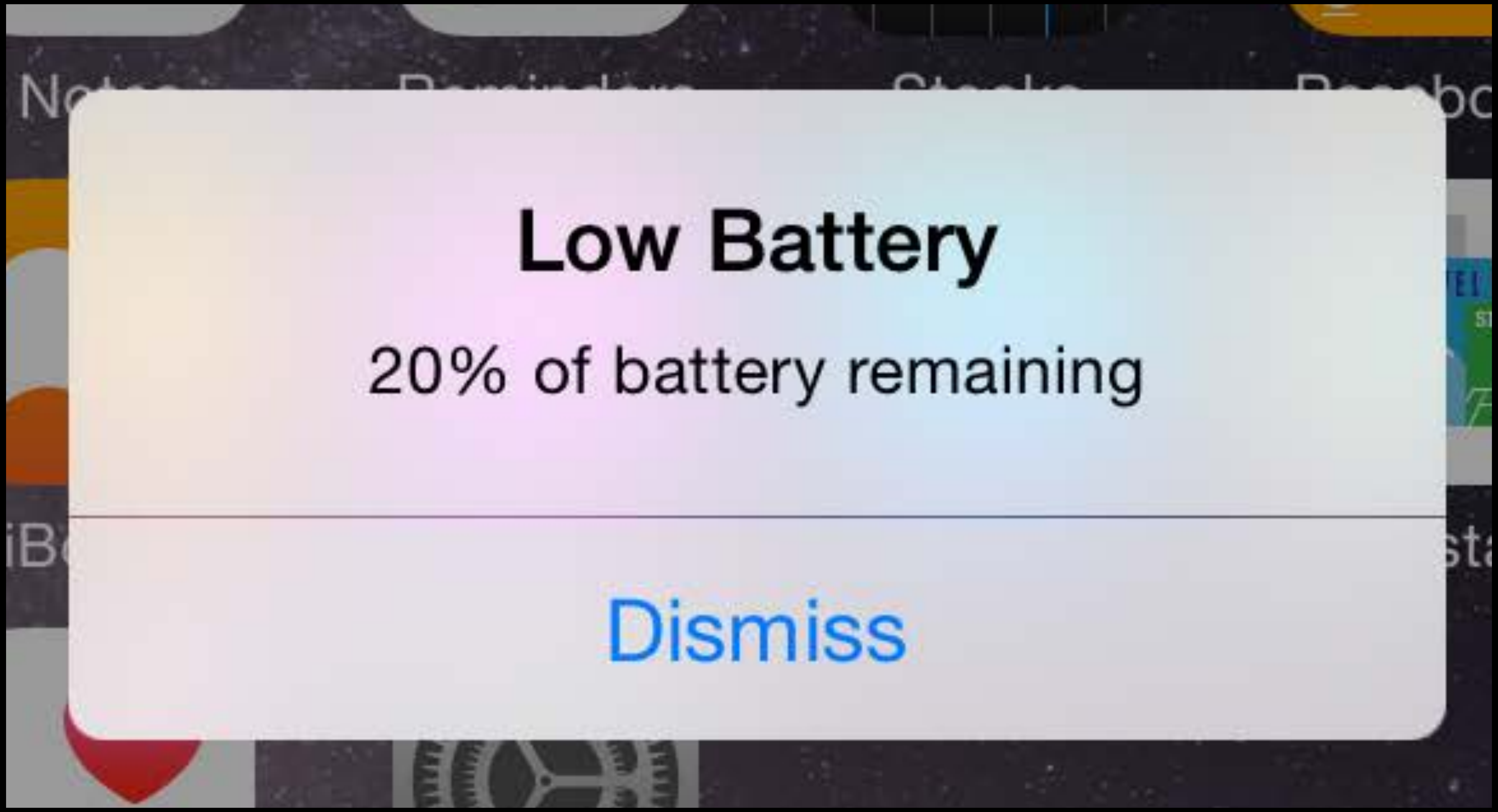
Achieving All-Day Battery Life

Knowing is half the battle

Session 707

Jon Andrews Core OS
Soren Spies Core OS

All-Day Battery Life?



Low Battery

20% of battery remaining

What Users Expect

Computing Energy

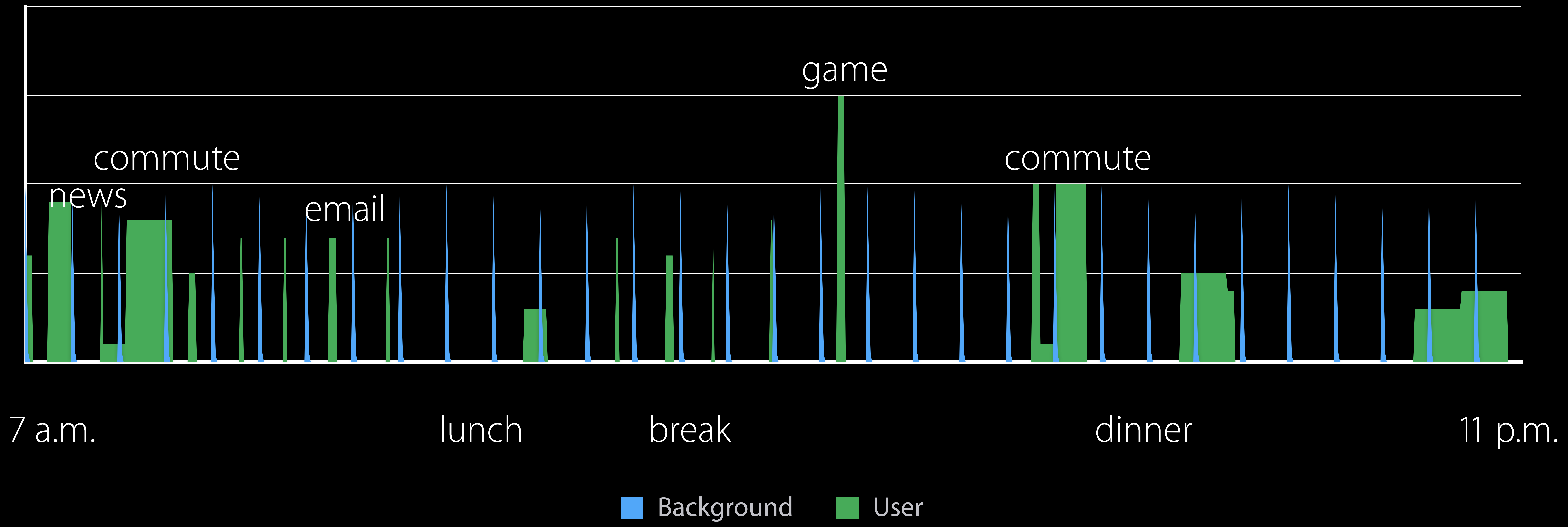
OS Energy Improvements

Developers’ Role

Your Software (Soren)

