

# Energy management (in the approach phase) Part 1 - Basics

## Pilots' tips and tricks

An aircraft is a moving thing operating in a three-dimensional environment. For the operation of an aircraft energy is vital. This article will explain to you in a slightly simplified way, how energy influences your flight – especially in the approach phase – and why energy-management plays a vital role in operating your aircraft safely and correctly.

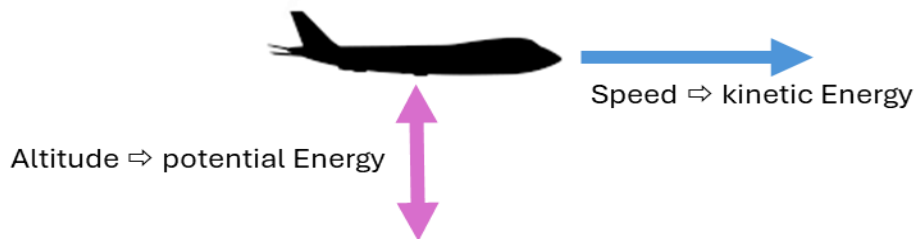
This article consists of two parts:

- Part 1 will deal with the basics of energy of an aircraft
- Part 2 will add some practical examples and top-of-the-head calculations

## 1. Energy of an aircraft

The total energy of a plane results basically out of two factors – altitude and speed.

Total Energy = potential Energy + kinetic Energy



At the gate, the (relative) energy of a plane is zero (no speed – no altitude). On cruise, the energy is very high (high speed – high altitude).

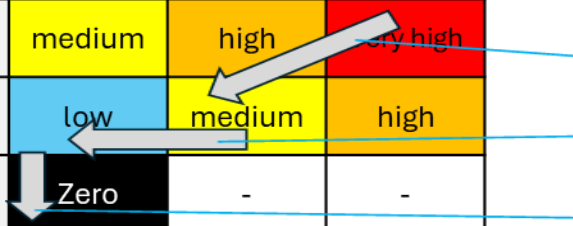
Let's have a look at the energy levels at different positions of the aircraft:

Total energy level		Altitude		
		On ground	Low	High
Speed	High	medium	high	Very high
	Low	low	medium	high
	Zero	Zero	-	-

## 2. Changing the energy of the aircraft

Take-off and climb will inject high amounts of energy, coming from the engines in form of thrust. This energy is converted into speed and altitude. During descent and landing the same amount of energy needs to “disappear” again. Whereas adding energy to the system by thrust is relatively simple (provided your aircraft has strong enough engines and enough fuel in the tanks), reducing this energy down to landing needs some consideration and careful planning. Otherwise, you may end up with too much energy just before touchdown (too high speed and/or too high altitude), which makes your landing unsafe if not impossible.

Total energy level		Altitude		
		On ground	Low	High
Speed	High	medium	high	very high
	Low	low	medium	high
	Zero	Zero	-	-



Approach

Landing

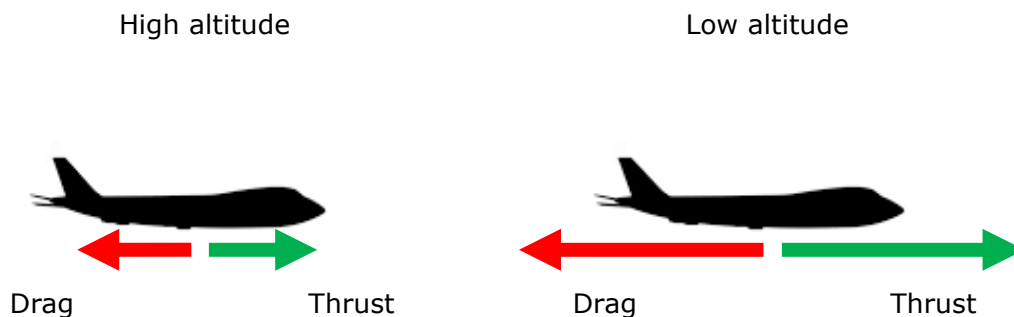
Breaking

## 3. How to reduce energy during approach

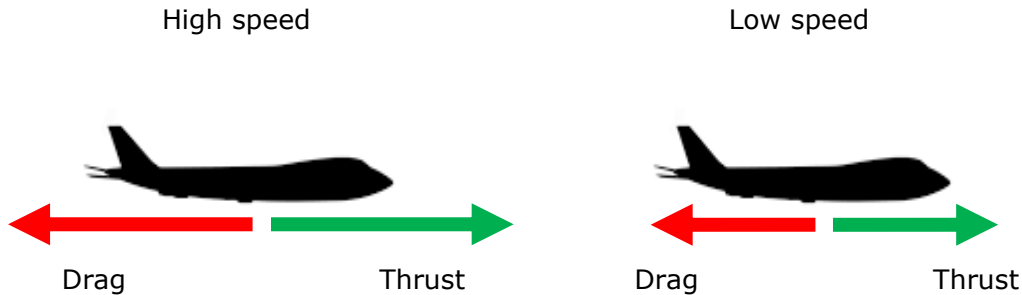
An aircraft (fortunately) is no perpetuum-mobile, where energy will never disappear from the system. In the sky the resistance of the air (drag) constantly takes energy out of the system. Part of the energy of the engines is there to overcome air resistance and keep the energy constant.

