be very useful when entering a room when your hands are full – or when getting up or using the restroom during the night.

- **Wireless dimmers/switches** may be programmed for use with any or all the lights and placed almost anywhere for convenience.

Nighttime navigation is basically utilizing night lighting for nighttime activities such as getting out of bed, using the restroom, etc. *Nighttime navigation may be achieved by utilizing any of the equipment previously discussed as well as some new ideas such as:*

- **Motion sensors** may be used to sense when a person gets out of bed and turn on low level under the bed lighting or dimly light a path to the restroom.
- **Wireless dimmers/switches** may be programmed to turn a warm amber night light on after a specific designated time to help our bodies calm down before bed. Once in bed, if we wake up, it can help keep the integrity of our night vision and hopefully help us fall asleep quicker upon returning to bed. Please do not turn on any bright white lighting during the night, this can hinder your night vision, cause your system to become alert and make it harder to fall asleep again.
- **Flood lights** may be added to rooms to help provide additional lighting in a space and increase the overall lighting levels without adding glare. These may be placed behind TVs, plants, furniture, etc. Make sure the light bulb is hidden so there's no glare.
- **Linear ribbons** may be used under furniture such as beds or nightstands or can be mounted under cabinets in bathrooms, kitchens or virtually anywhere. This type of lighting can fit in small places and should be shielded so the LEDs aren't too bright. Linear ribbons give a great effect of light without the light bulbs being seen.

Lighting strategies for your home

- **Smart table lamps** are also a great option for rooms without overhead or wall mounted lighting. Smart table lamps may be controlled via an App, wireless switches/dimmers or even with voice-activated systems. Many styles are available to complete the look of your home.

- **Voice-activated systems** such as Amazon Alexa, Google Assistant, Apple HomeKit and others are also a great option to control your lighting. With a simple voice command your lights will do whatever they're programmed to do. Music may also be incorporated with these systems for a soothing evening atmosphere.

- All light bulbs and light fixtures should be low lighting levels (intensity) and amber or red in color.

- If you do not need much light at night, **simple nightlights** may be used as well. Amber and red are good colors that do not interfere with our circadian system.

Conclusion

Changing the lighting in your home to follow the color of light outside can have many benefits for your life, health and overall daily activities. It may help you feel more energized during the day and help you sleep better at night. This booklet should serve as a guide in helping you add circadian lighting to your home.

Much research has been done on this type of lighting and we recommend you don't just take our word for it, but allow the research to speak for itself.

Resources

Lighting Research Center Light & Health Research | **lrc.rpi.edu**
Department of Energy (DOE) Reports | **energy.gov**
SMUD Customer Advanced Technologies Reports | **smud.org**

We wish you and your household many great active days and restful nights!

About the authors

Dave Bisbee is a Certified Energy Manager with over 29 years of experience in the energy industry working with commercial, residential and public-sector customers. Bisbee has served as a Project Manager for SMUD's Customer Advanced Technologies program for the past 18 years, testing emerging energy efficient technologies in real-world environments. He was awarded the California Military Department Medal of Merit while serving as a Resource Efficiency Manager for the California National Guard.

Connie Samla, PE, LC, is SMUD's Lighting Specialist with over 25 years of experience working with commercial, residential and industrial customers. Samla has a Bachelor of Science in Architectural Engineering from the University of Kansas, a Bachelor of Arts in Ministerial Studies, is a registered electrical engineer and is lighting certified. She has been working with customers on how circadian lighting and proper lighting design can help them with sleep, health and their daily activity.

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