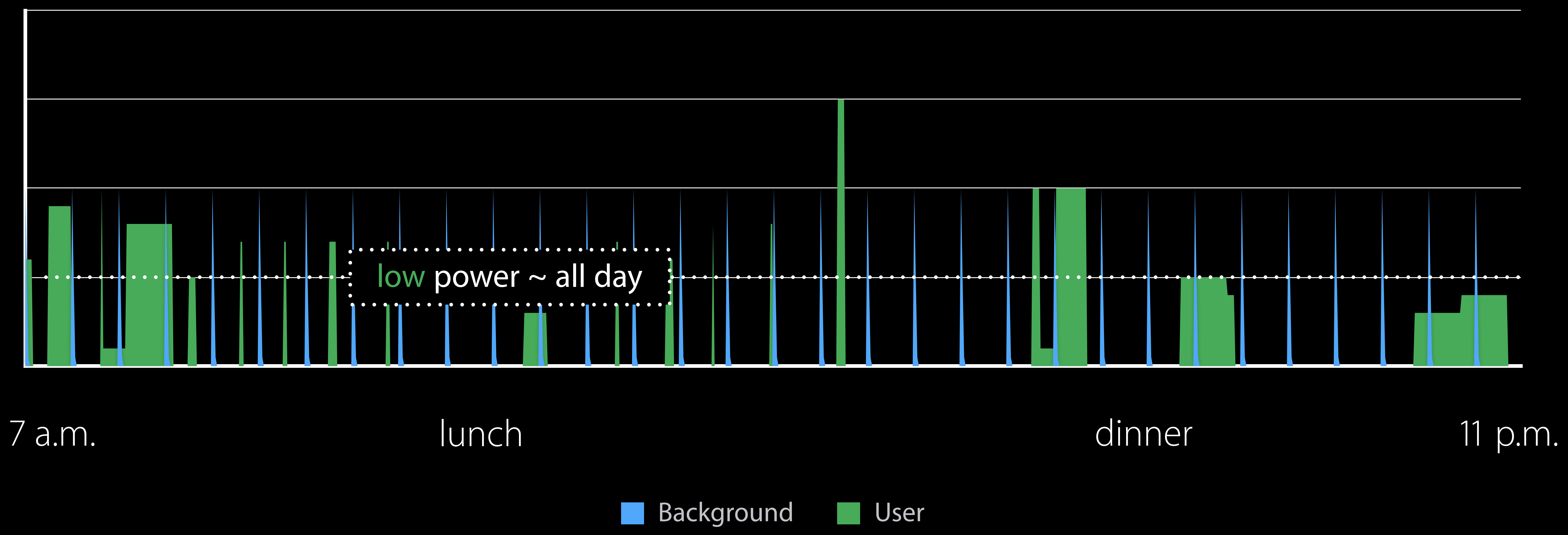
What Users Expect

All-day battery life



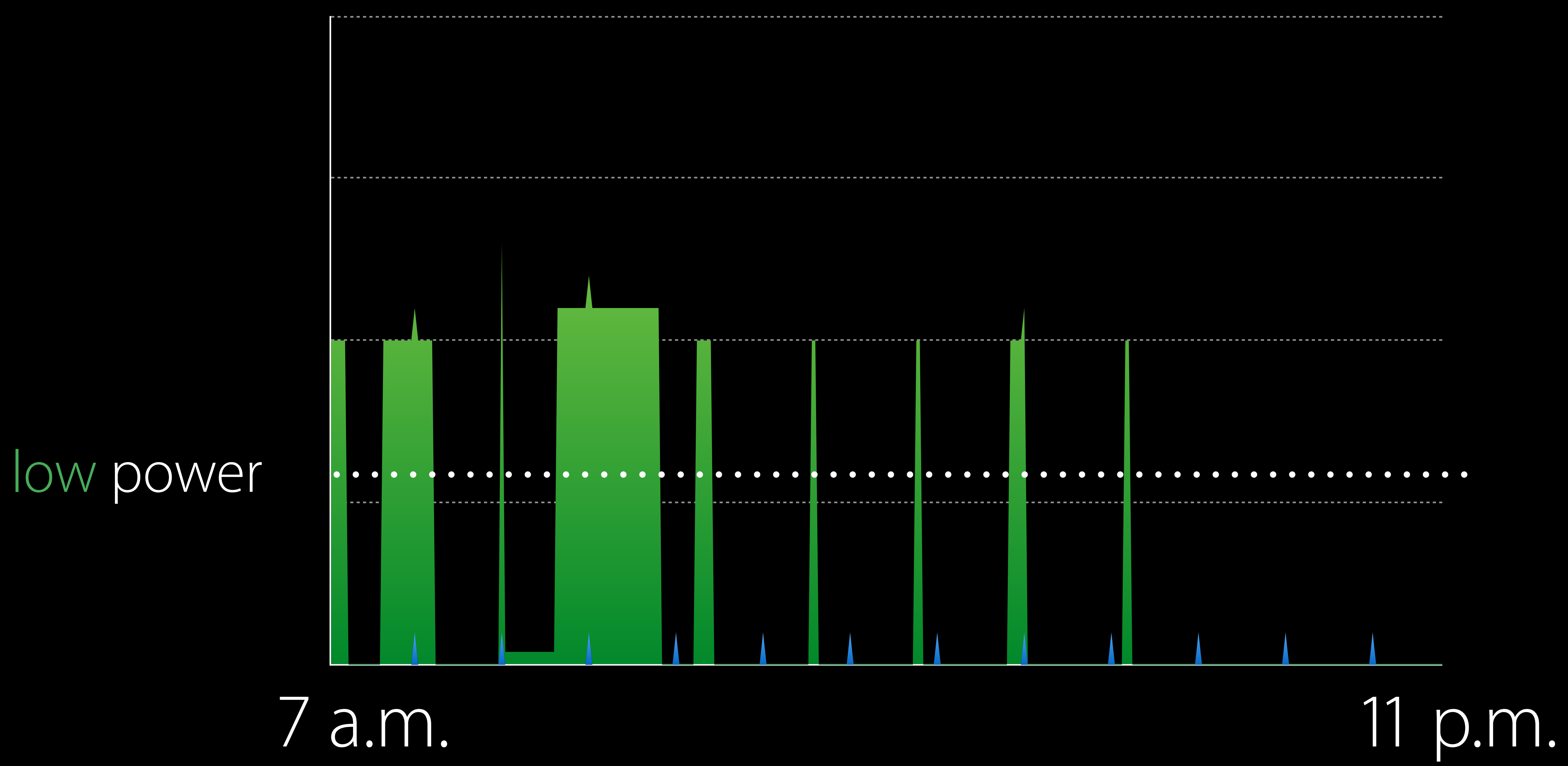
What Users Expect

All-day battery life



What Users Expect

Low power ~ all-day battery life

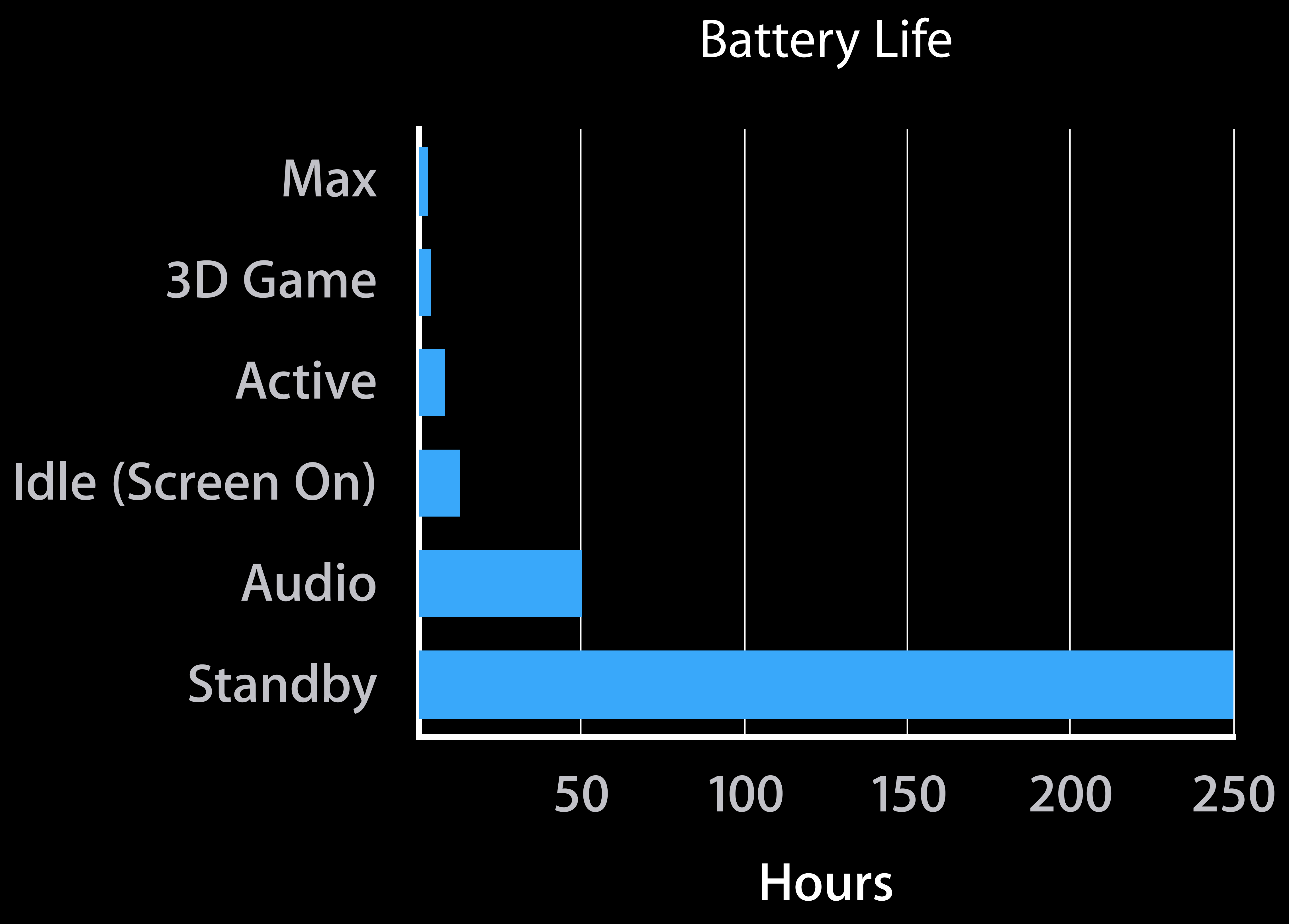


Computing Energy

Fundamentals

Energy = power × time

Less power = more time

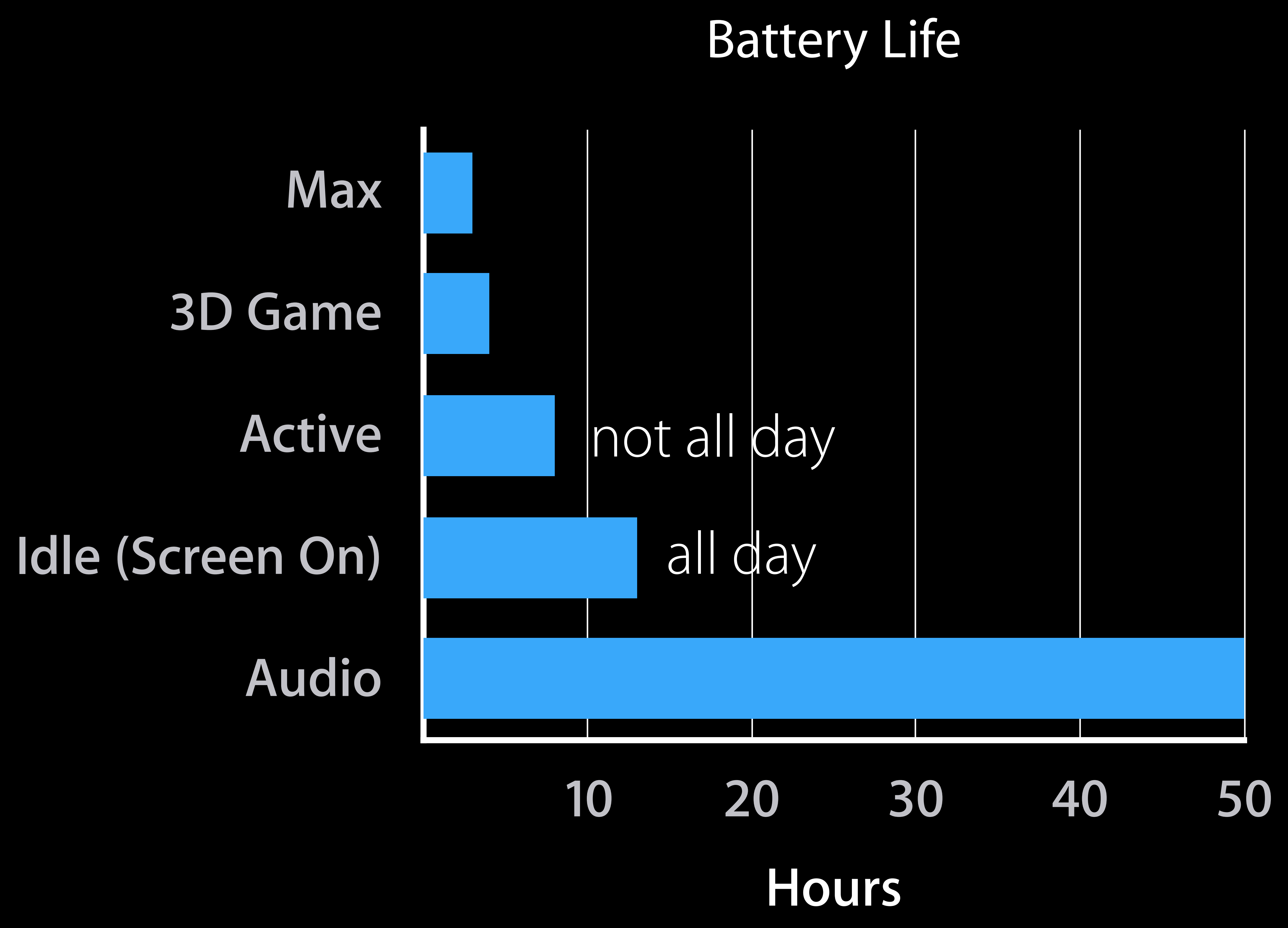


Computing Energy

Fundamentals

Energy = power × time

Make your app more like idle



Computing Energy

Trends

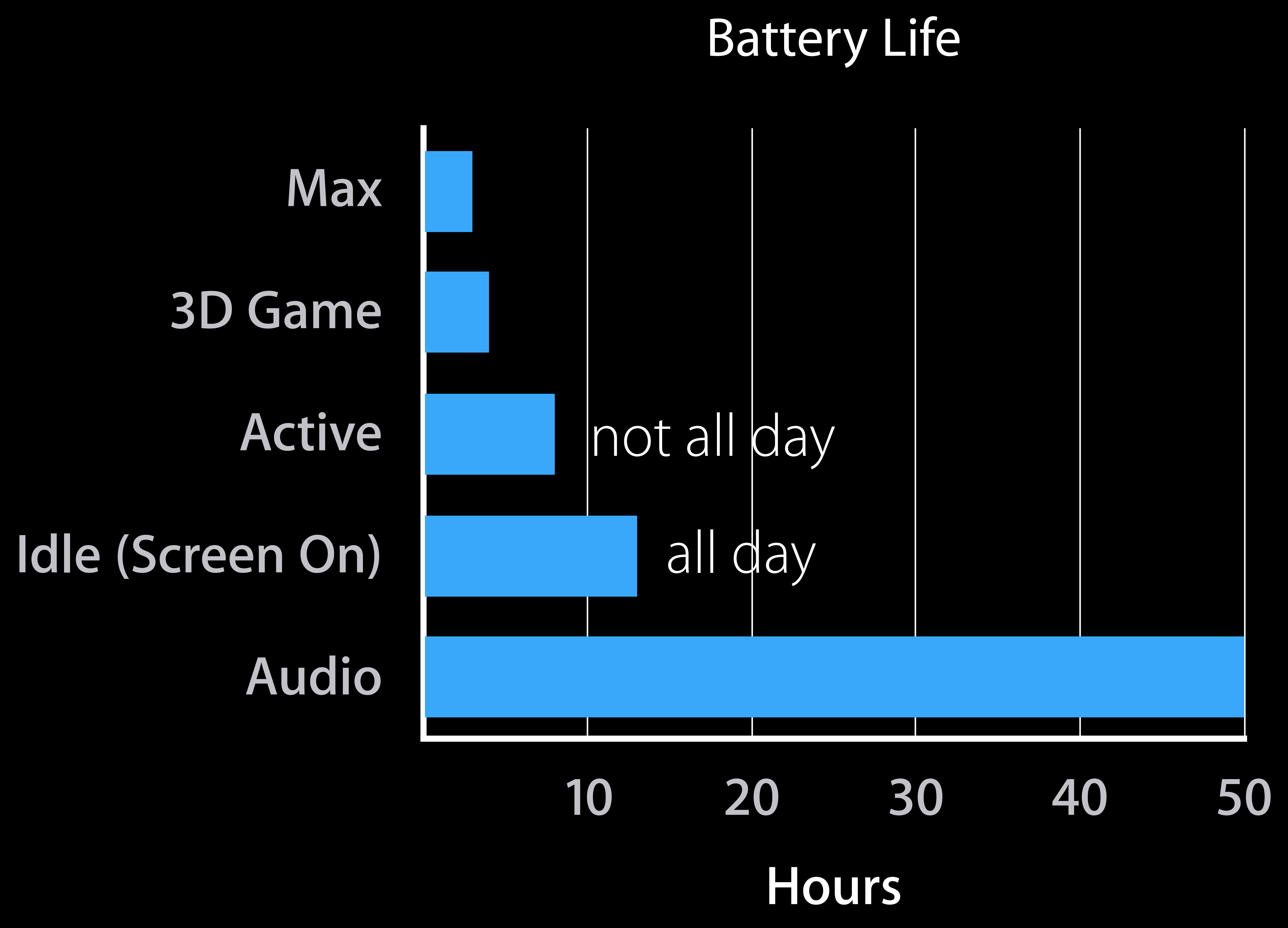
Energy = power × time

Dynamic range growing

- iOS devices getting closer to MacBook

New products more power-efficient

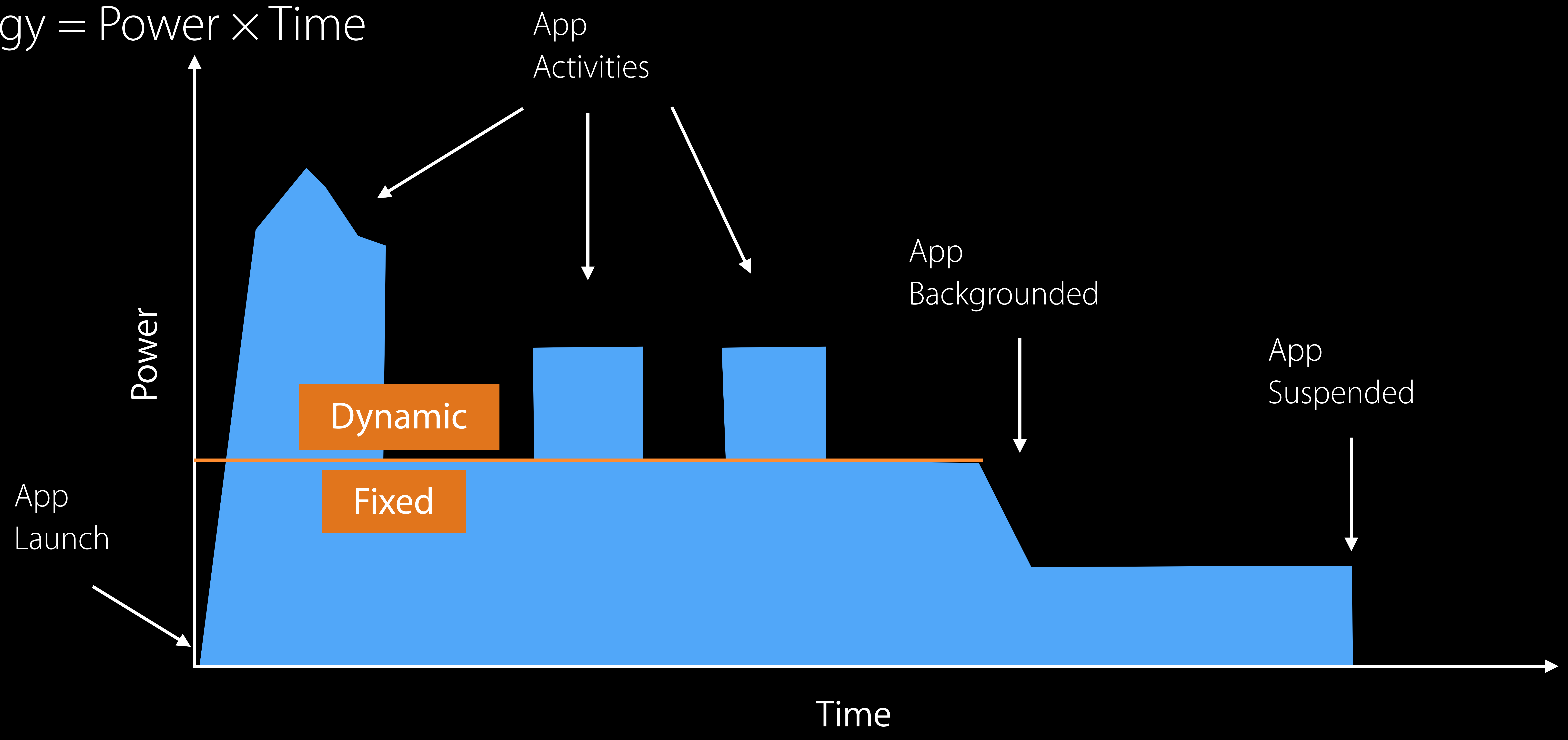
- Yet peak power increases



Computing Energy

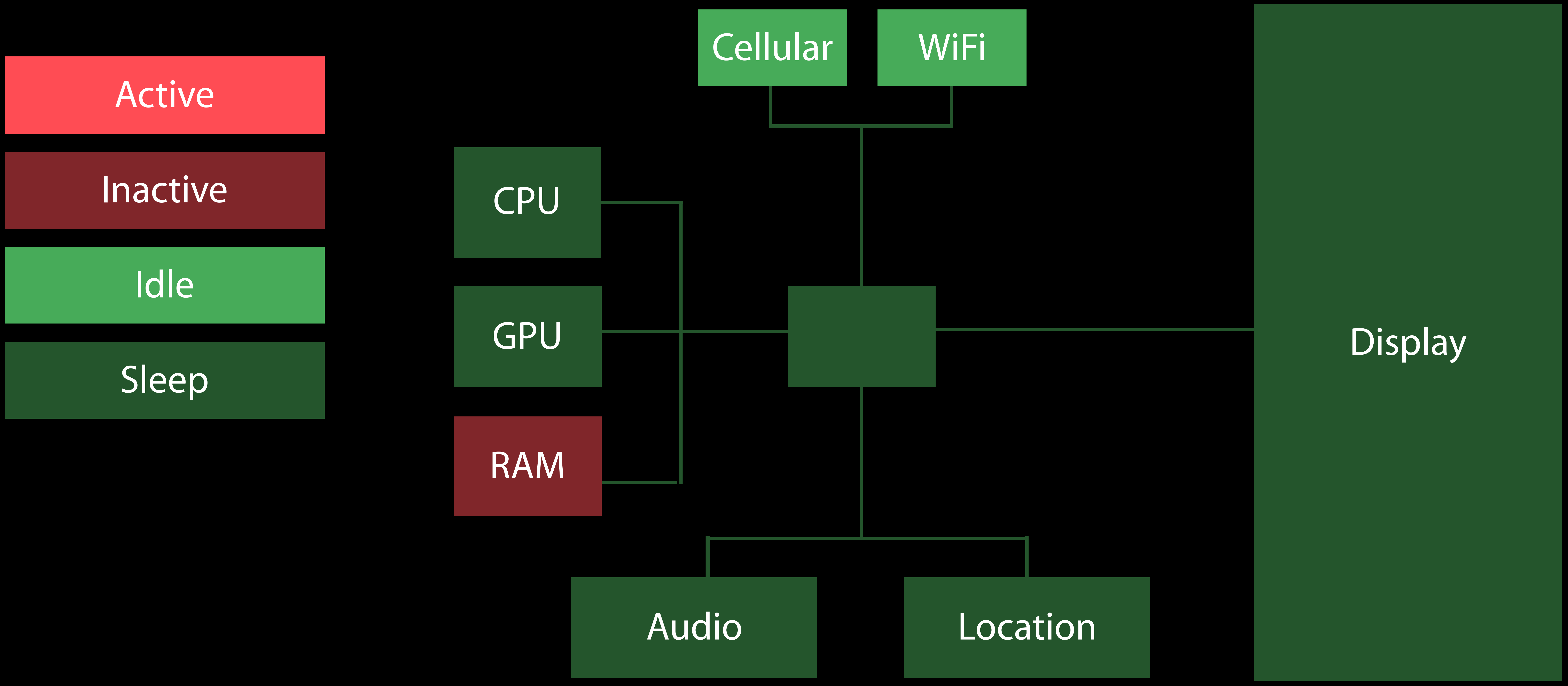
Fixed and dynamic costs

Energy = Power × Time



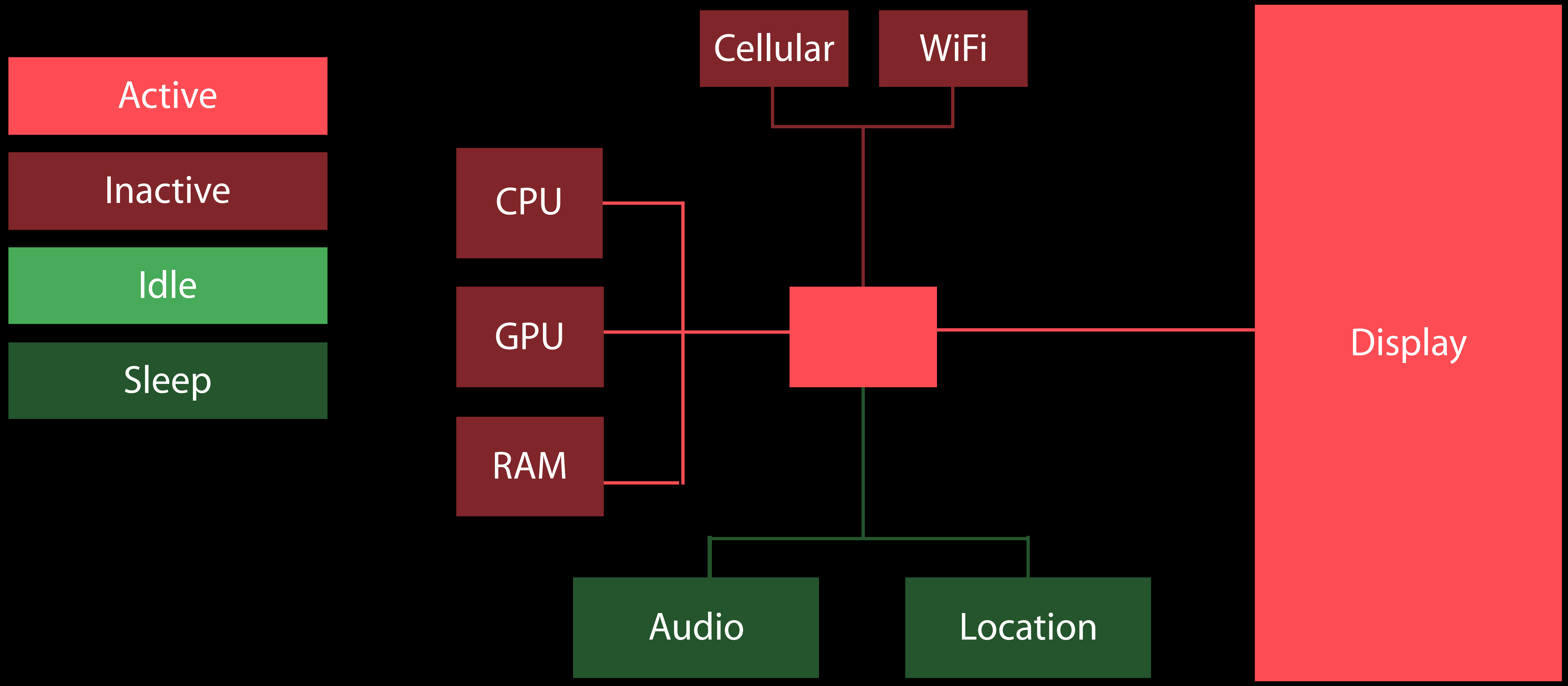
Computing Energy

Standby



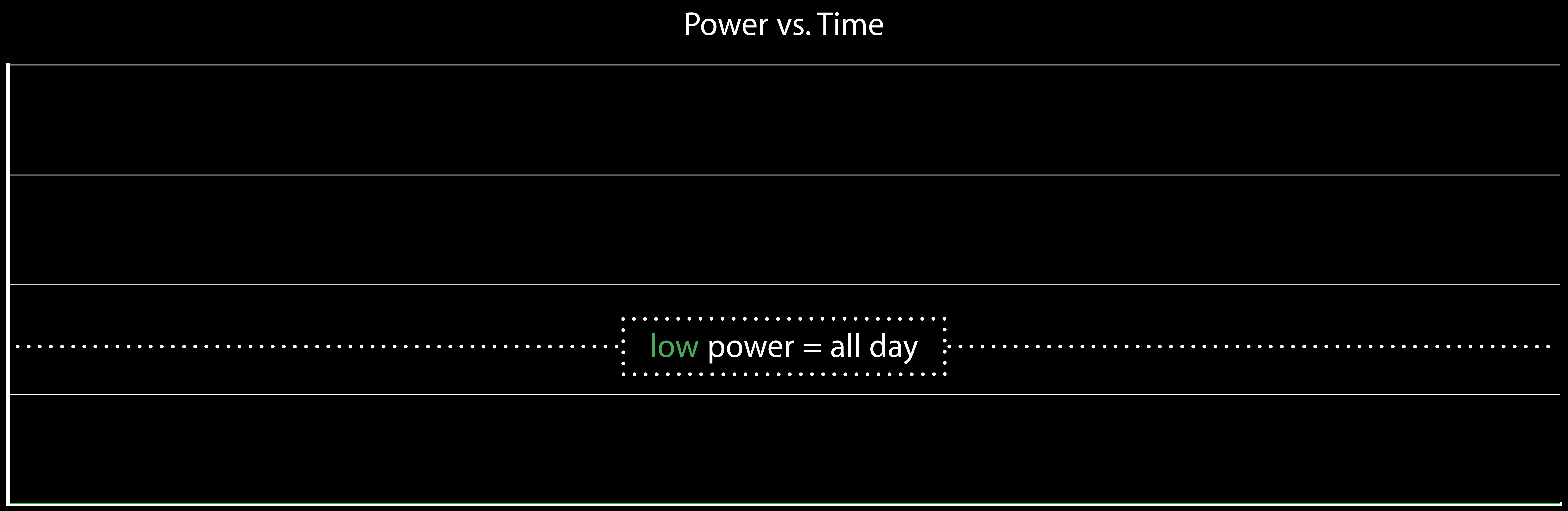
Computing Energy

User idle



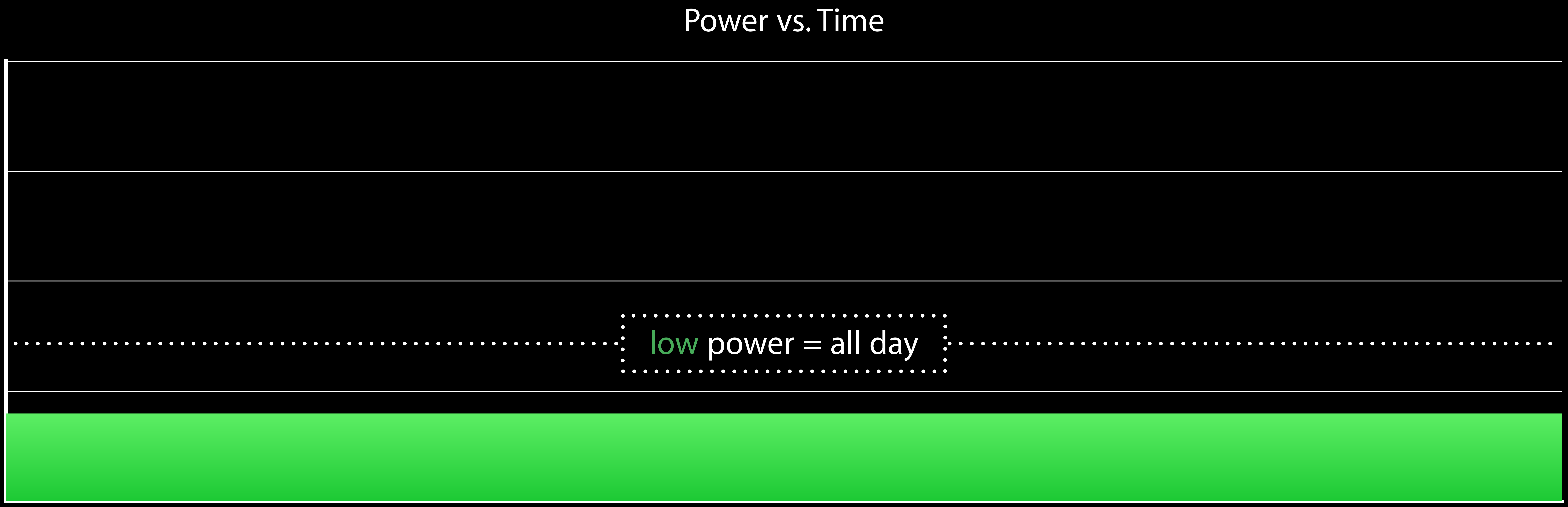
Battery Drain Rate

User idle



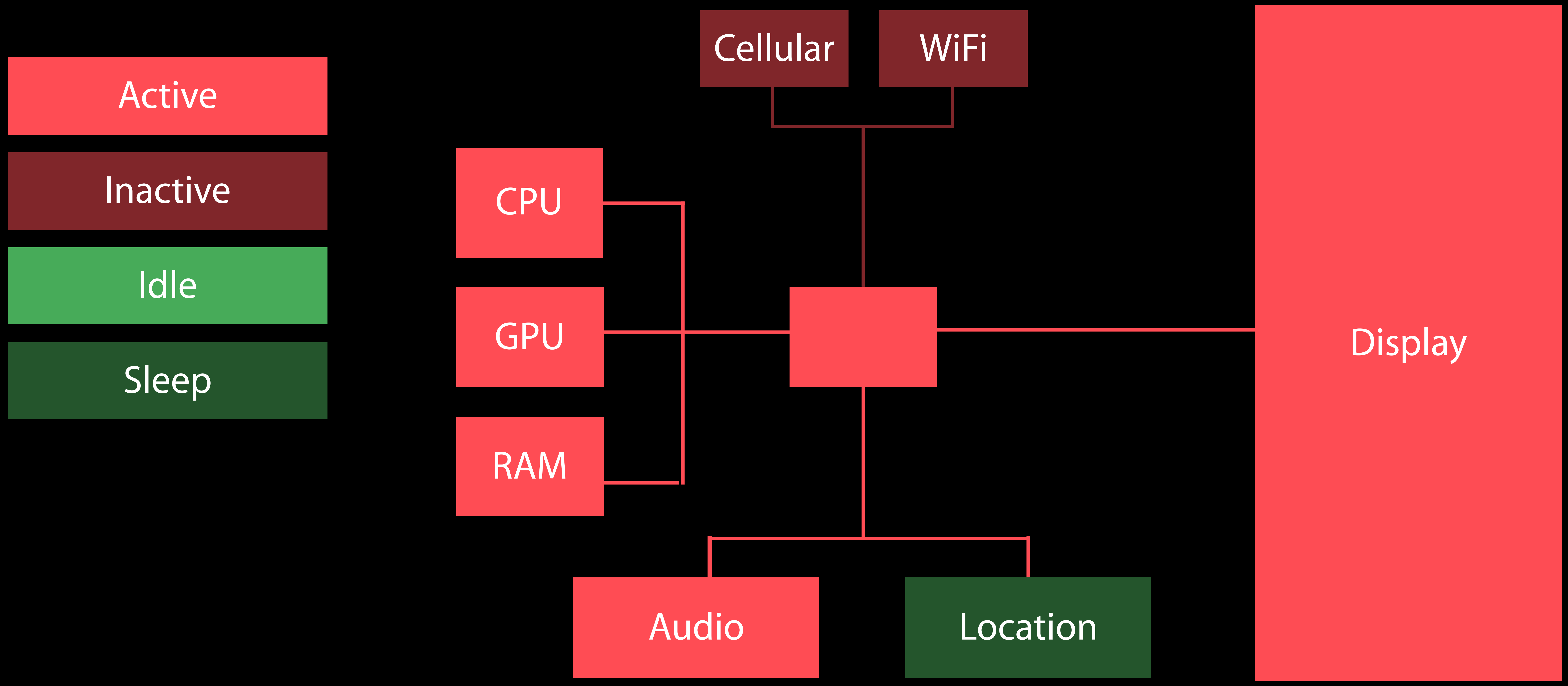
Battery Drain Rate

User idle



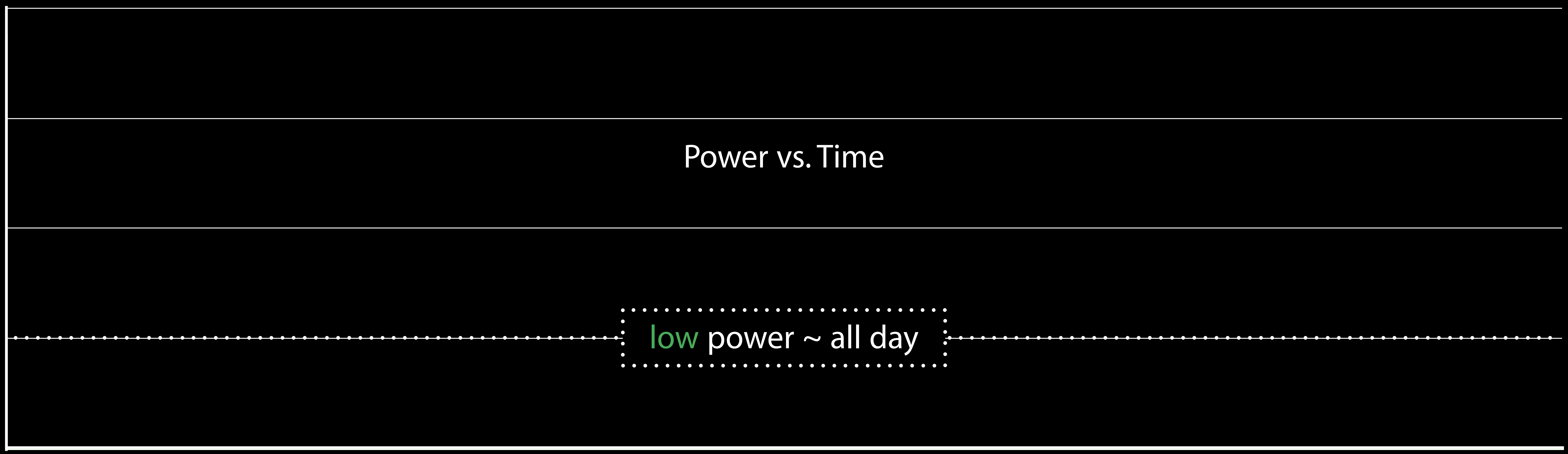
Computing Energy

3D game



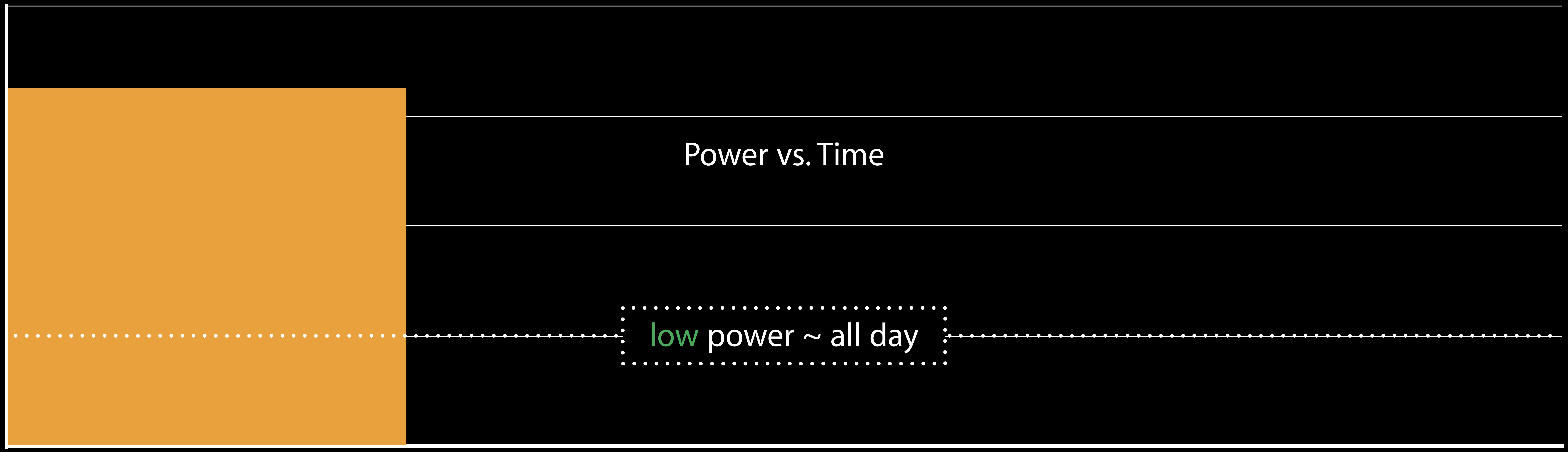
Battery Drain Rate

3D game



Battery Drain Rate

3D game



Energy Optimization Strategy

Do work less

Do work later

Do work efficiently

iOS 9 Improvements

iOS battery life best-in-class

- … our customers want better

iOS 9 is better on existing hardware

- Up to one hour better battery life
- iOS and system apps energy-optimized

Like OS X Mavericks

