# Energy Zones in Swimming

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The following article is a review of energy zones and their application to the training of swimmers. USA Swimming previously used seven energy zones or categories. These include Recovery (Rec), Endurance 1 (EN1), Endurance 2 (EN2), Endurance 3 (EN3), Sprint 1 (SP1), Sprint 2 (SP2), and Sprint 3 (SP3). Coach Jon Urbanchek of the University of Michigan suggested color-coding each energy category for ease of understanding, especially for the athletes (see Table 4). Many coaches are familiar with the color system. The seven-category system has been modified into a five-zone system, which is easier to use in training. A chart is included later in this article to explain the modification and to make it easier for coaches to share a common language.

## Why Are Energy Zones Important For Swimmers?

The importance of energy zones in swimming is based on the existence of several different pathways to recycle energy in the muscle cells during exercise. The main pathways of energy recycling are non-aerobic metabolism (creatine phosphate), anaerobic metabolism (anaerobic glycolysis), and aerobic metabolism. Metabolism is the process of storing and releasing the energy. Energy for the body is stored in different forms and pathways are used to convert these forms into accessible energy that an athlete can use to perform work. There are no "borders" to energy pathways in a body. At any given time, several pathways, not just one, may be engaged in energy production, but dominance of an energy source depends on the duration and intensity of the exercise. Usually workload is broken into several energy "zones" based on the duration and intensity of the training. Energy "zones" allow athletes and coaches to develop a specific pathway of energy recycling and to quantify, track, and plan the physiological adaptations desired for their specific event.

## There are several reasons for understanding energy zones in swimming:

1. Swimming sets of different duration and intensity are supported by energy from different sources. During high intensity short-term swimming bouts most energy is recycled through the anaerobic pathway. It is a fast and non-oxidative way of energy recycling. During low intensity long-term swimming bouts, the energy is recycled mostly aerobically using oxygen. This way is slow, but more efficient than the anaerobic way.

2. Improvement of one energy system does not influence another one. When athletes swim long distances, they develop mostly aerobic energy sources. High intensity swimming develops the anaerobic energy sources. Different swimming events require the training of different energy pathways.

3. The same swimming set can be swum in different energy zones. For example, swimmers can swim sets with higher or lower intensities. This will recruit different pathways of energy recycling.

4. The preparation of competitive swimmers requires evaluation of individual swimming intensities in each energy zone. The same swimming intensity or even heart rate affects the energy recycling pathways differently when athletes are at different stages of the season (i.e., in the beginning of the season, after a sickness, or at peak performances). Adaptation in athletes to the same swimming intensity depends on their current condition, types of muscle fibers, training history, and other factors. Therefore, it is important to test athletes during a season and to select appropriate swimming intensities (by using heart rate) to train different energy zones.

### Energy Forms In The Body

Adenosine Triphosphate (ATP) is the only source of potential chemical energy in the body. It consists of one molecule of protein (adenosine) and three molecules of phosphate. Muscle cells always contain free ATP, which reduces to ADP (adenosine diphosphate) and releases the energy during the first few seconds of work (figure 1). Decomposition of ATP into ADP releases the energy and phosphoric acid, which increases the acid environment in the muscles. Then other energy storage forms are used to recycle ADP back to ATP through different pathways.

Energy forms in the body include:

- Adenosine Triphosphate (ATP)
- Creatine Phosphate (CP)
- Glycogen (glucose)
- Fats
- Proteins

Working capacity in athletes depends more on the rate of recycling ATP (from CP, glycogen, fats and proteins) than on the amount of ATP. With training, ATP-CP increases less than 20%, while working capacity (swimming velocity) increases more dramatically.

**Pathways of Energy Metabolism**

There are three main pathways of energy metabolism:

1. Creatine Phosphate (immediate non-oxidative way of energy recycling)

2. Anaerobic Metabolism (anaerobic-glycolitic non-oxidative way of energy recycling)

3. Aerobic Metabolism (oxidative way of energy recycling)

Metabolism of Creatine Phosphate is the process of recycling ATP from CP. CP is stored in muscle cells. It very rapidly recycles ATP from ADP. Usually after 2-3 seconds of high intensity work, free ATP stores in muscle cells are depleted. Then CP phosphate is involved to recycle ATP. After 10-15 seconds of high intensity work the rate of recycling ATP from CP is slowed down. Creatine Phosphate has very high power, low capacity, and low efficiency.

Examples of swimming sets and distances to develop creatine phosphate metabolism: diving and turns, short distances (10-25 M/Y) with maximum intensity, swimming sets with short distance and long rest interval (i.e., 4-6 x 12.5 M/Y, 2-4 x 25 M/Y with rest interval 1-3 min.).

Anaerobic Metabolism (Anaerobic-Glycolitic) is the non-oxidative process of recycling of ATP from glycogen. Glycogen is stored in the muscle cells. Glycogen fairly rapidly recycles ATP, but it is slower than from CP. Anaerobic metabolism produces lactate. It is the main energy system for exercise bouts of 30 sec until 3 min. When distances are longer, aerobic metabolism predominates. Anaerobic metabolism has high power, middle capacity, and low efficiency.

Examples of swimming sets and distances that develop anaerobic metabolism: distances of 50 to 300 M/Y, high intensity swimming sets with a short rest interval (i.e., 6-16 x 25 M/Y, 4-8 x 50 M/Y, 2-4 x 100 M/Y, 2 x 200 M/Y with rest interval 20-30 sec etc.).