The drag however is not constant itself. It changes depending on the altitude and on the speed.

In high altitudes drag is smaller, in low altitudes drag is more important. This is due to the density of the air, which in low levels is higher and therefore causes more air resistance.



At high speed, drag is higher, at low speed, it is lower. (Exception: if your speed gets even lower and you get behind the power curve ([Behind the power curve - Skies Mag](#))). It is worthwhile to remember that air resistance increases with the square of the increasing speed.



Let's have a look at this in numbers:

If we define the drag at minimum clean speed as 1 (I refer to the B77W values as an example), the approximate amount of drag will develop as shown below:

IAS	Square of the speed	Equivalence number
220 KN (minimum clean speed)	48'400	1
250 KN	62'500	1.29
280 KN	78'400	1.62
320 KN	102'400	2.12

These numbers show that the drag at 320 KIAS is more than double the drag at minimum clean speed. At 280 KIAS it is more than 60% bigger. Therefore, it is easier to decrease the energy of your aircraft at high speed. As a consequence, it is more efficient in terms of energy reduction to first descend at high speed and later reduce the speed.

## 4. The challenge

Let's move on to the real practical things: When leaving cruise level, the pilot must have a plan on the following challenge:

***How much time/distance will it take to reduce the energy of my aircraft from the actual level/speed down to the Final Approach Fix (e.g. FL370/Mach .80 to 4000FT/180KIAS).***

If the pilot was completely free to operate where and how he desires, he'd stop injecting energy (means set thrust to idle) at the right moment and starts descending and slowing down his aircraft, maintaining clean configuration for as long as possible until he reaches the FAF (e.g. at 4000ft and 180KIAS). This is called continuous descent. However, an airman's life is rarely that easy. Some restrictions must be taken into account. There is a thing called approach instruction, published in the STAR and Transition Charts (which must be consulted prior to descent). They stipulate not only the track but also certain levels and certain speeds at certain points. There is also ATC, who - for the sake of separation and good traffic flow - have some wishes as well.

How can a pilot know whether he is still fine with reducing energy or if there is a need for intervention?

## 5. The tools

### 5. A. First – energy planning

Important is a proactive and forward-looking descent/approach planning. Helpful are some rules of thumb on energy reduction. These rules are not precisely defined and may differ from aircraft to aircraft and depending on the real situation, however as a rough guideline they are valid and regularly applied by smart pilots.

*Modern aircrafts calculate themselves a so-called "vertical profile" and give a permanent indication to the pilot, whether or not he is on, above or below the "ideal" descent path. However, when the aircraft leaves the planned track (e.g. due to vectoring by ATC), these calculations become partly inaccurate and own calculations of the pilot are required. Moreover, every system can fail, and it is good practice to verify the descent profile by own calculations independent from aircraft systems.*

- *Rule No 1: the faster you fly the bigger the drag*
- *Rule No 2: on the approach phase, you will be able to reduce altitude by 1000ft every 3 NM (thrust idle, without your speed increasing)*
- *Rule No 3: you will be able to reduce your speed by 7 to 10KIAS per NM in level flight*
- *Rule No 4: if you'd like to achieve both, you cannot simply add the two together. Of course, you can simultaneously descent and reduce speed, but for the calculation you need to separate the two.*
- *Rule 5: Wind can mess up everything you have planned for if you don't take it into consideration; every 10kts of tailwind reduce your descent capabilities by about 0.1°*

### 5. B. Second – adding additional resistance if required

Should your calculation show, that your aircraft has too much energy for the remaining track miles, you can apply additional resistance. Apart from the generic drag of the aircraft in clean configuration (no gear, no flaps), which we already had a look at, there are additional sources of drag, such as using speedbrakes, extending flaps and gear – in very specific situation even slip – though that is generally not an option in an airliner under normal circumstances.

These are excellent means to add additional drag, despite the fact that restrictions have to be taken into account, such as the maximum speed and altitude they can be extended at. The pilot therefore must be smart enough to know those max speeds by heart and to plan his descent such, that he could add an additional source of drag when needed.

This concludes Part 1 of this bulletin. In Part 2 we will have a closer look at some examples and the practical application of the above rules.

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