Eliminated polling in apps, frameworks, drivers, kernel

Quality of service (QoS) for CPU and IO

Timer coalescing and rate limiting

More efficient CPU power management

“Significant Energy” in battery menu

iOS 9 Improvements

Focused on iPhone

Improve all iOS products

iOS 9 Improvements

Do less work

Optimized sleep timers

Idle power

- Reduce CPU wake-ups

Face-down detection

- Don’t light the screen on notifications

iOS 9 Improvements

Do work later

Defer more work until plugged in

Defer some networking until WiFi

Leverage persistent connection API

iOS 9 Improvements

Do work efficiently

Optimized iOS networking stack for LTE

Optimized power management

Reduced cost of logging

More numerics optimizations

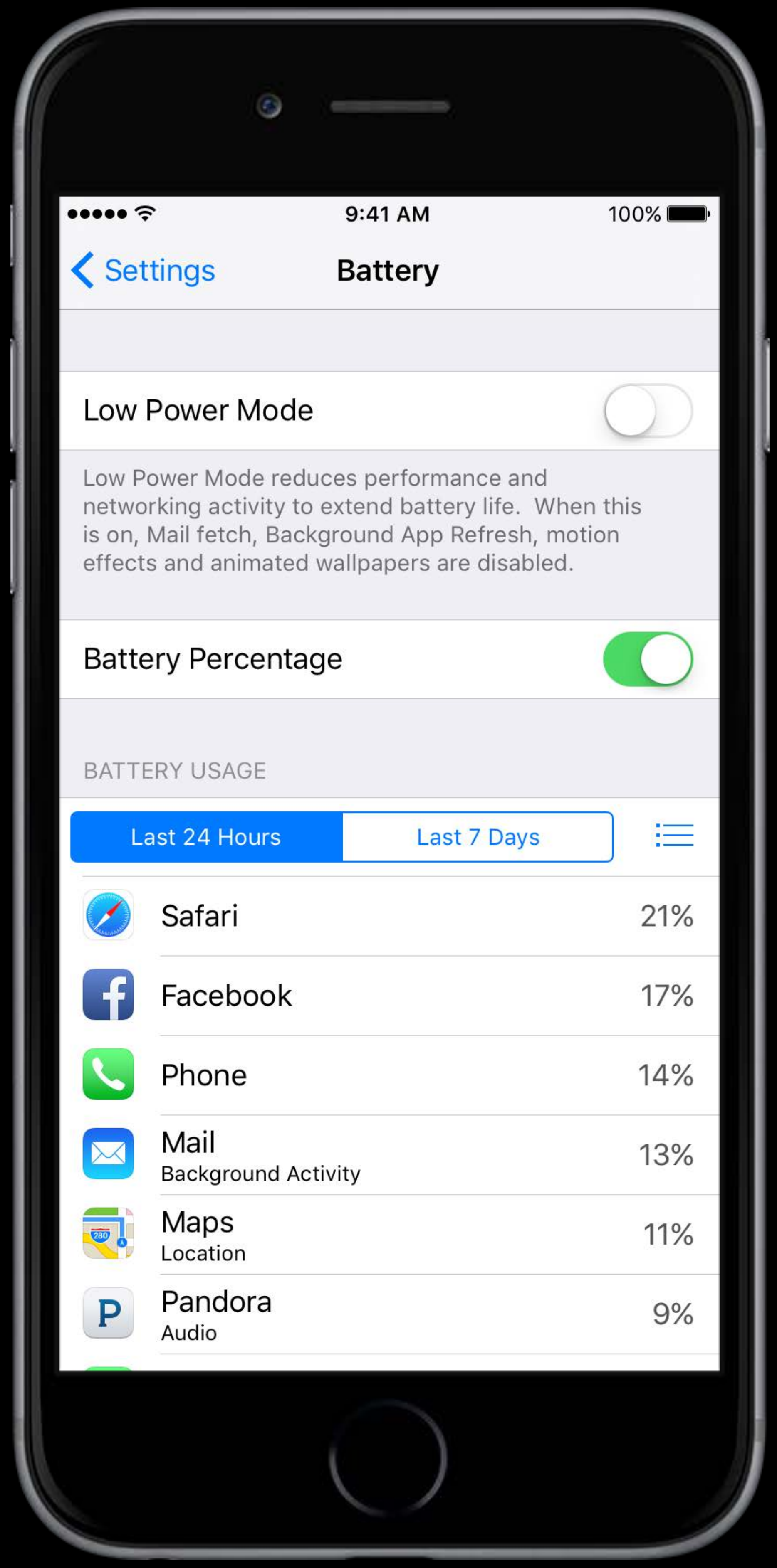
iOS 9 Improvements

User feedback

Per-app battery usage

Environmental factors

Intelligent suggestions



Low Power Mode ○

Low Power Mode reduces performance and networking activity to extend battery life. When this is on, Mail fetch, Background App Refresh, motion effects and animated wallpapers are disabled.

Battery Percentage ●

BATTERY USAGE

Safari	21%
Facebook	17%
Phone	14%
Mail Background Activity	13%
Maps Location	11%
Pandora Audio	9%

iOS 9 Improvements

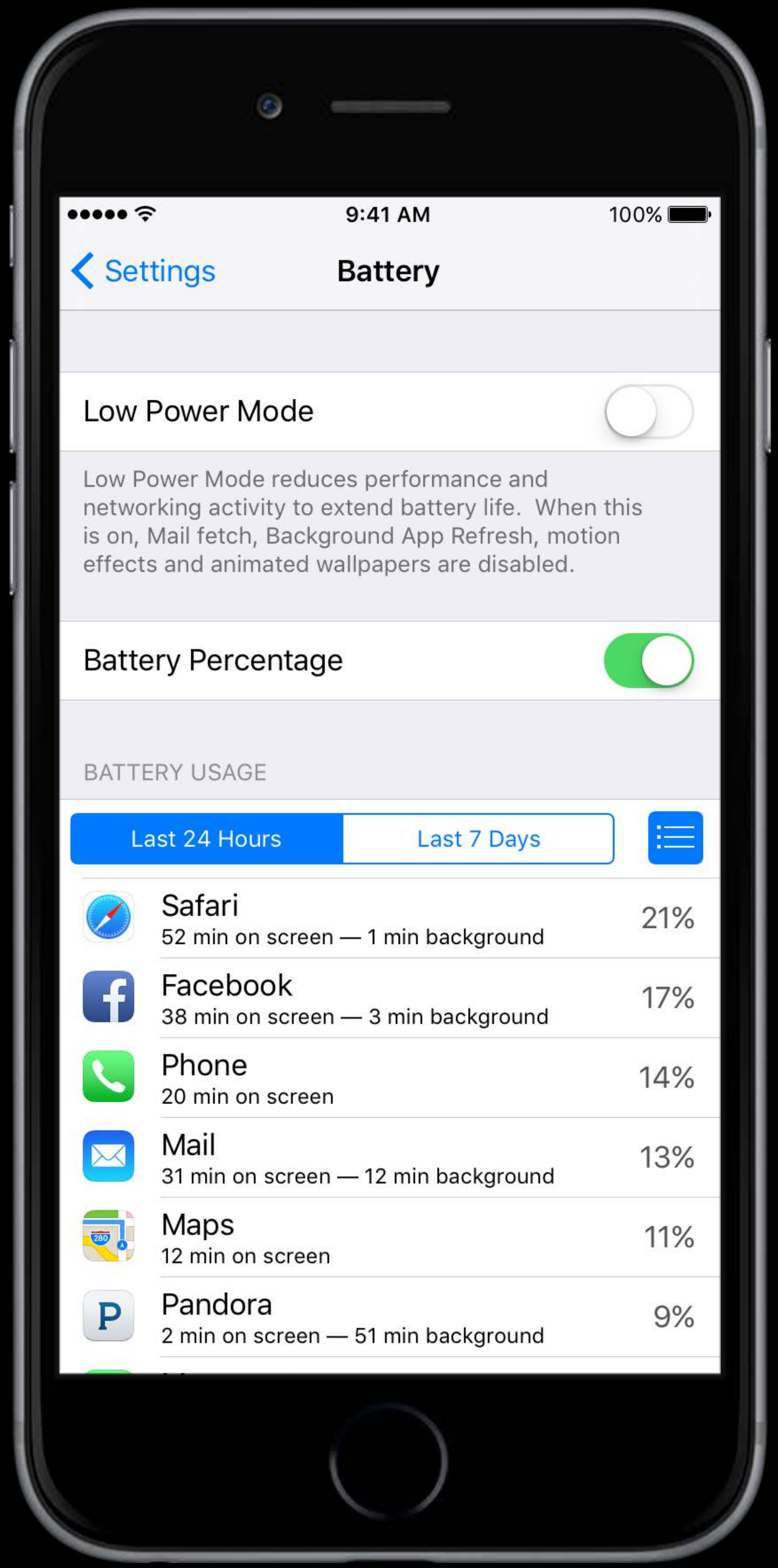
User feedback

Per-app battery usage

Environmental factors

Intelligent suggestions

New: Per-app screen and background time



9:41 AM 100%

Settings Battery

Low Power Mode ○

Low Power Mode reduces performance and networking activity to extend battery life. When this is on, Mail fetch, Background App Refresh, motion effects and animated wallpapers are disabled.