Aerobic Metabolism is the oxidative process of recycling ATP primarily from glycogen. It is a slow process of recycling ATP. Glycogen for aerobic metabolism is stored in muscle, liver, and blood. Fats and proteins can be involved in aerobic metabolism also, but this process is very slow (long distance swimming). Aerobic metabolism is the main energy system for distances longer than 4 min. The longer distance, the more energy derived from aerobic metabolism. Aerobic metabolism takes place in a small intracellular organelle called mitochondria. Aerobic metabolism has low power, high capacity, and high efficiency.

Examples of swimming sets and distances that develop aerobic metabolism: distances of 2000 M/Y and longer, low and middle intensity swimming sets with short rest interval (i.e., 20 and more x 100 M/Y, 10 and more x 200 M/Y, 7 and more x 300 M/Y, 5 and more x 400 M/Y etc.).

**Energy Zones In Swimming**

Based on the physiological responses of athletes to different intensities, workload volume can be divided into the several energy zones in swimming. There are several classifications of workload. Characteristics of energy zones are presented on table 1.

**Table 1**

**CHARACTERISTICS OF ENERGY ZONES**

| Energy system | Energy supply | Duration of exercise | Swimming distance, m | Lactate amount, mmol/L | Heart rate, bpm |
|---|---|---|---|---|---|
| REC,<br><br>Zone 1 | Aerobic (oxidative) | Different | 3000 and more | 0 – 2 | 120 and less |
| EN1,<br><br>Zone 2 | Aerobic (oxidative) | 12 min and more | 1500 - 3000 | 2- 4 | 120 – 145 |
| EN2-3,<br><br>Zone 3 | Mix aerobic anaerobic | 3 – 12 min | 400 – 1200 | 4 – 8 | 145 – 175 |
| SP1-2,<br><br>Zone 4 | Anaerobic (non-oxidative) | 10 sec – 3 min | 100 – 200 | 8 and more | 175 and more |
| SP3,<br><br>Zone 5 | Anaerobic Creatine Phosphate | 0 – 15 sec | 15 – 50 | - | - |

The Five Zone Classification is based on sources of energy recycling:

Zone 1 – aerobic recovery,

Zone 2 – aerobic development,

Zone 3 – mix aerobic anaerobic,

Zone 4 – anaerobic, and

Zone 5 – creatine phosphate.

Since both zones 1 and 2 are aerobic, often these zones are combined leaving four major energy zones (aerobic, mix, anaerobic, and creatine phosphate). Swimming sets in these zones depends on the rest interval and intensity. Classifications for the four energy zones with 15 to 20 seconds rest interval are presented in Tables 2 and 3. If the rest interval is longer (30 to 40 sec), swimmers can maintain higher intensity for a longer time at the same energy zone (table 3).

Table 2

**EXAMPLES OF TRAINING SETS IN ENERGY ZONES**

USING A 15-20 SECOND REST INTERVAL

| Distance in meters or yards | Zone 4<br><br>SP1-2 | Zone 3<br><br>EN2-3 | Zone 1&2<br><br>EN1 & REC |
|---|---|---|---|
| | (number of repetitions) | | |
| 25 | 4-16 | 18-60 | 62 & more |
| 50 | 2-7 | 8-26 | 27 & more |
| 75 | 1-4 | 5-16 | 17 & more |
| 100 | 1-3 | 4-12 | 13 & more |
| 150 | 1-2 | 3-8 | 9 & more |
| 200 | 1 | 2-6 | 7 & more |
| 400 | | 1-3 | 4 & more |

Table 3

**EXAMPLES OF TRAINING SETS IN ENERGY ZONES**

USING A 30-40 SECOND REST INTERVAL

| Distance in meters or yards | Zone 5<br><br>SP3 | Zone 4<br><br>SP1-2 | Zone 3<br><br>EN2-3 | Zone 1&2<br><br>EN1 & REC |
|---|---|---|---|---|
| | (number of repetitions) | | | |
| 15 | 6-8 | | | |
| 25 | 3-4 | 6-20 | 22-70 | 72 & more |
| 50 | 1 | 2-9 | 10-32 | 33 & more |
| 75 | | 1-6 | 8-21 | 22 & more |
| 100 | | 1-4 | 5-15 | 16 & more |
| 150 | | 1-3 | 4-10 | 11 & more |
| 200 | | 1-2 | 3-7 | 8 & more |
| 400 | | | 1-4 | 5 & more |

From these tables coaches can select any swimming set in all energy zones. For example, if athletes need to swim 300 m or yards in anaerobic energy zones (Zone 4), the coach can select swimming sets according to Table 2 and 3: 12 x 25 @: 15-30 sec rest, 6 x 50 @ :15-30 sec rest, 4 x 75 @ :15-30 sec rest and so on.

All energy zones are based on the duration of exercise. When athletes swim sets with longer durations, the relative intensity of sets is lower. Therefore, athletes use a lower energy zone. Some swimming sets may be designed for technical improvement. For example, athletes are doing drills or skill exercises. These skill exercises can also be done with various efforts (50%, 90%, or 100%) and the energy zone charts can still be used. It is important to note that drills, kick sets, and pull sets all use energy and can be placed on the charts in the desired energy zones.

**Conclusions About Energy Zones**

All energy zones are relative. There are no borders between energy zones. However, each zone has a primary pathway for energy recycling. Understanding energy zones is helpful in classifying swimming sets and developing particular pathways for energy recycling.

It is recommended to use five energy zones with senior swimmers. The training of age group swimmers does not require using all five energy zones. Some zones might be combined and used as one broader zone. For instance, zones one and two could be combined to form the aerobic zone, while zones four and five could be combined to form the anaerobic zone. This will decrease the number of energy zones for age group swimmers from five to three zones: aerobic, mix, and anaerobic.