Battery Percentage ●

BATTERY USAGE

Last 24 Hours | Last 7 Days

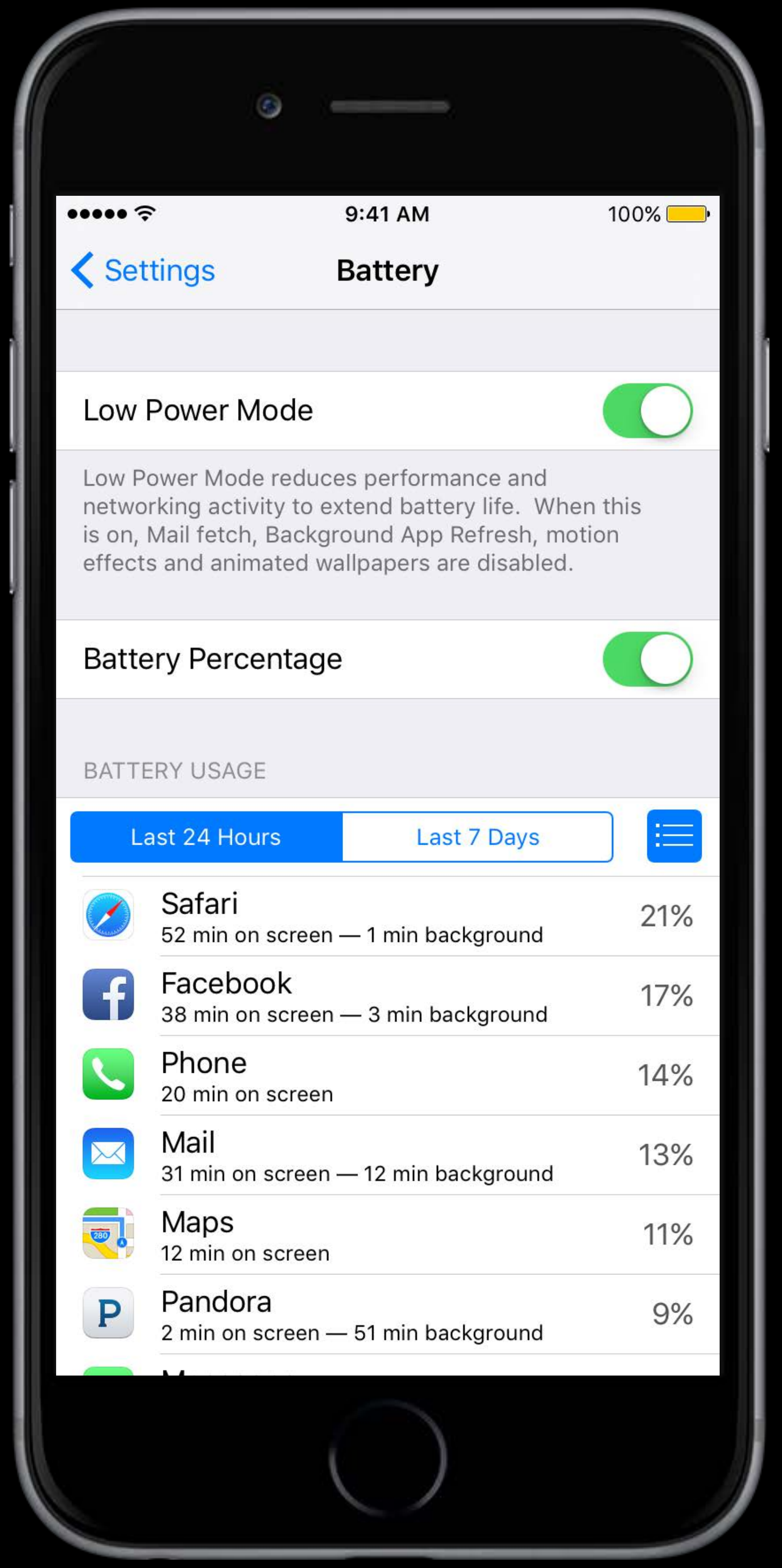
Safari 52 min on screen — 1 min background	21%
Facebook 38 min on screen — 3 min background	17%
Phone 20 min on screen	14%
Mail 31 min on screen — 12 min background	13%
Maps 12 min on screen	11%
Pandora 2 min on screen — 51 min background	9%

iOS 9 Improvements

User feedback

User-initiated Low Power Mode

- Limit CPU performance
- No Background App Refresh
- No discretionary/background downloads
- No mail fetch



Low Power Mode ●

Low Power Mode reduces performance and networking activity to extend battery life. When this is on, Mail fetch, Background App Refresh, motion effects and animated wallpapers are disabled.

Battery Percentage ●

BATTERY USAGE

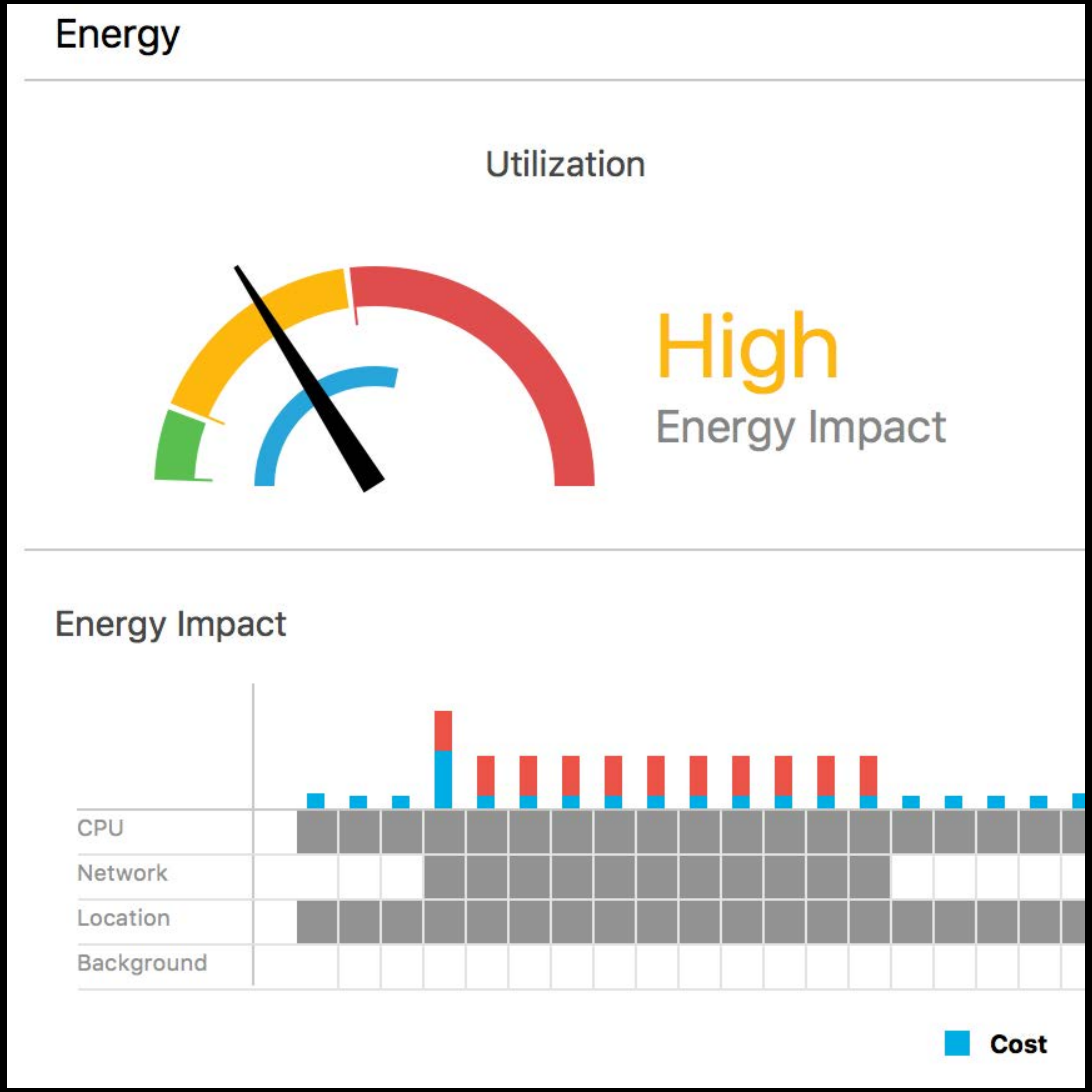
Safari 52 min on screen — 1 min background	21%
Facebook 38 min on screen — 3 min background	17%
Phone 20 min on screen	14%
Mail 31 min on screen — 12 min background	13%
Maps 12 min on screen	11%
Pandora 2 min on screen — 51 min background	9%

iOS 9 Improvements

Developer feedback

iOS energy gauge in Xcode

Location instrument



Developers' Role

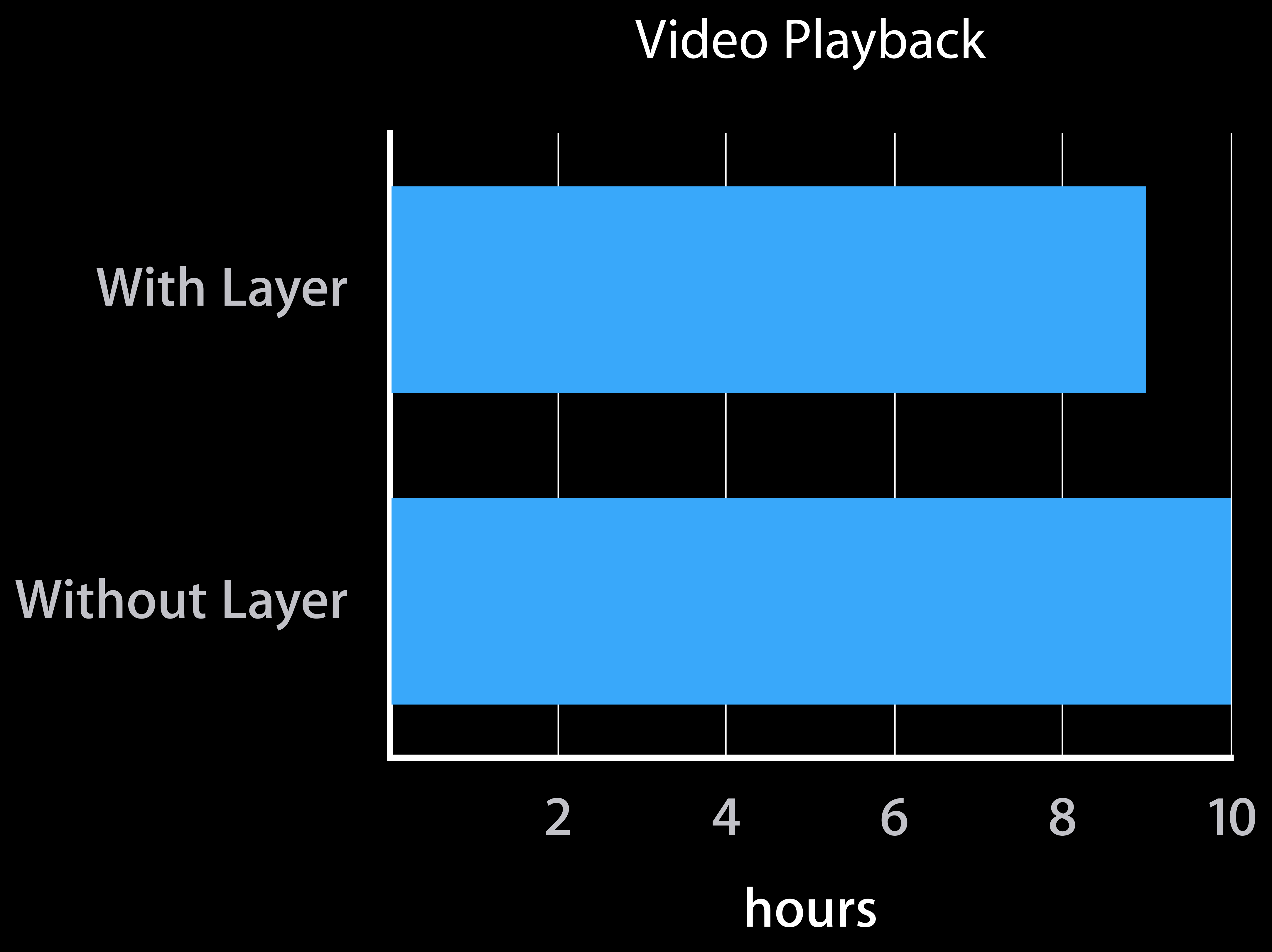
Example: Video playback

Full-screen video optimization

- Reduce backlight
- Adjust gamma to compensate

Overlay UI disables

Power delta is small, but videos often long



Developers' Role

OS X

MacBook

- Thermally constrained (no fan)
- Works best with bursts
- QoS is critical for responsiveness

Optimize

- Existing OS X gauge & instruments
- Prioritize work with NSOperation/GCD

Developers’ Role

Understanding

Energy = power × time

Hardware has a large dynamic range

Low power for all-day battery life

Reducing Software Energy

Your code vs. users' batteries

Soren Spies, Core OS

The Battery Is for the User

CPU and GPU Energy

Achieving Low (Average) Power for All-Day Battery Life

iOS Energy Consumption

Energy-Aware Development

The Battery Is for the User

Strategy

Do less work, less often

- Eliminate polling, timers
- Respond to user, then absolute idle

The Battery Is for the User

Strategy

Do less work, less often

- Eliminate polling, timers
- Respond to user, then absolute idle

Do work later

- Does the user need this NOW?

The Battery Is for the User

Strategy

Do less work, less often

- Eliminate polling, timers
- Respond to user, then absolute idle

Do work later

- Does the user need this NOW?

Do work efficiently

- Batch work into user-driven bursts
- Optimize power and time ~ lower energy

The Battery Is for the User

Strategy

Do less work, less often

- Eliminate polling, timers
- Respond to user, then absolute idle

Do work later

- Does the user need this NOW?

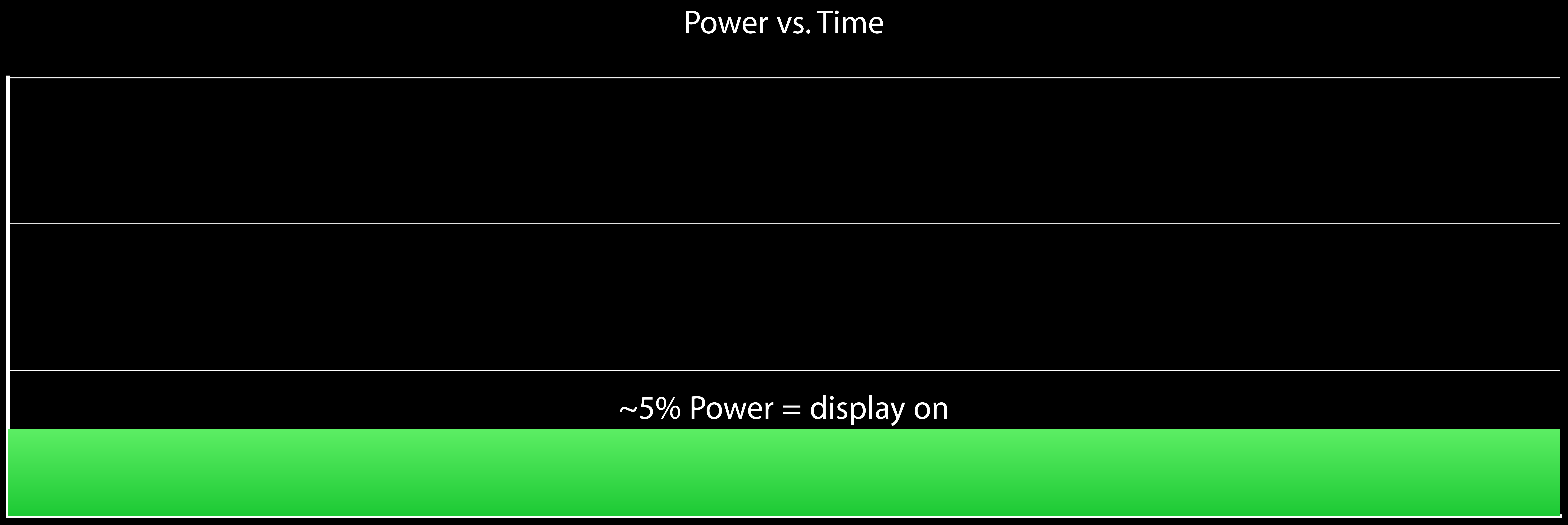
Do work efficiently

- Batch work into user-driven bursts
- Optimize power and time ~ lower energy

All-day battery life
assumes ~10% load

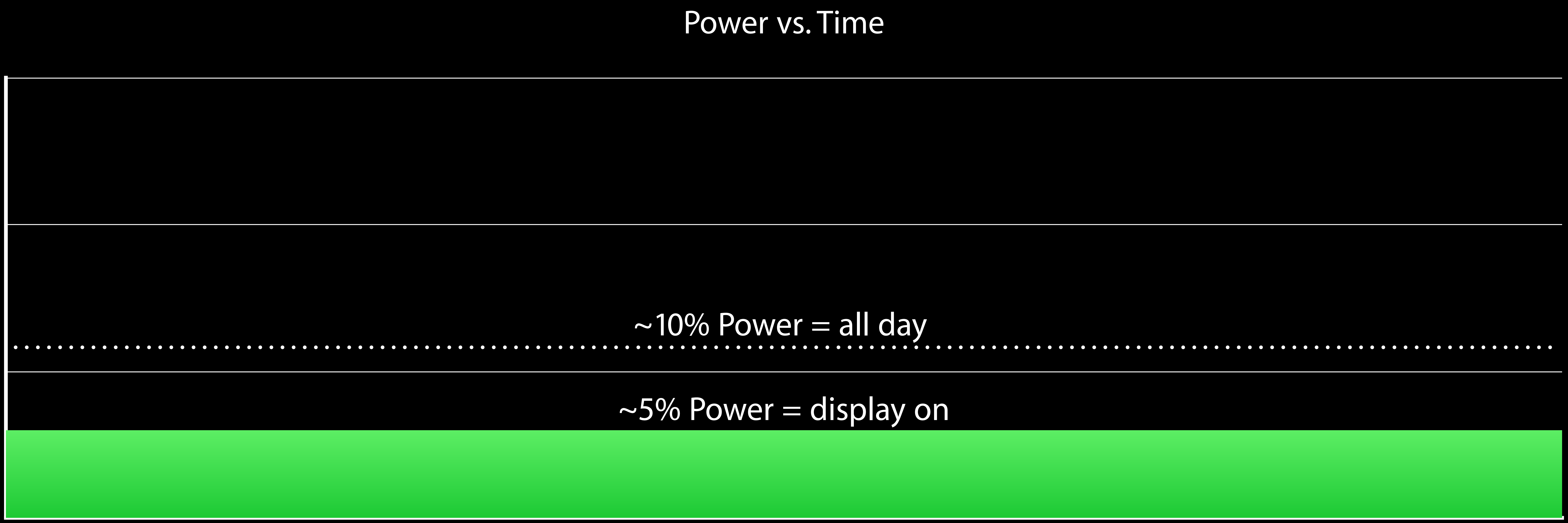
The Battery Is for the User

User should control energy use



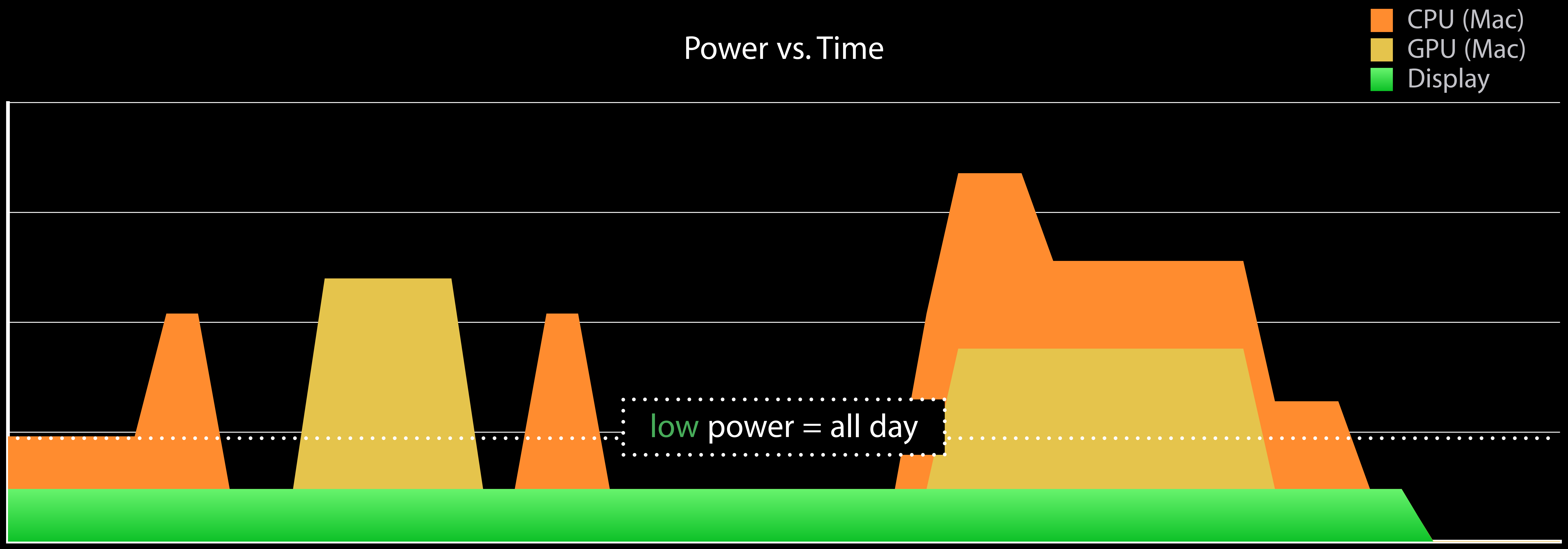
The Battery Is for the User

User should control energy use



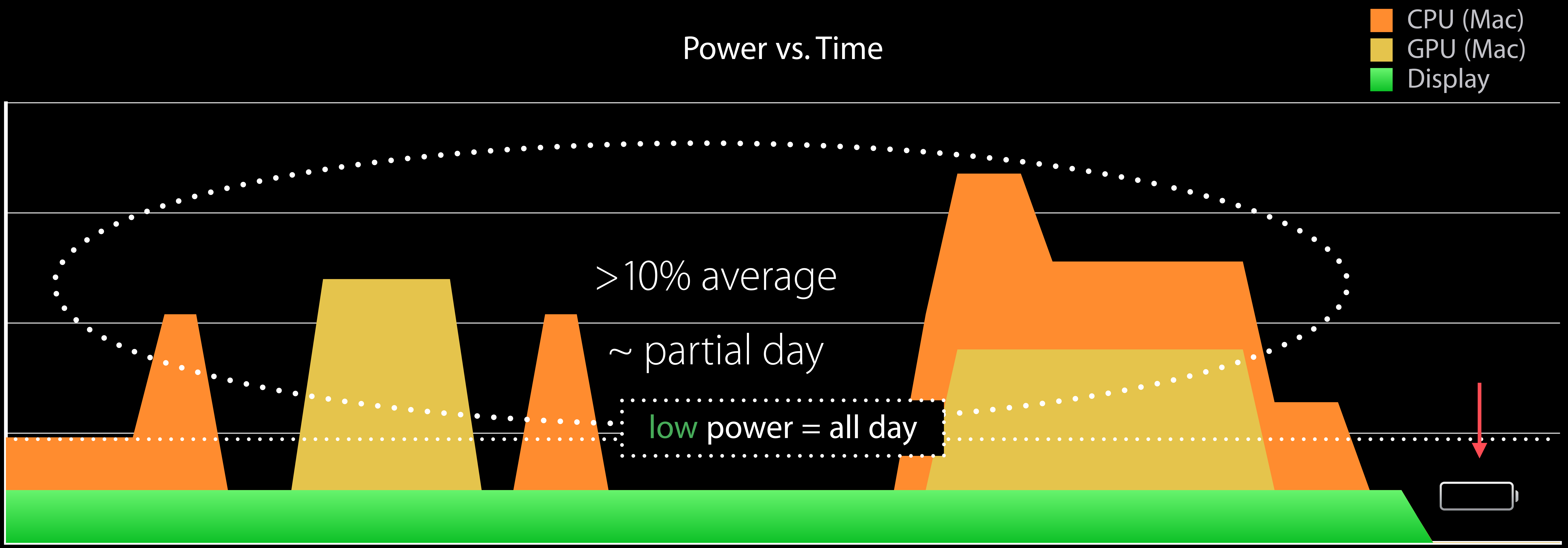
CPU and GPU Energy

Biggest consumers on OS X



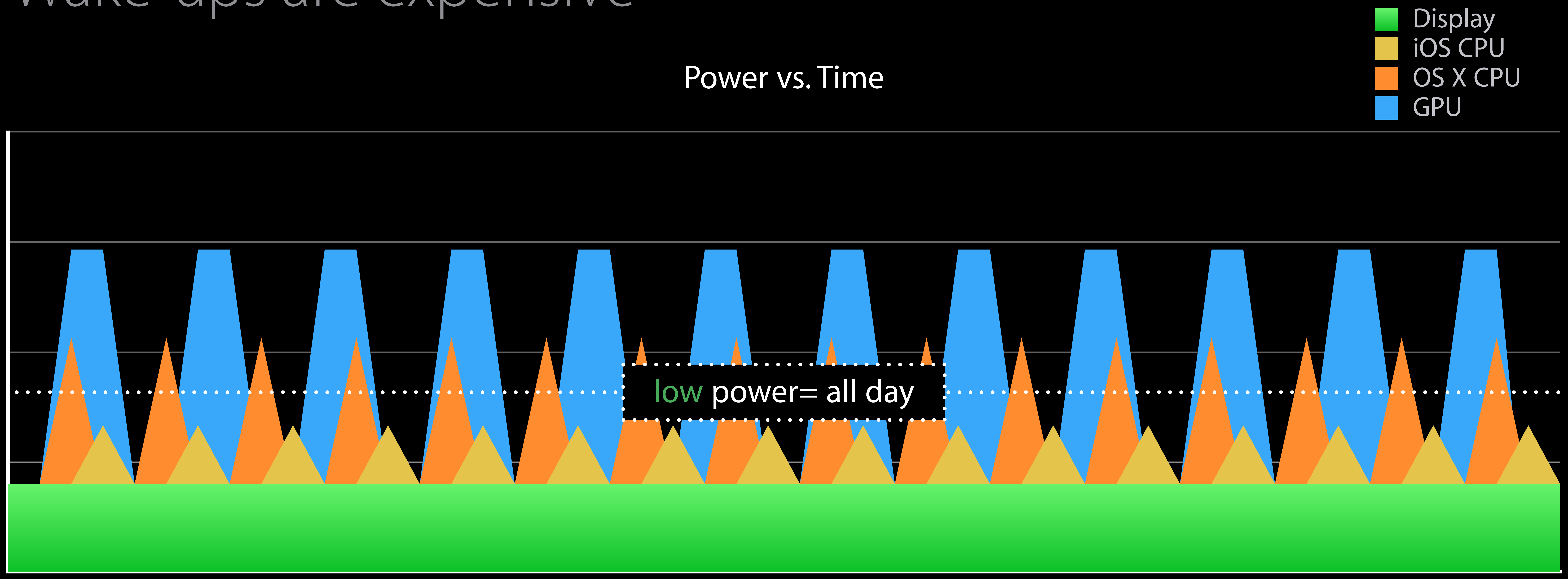
CPU and GPU Energy

Biggest consumers on OS X



CPU and GPU Energy

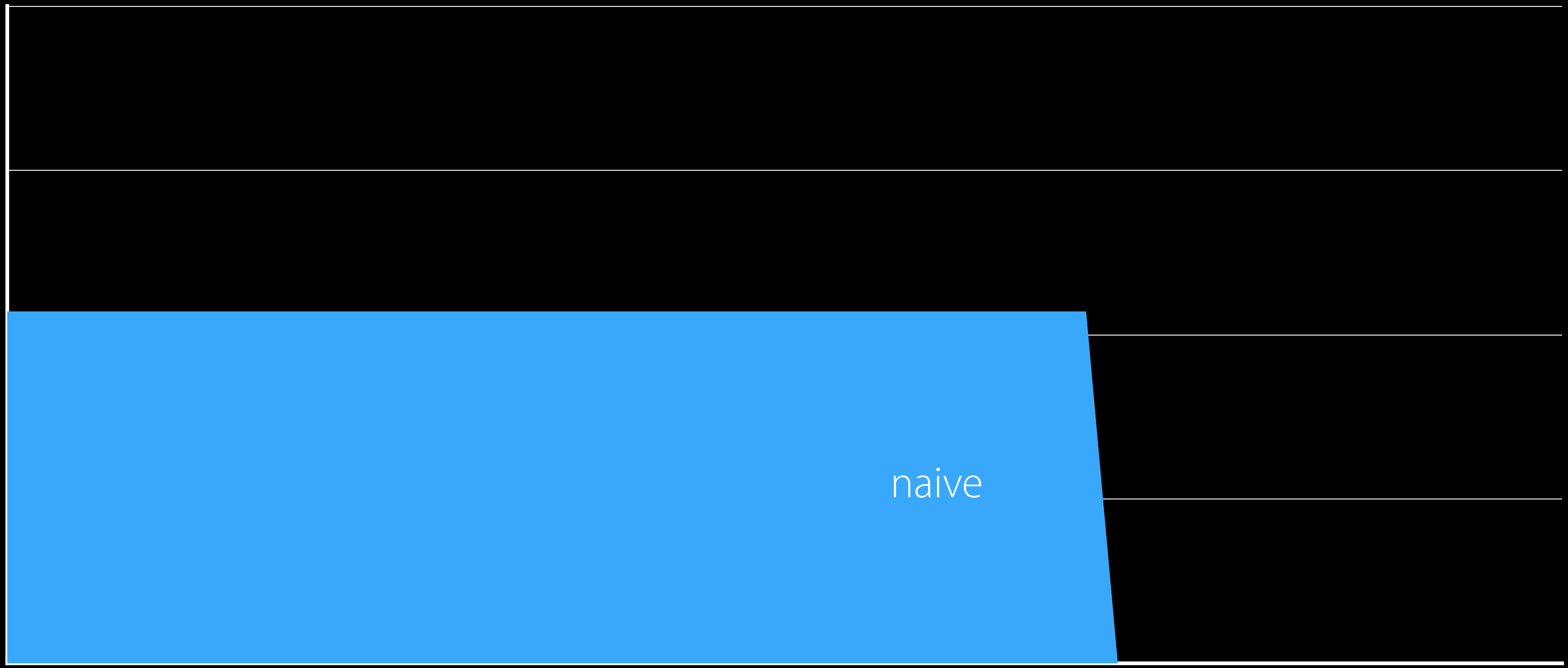
Wake-ups are expensive



CPU and GPU Energy

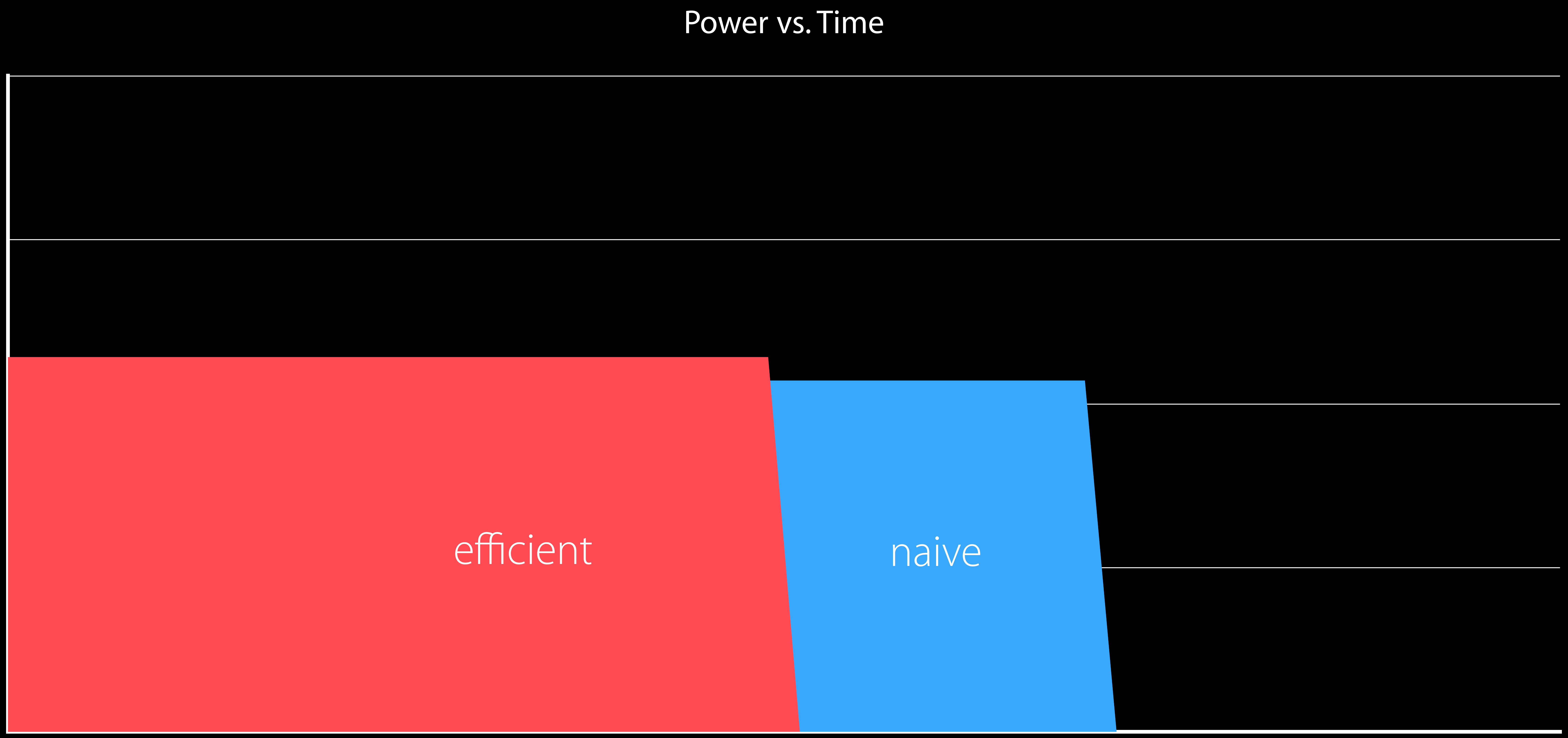
Faster = less energy

Power vs. Time



CPU and GPU Energy

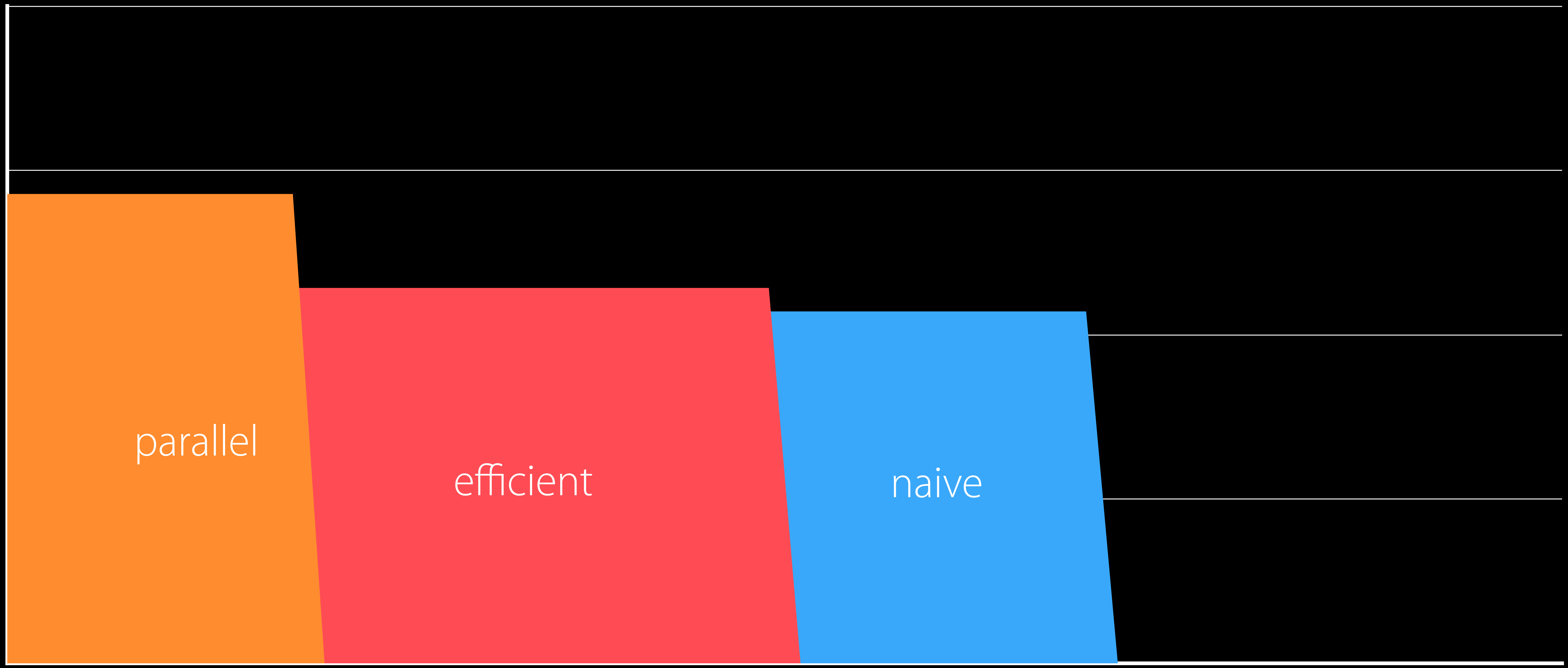
Faster = less energy



CPU and GPU Energy

Faster = less energy

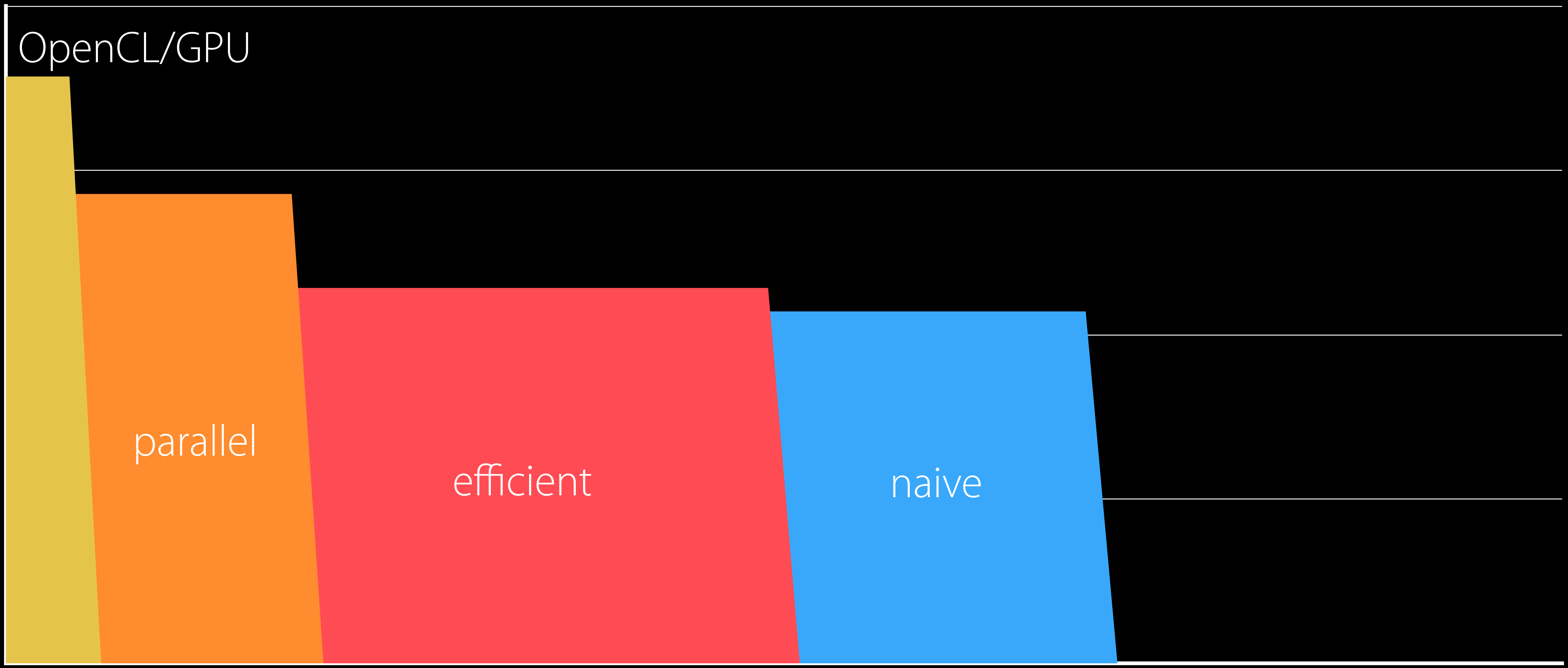
Power vs. Time



CPU and GPU Energy

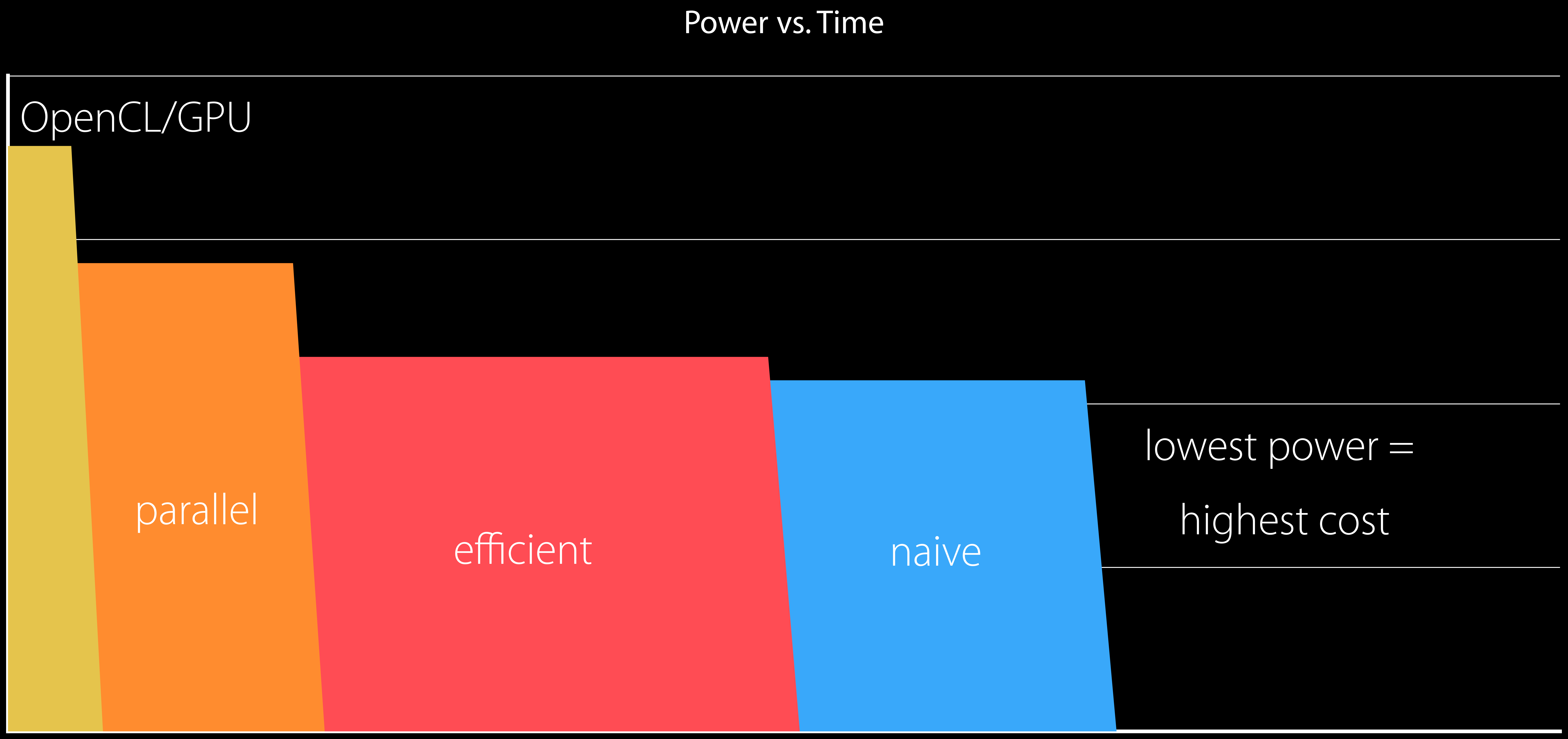
Faster = less energy

Power vs. Time



CPU and GPU Energy

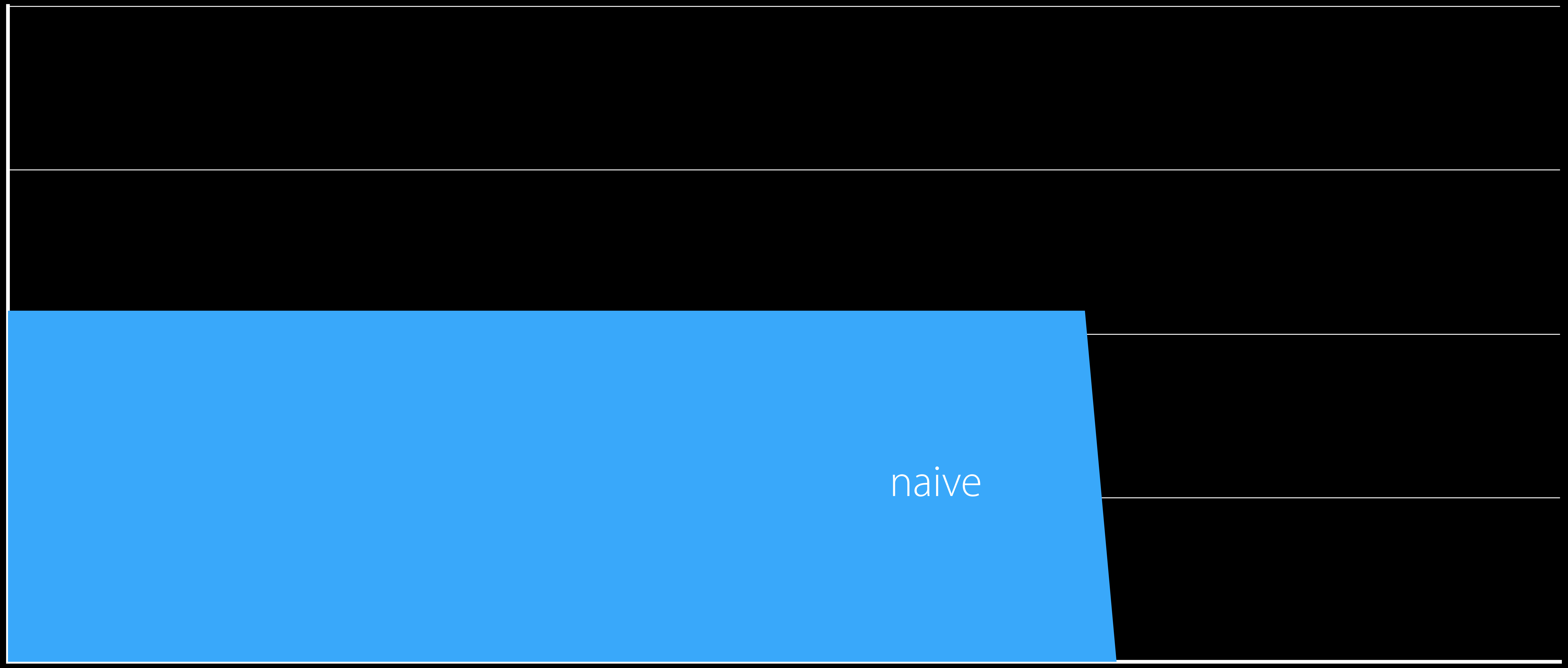
Faster = less energy



CPU and GPU Energy

Why?

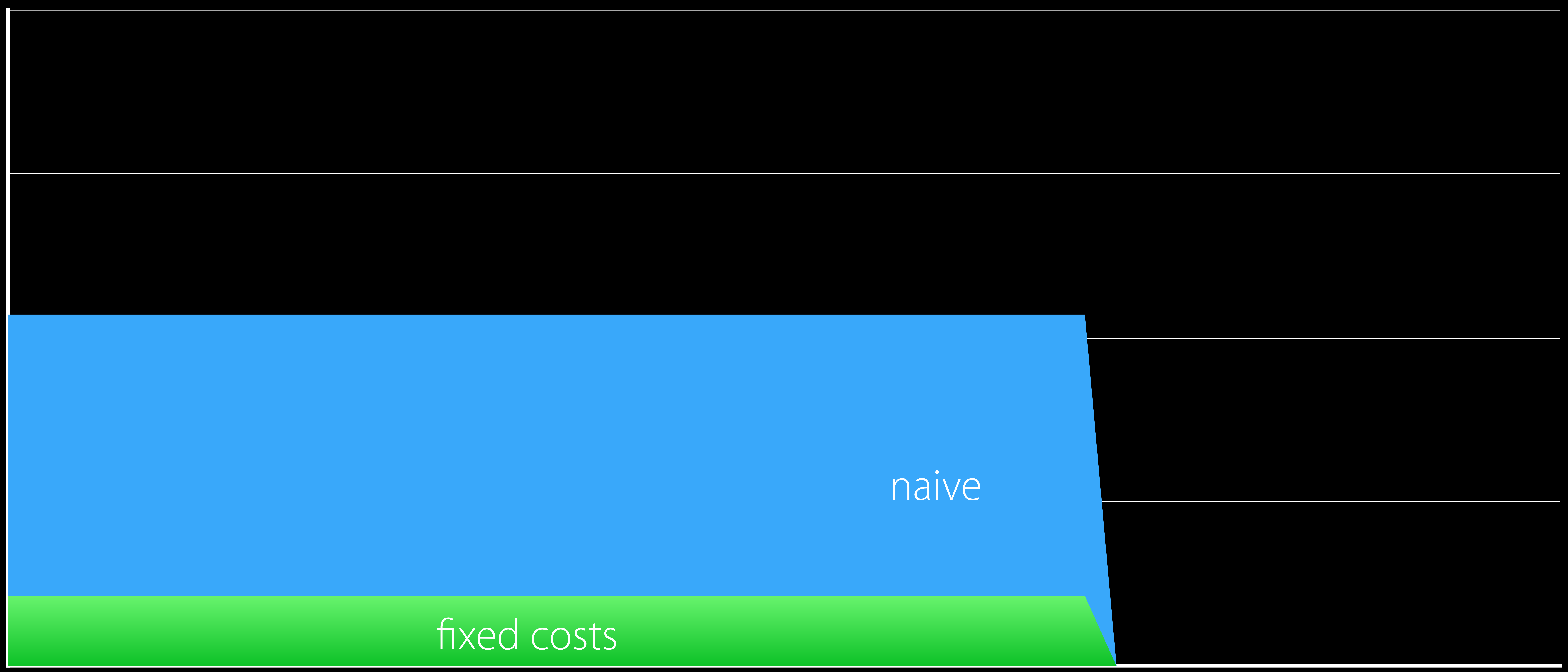
Power vs. Time



CPU and GPU Energy

Less time with fixed costs

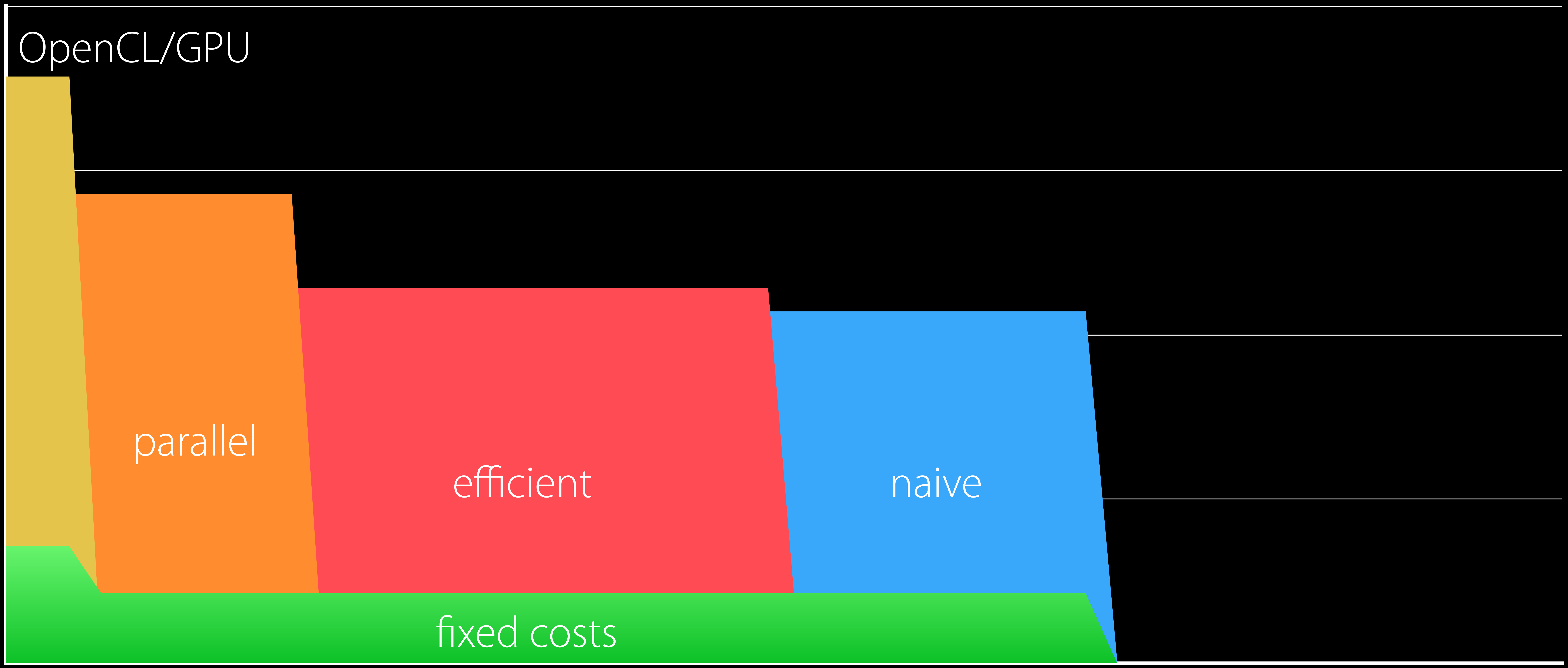
Power vs. Time



CPU and GPU Energy

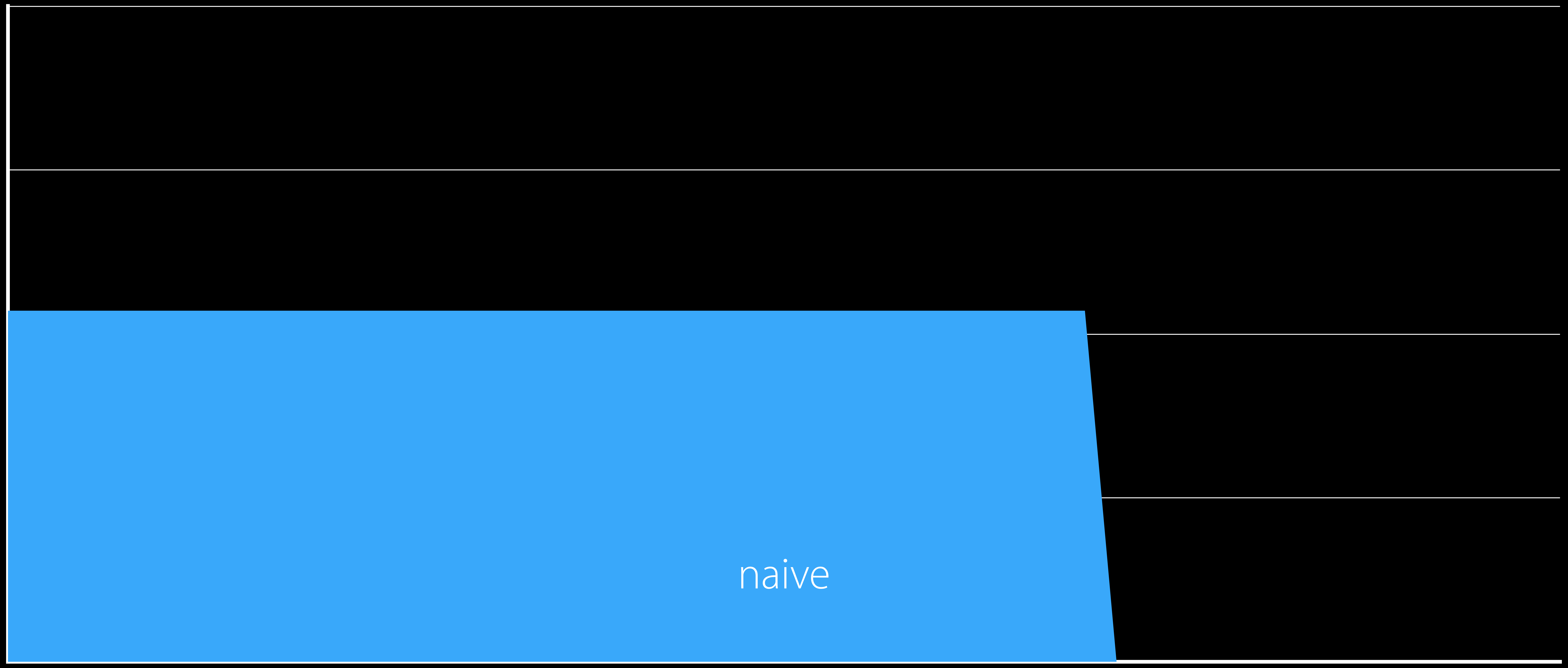
Less time with fixed costs

Power vs. Time



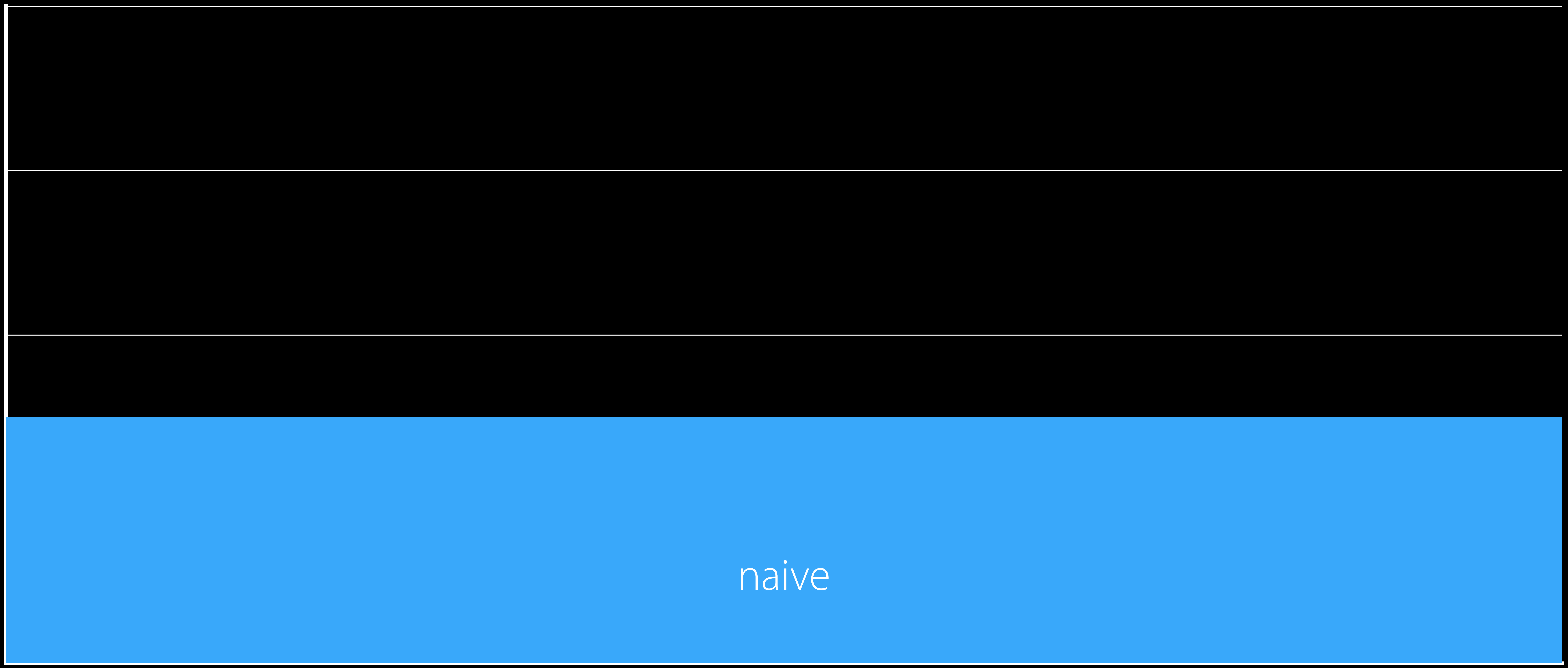
CPU and GPU Energy

Average power



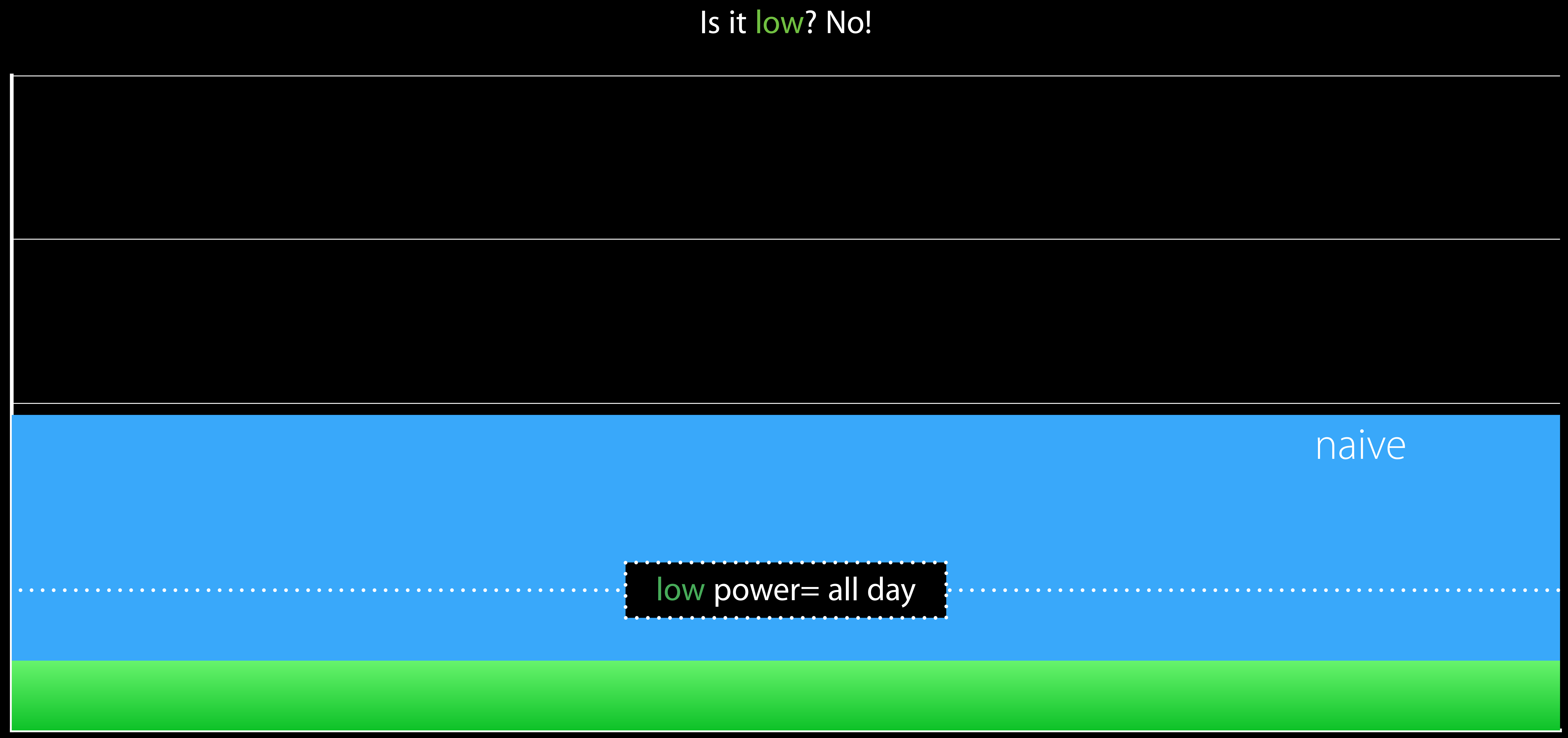
CPU and GPU Energy

Average power



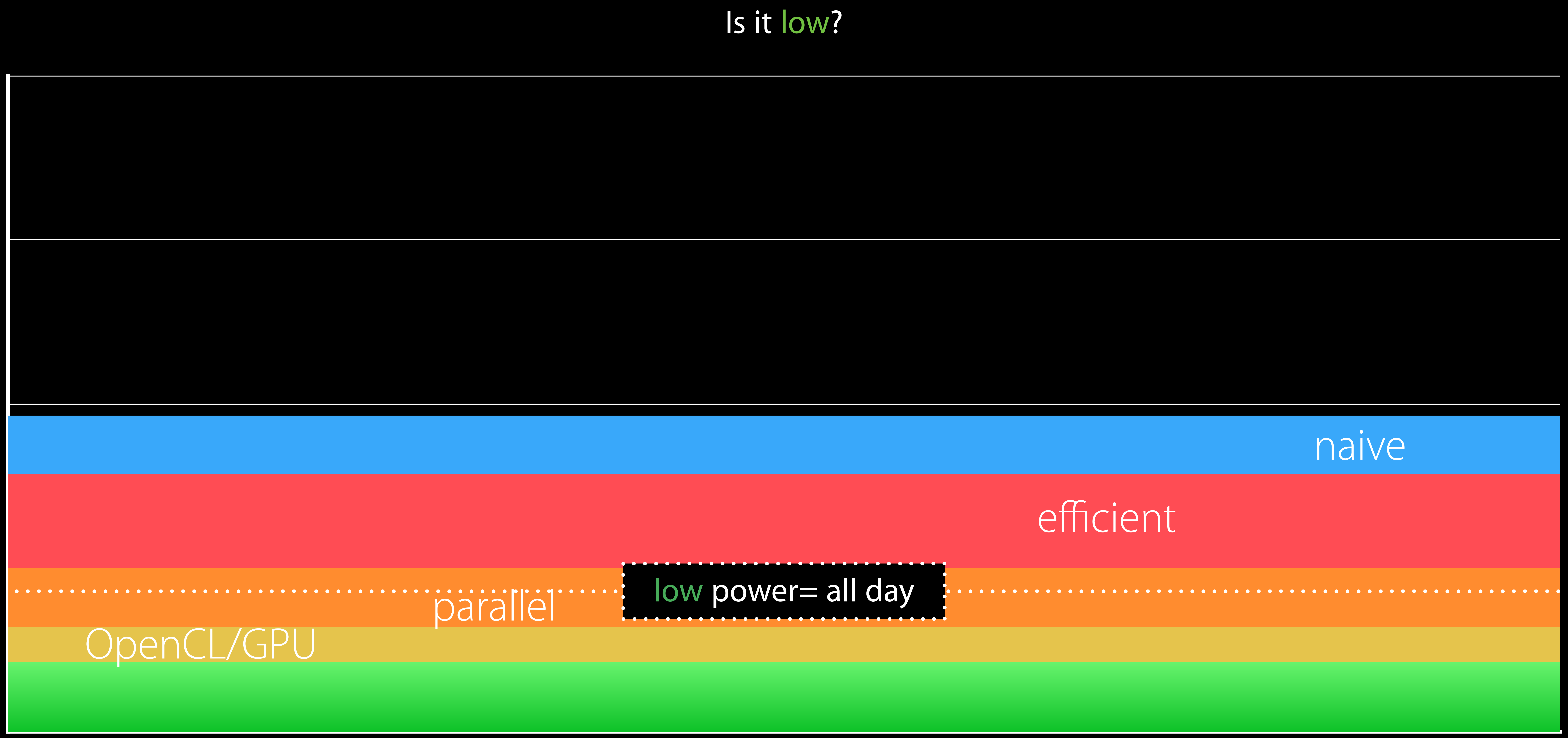
CPU and GPU Energy

Average power



CPU and GPU Energy

Average power



iOS Energy Consumption

Low-hanging fruit

Networking

- Beware high, fixed costs

Location

- Don’t leave it leaking

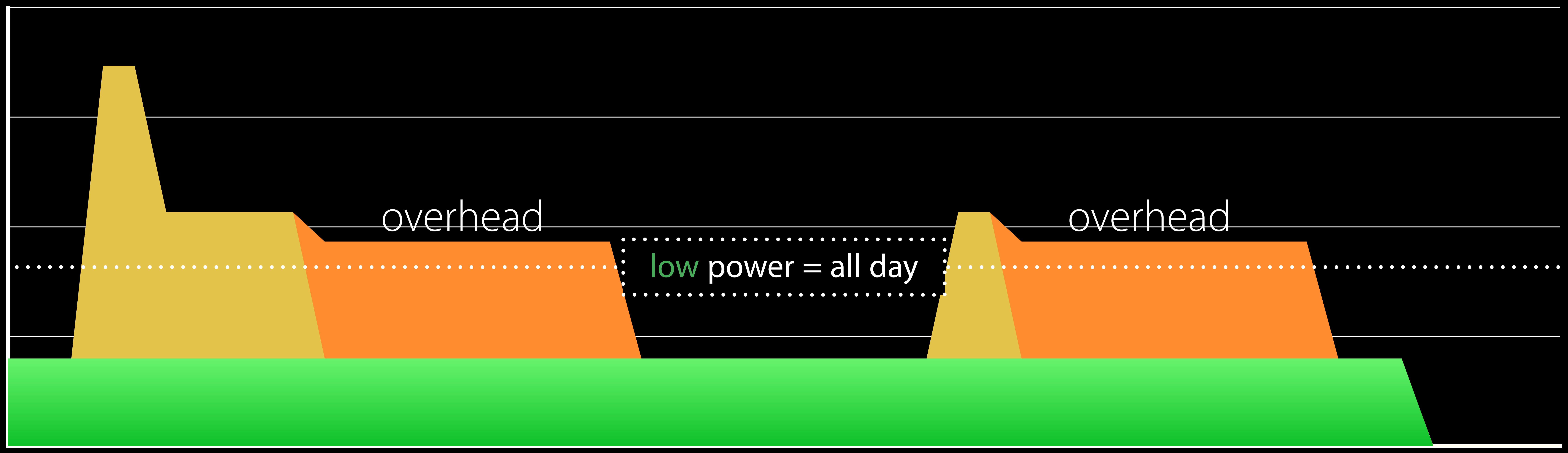
Background operation

- Don’t delay sleep

iOS Networking

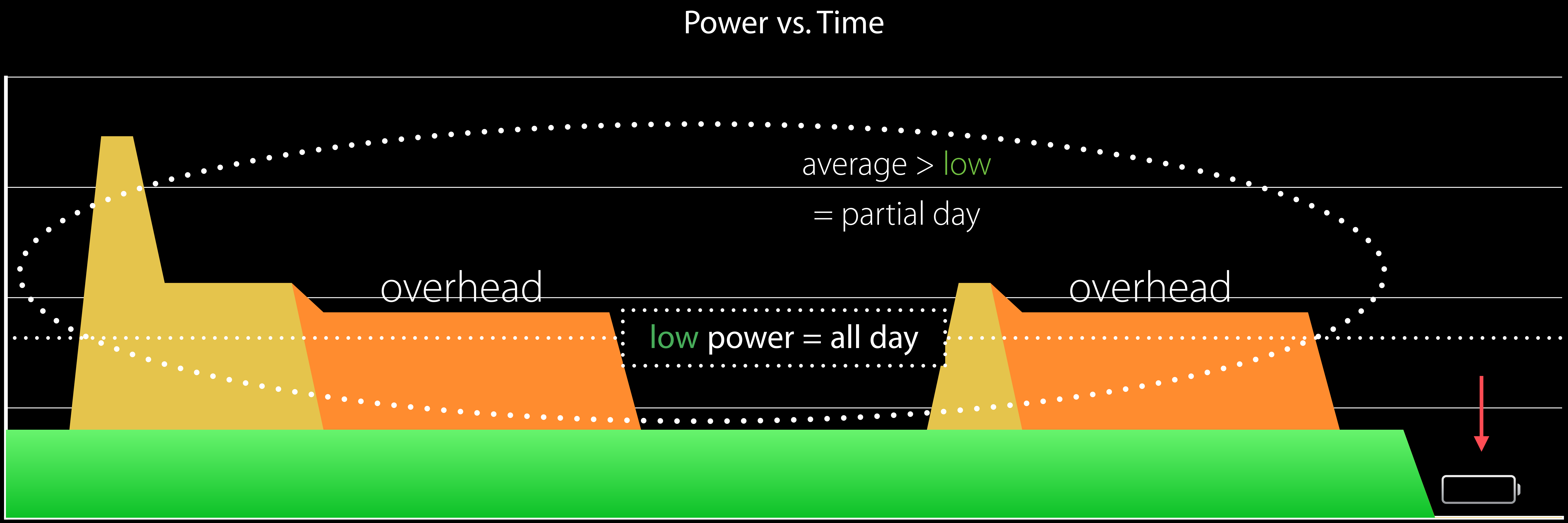
High, fixed costs

Power vs. Time



iOS Networking

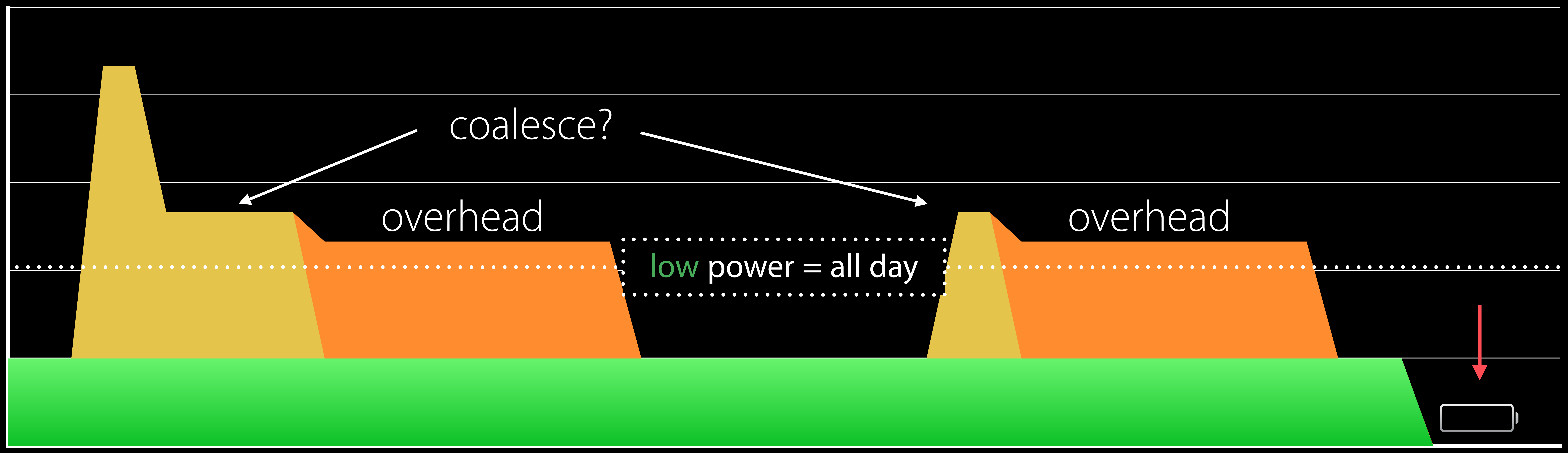
High, fixed costs



iOS Networking

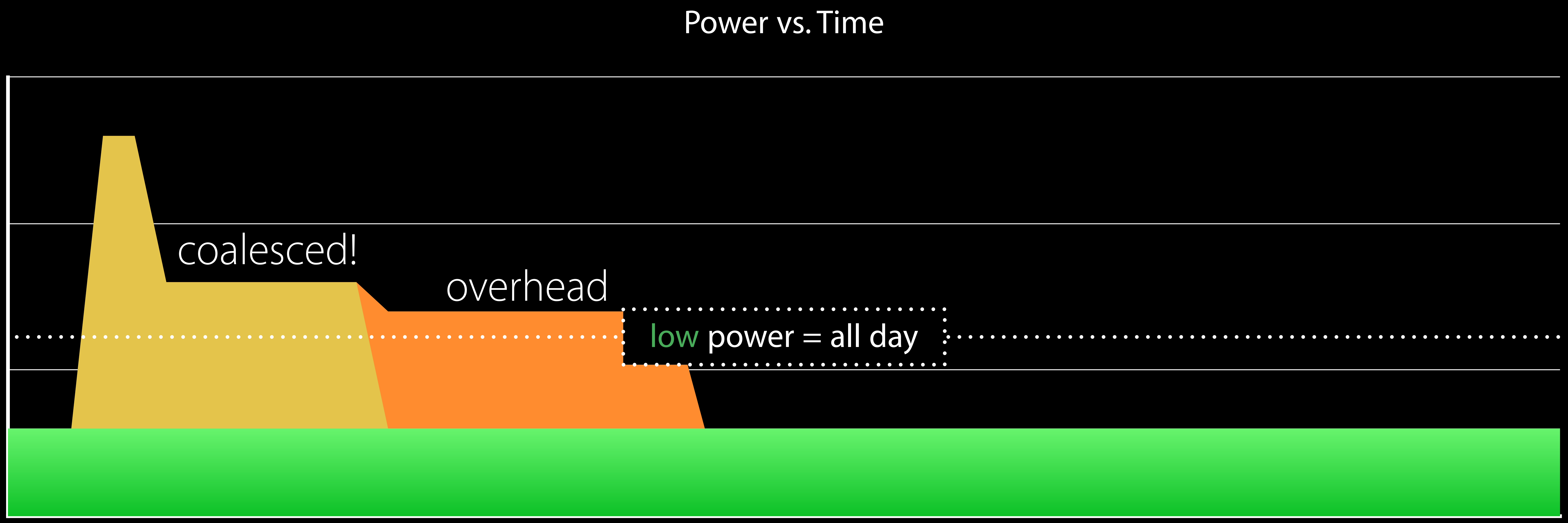
Batch work to minimize overhead

Power vs. Time



iOS Networking

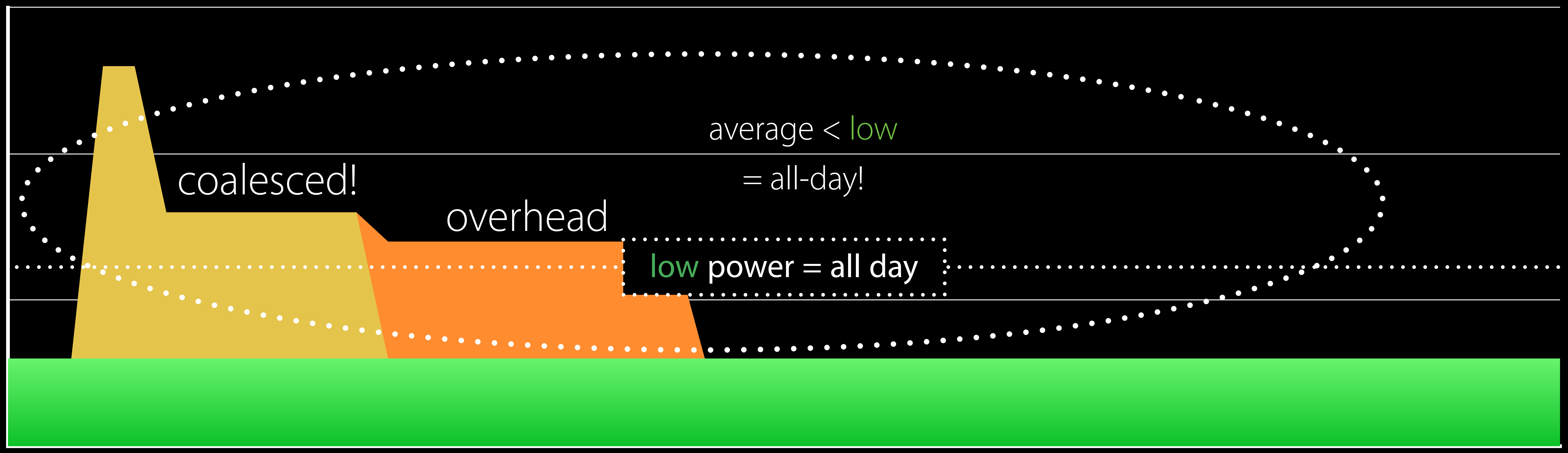
Batch work to minimize overhead



iOS Networking

Batch work to minimize overhead

Power vs. Time



iOS Networking

Optimization

Use network less

- Design it down or out
- Once a minute is a lot

iOS Networking

Optimization

Use network less

- Design it down or out
- Once a minute is a lot

Use network later

- Can it wait?
- Background update, NSURLSession

iOS Networking

Optimization

Use network less

- Design it down or out
- Once a minute is a lot

Use network later

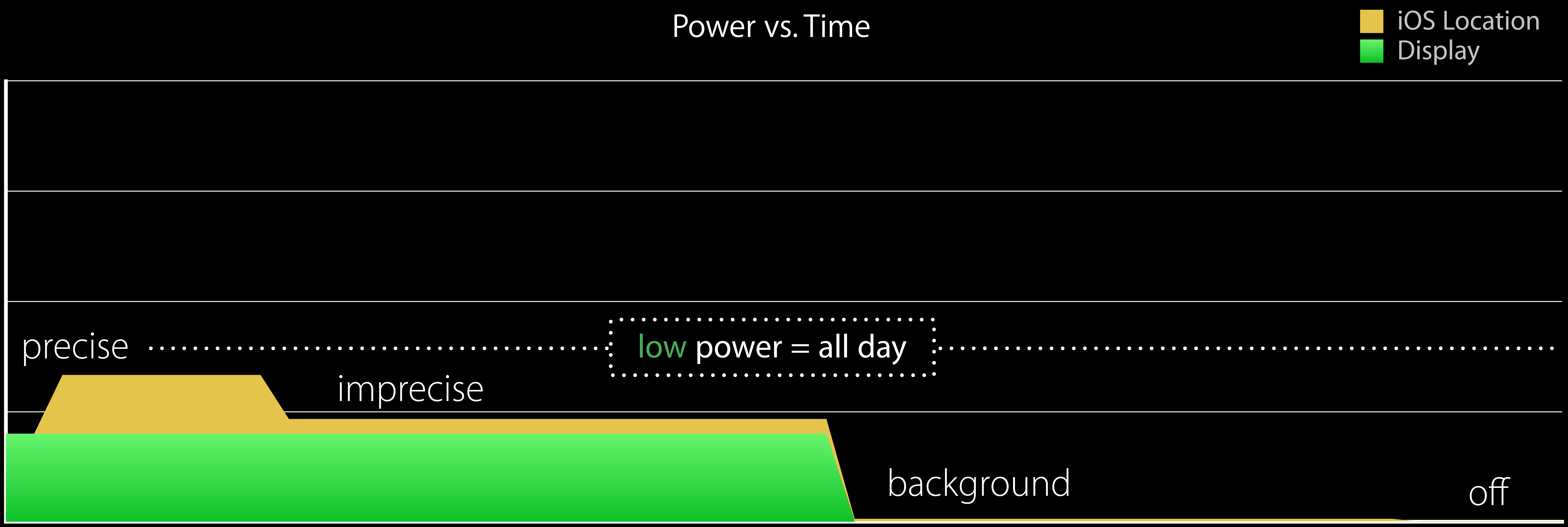
- Can it wait?
- Background update, NSURLSession

Use network efficiently

- Batch work
- Use notifications…sparingly

iOS Location

Precision ~ power



iOS Location

Optimization

Use location less

- Don’t call `startUpdatingLocation()` until needed
- Call `stopUpdatingLocation()` as soon as possible

iOS Location

Optimization

Use location less

- Don't call `startUpdatingLocation()` until needed
- Call `stopUpdatingLocation()` as soon as possible
- For single-fix, iOS 9 introduce `requestLocation()`
- `locManager.allowsBackgroundLocationUpdates = false`

iOS Location

Optimization

Use location less

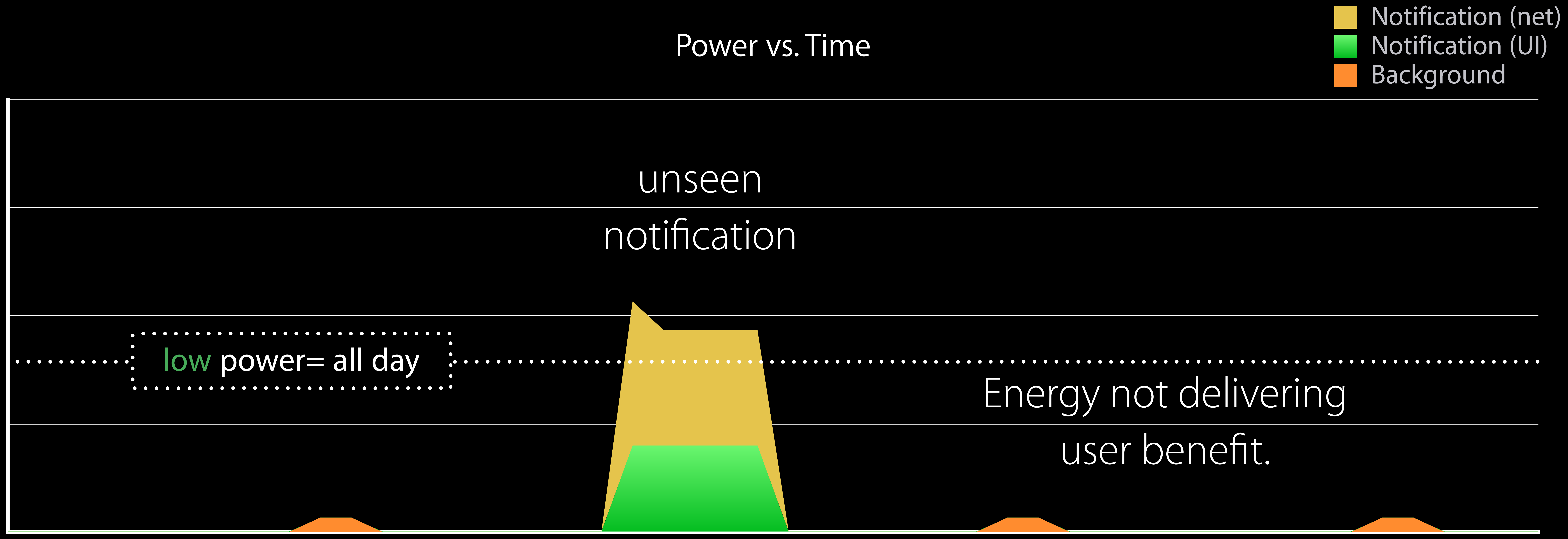
- Don't call `startUpdatingLocation()` until needed
- Call `stopUpdatingLocation()` as soon as possible
- For single-fix, iOS 9 introduce `requestLocation()`
- `locManager.allowsBackgroundLocationUpdates = false`

Use location efficiently

- Lower accuracy = lower power
- `allowDeferredLocationUpdatesUntilTraveled:timeout:`

iOS Background Operation

Cut it out!



unseen notification

low power= all day

Energy not delivering user benefit.

iOS Background Operation

Optimization

`startBackgroundTask()` keeps device awake

- Only start for non-trivial user work

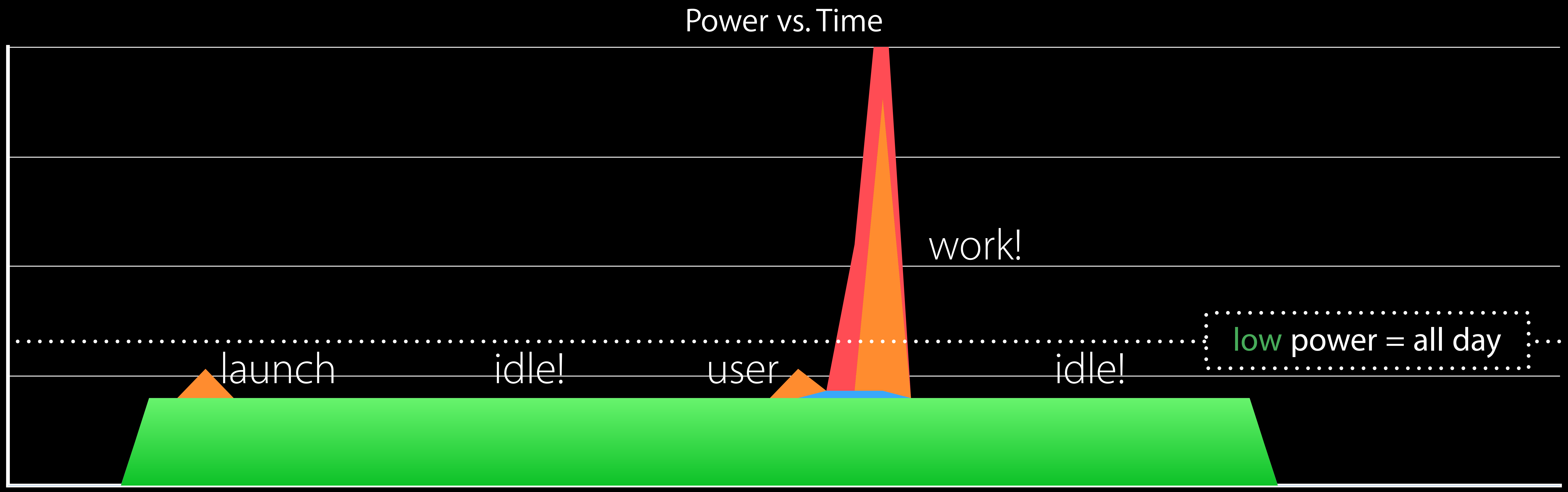
Call `endBackgroundTask()`

- As soon as possible
- In all cases

Delegate indeterminate networking to OS

The Ideal App

User-driven, fast, and idle



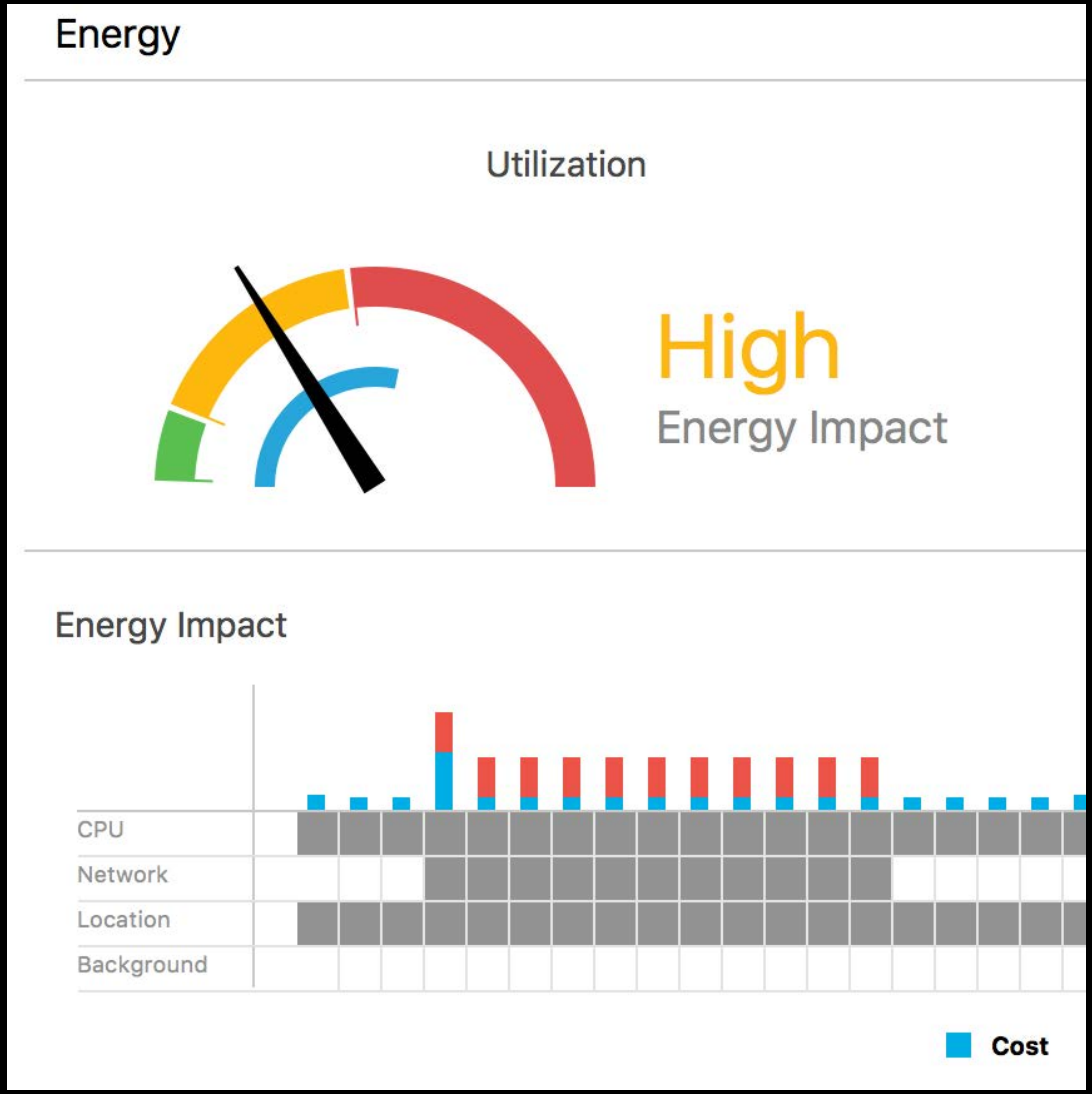
How Is My App Doing?

Xcode now highlights

- CPU
- Networking
- Location
- Background

Instruments support

Come to our next talk



Think Energy

Everyday workflow

Design

- Plan to work less/later/efficiently
- User expectation given app function

Think Energy

Everyday workflow

Design

- Plan to work less/later/efficiently
- User expectation given app function

Implementation

- Yours, Apple's, third-party code

Think Energy

Everyday workflow

Design

- Plan to work less/later/efficiently
- User expectation given app function

Implementation

- Yours, Apple’s, third-party code

Test

- Verify correct behavior

Additional Optimizations

Doing more with less

Careful background updates

Notifications – use PushKit, including VOIP

Display brightness – leave to user

Drawing – 2014 talk

Energy Guide!

Energy = Power × Time

Low Power ~ All-day Battery

Do Less Work
Do It Later
Do It Efficiently

More Information

Documentation and Videos

iOS Energy Guide
http://developer.apple.com/go/?id=ios-energy-efficiency-guide

OS X Energy Guide
http://developer.apple.com/library/mac/documentation/Performance/Conceptual/power_efficiency_guidelines_osx/

Writing Energy Efficient Code, Parts 1 & 2 (2014)
http://developer.apple.com/videos

More Information

Technical Support

Apple Developer Forums

http://developer.apple.com/forums

Developer Technical Support

http://developer.apple.com/support/technical

General Inquiries

Paul Danbold, Core OS Evangelist

danbold@apple.com

Related Sessions

Learn more

Debugging Energy Issues	Nob Hill	Wednesday 10:00AM
Networking with NSURLSession	Pacific Heights	Thursday 9:00AM
Low Energy, High Performance: Compression and Accelerate	Nob Hill	Thursday 10:00AM
What's New in Core Location	Pacific Heights	Thursday 1:30PM
Advanced NSOperations	Presidio	Friday 9:00AM
Building Responsive and Efficient Apps with GCD	Nob Hill	Friday 10:00AM
Performance on iOS and watchOS	Presidio	Friday 11:00AM

Related Labs

We’re here for you!

Power and Performance Lab	Frameworks Lab B	Wednesday 1:30PM
Networking Lab	Frameworks Lab E	Thursday 10:00AM
Core Location Lab	Frameworks Lab A	Thursday 2:30PM
Power and Performance Lab	Frameworks Lab C	Friday 12:00PM
Networking Lab	Frameworks Lab B	Friday 1:30PM

WWDC15