VSWR, (Voltage Standing Wave Ratio). VSWR indicates only the degree of mismatch not the efficiency of an antenna circuit . Transmission efficiency is a two variable function of both mismatch and line attenuation!

Example: Joe Newham installs a ¼ wave vertical antenna (36 +j22 ohms), and this becomes 32 ohms when shortened to resonance. He decides he will install this antenna the way the real experts would, feed it with good quality, fresh 50 ohm coax feedline.

He is going to place 60 radials for a ground system, (one every 6...) A lot of work but he carries it out and goes on the air, but finds his antenna is resonant at 7025 Khz right on the design frequency, with a VSWR of 1.6:1 and it increases gradually either side of this frequency. This is the lowest VSWR he achieves and this disturbs him no end. All this work and no 1:1.

In a panic, he consults with his on the air experts (also new hams) and is told he has too many radials? Oh boy all that work! The experts also tell him that a VSWR of 1.6:1 represents a 2 dB loss. Holy Canola its getting worse all the time. What to do? What to do?

He is now told to keep removing radials from the antenna system until the VSWR comes down to 1:1 at his chosen frequency.

So Joe Newham starts removing one radial at a time until he reaches the magic 1:1 VSWR and now has 10 radials left. Wow, joy, Holy 1:1 VSWR at last. Joe Newham now has an antenna with a 1:1 VSWR and he can now sleep at night again. He can also brag how great his antenna is to his expert friends and everyone is happy.

Over a period of weeks, as Joe Newham is on the air regularly, he notices he is not getting the signal reports that he expected from an antenna with such a low VSWR! Again consulting with his on the air expert buddies is informed yes they also find the same thing at their stations but heck its band conditions, things should improve with the solar cycle. In truth things will not improve for several reasons:

He had it right from the beginning! Because neither he or his friends have a fundamental understanding of VSWR or dB's, they and Joe Newham have assumed the wrong concepts and strived for a low VSWR for the wrong reasons.
Again not many hams would go to the trouble and expense of laying 60 radials for a ¼ wave vertical antenna. This type of antenna has a feed impedance of 36.5 +j22 ohms which becomes 32 ohms as the antenna is shortened to achieve resonance. This will result in a VSWR of 1.6:1 (50/32=1.5625:1). This results in a power ratio (not loss) of 2 dB between the forward power and the reflected power. So now Joe Newham believes his antenna is radiating 2 dB of power less than he is feeding into it! WRONG, it is not a loss but a ratio between the two powers. What Joe Newham did by removing some of the radials was raise his ground resistance to 18 ohms and since this is in series with his antenna Rr, he now has a perfect match of 50 ohms and a VSWR of 1:1, (32+18=50).

The fact that now 36% of his power is used in heating the ground around the base of his antenna is the main reason his signal reports do not reach the expectations he attached to the magic 1:1 VSWR. (18/50 X 100=36%)

Also Joe Newham will find that 40 metre propagation is not effected to the same degree by the solar cycle as the higher bands are, that's what makes it so popular to the hams who have been around for a couple of solar cycles. Joe is using 50 feet of RG213AU to feed his antenna in the back yard. 50 feet of this type of coax has an attenuation loss of 0.1 dB at 7 Mhz. This attenuation is independent of VSWR . The line will have the same loss whether the VSWR is 1:1 or 3:1 or even 10:1.

FACT: An antenna will radiate all of the power it receives from a generator regardless of the VSWR. Where else is going to go?

At the transmitter output with one of the modern transceivers we have a conjugate* condition between the transmitter and the feedline. At this point all of the reflected power is going to be rereflected to the antenna and radiated as per the mismatch ratio! The only loss is going to be the 2% on the reflected trip and the 2% on the rereflection trip. Remember with respect to the forward power the current and voltage are in phase so the forward power is only subject to the 2% loss factor.

If Joe Newham is really concerned about his HIGH VSWR he could have solved the problem with a simple capacitor and coil matching network at the base of his antenna or a simple ASTU at the transmitter end which would have enabled him to move around the band and continue to have that magic 1:1 VSWR.

The term antenna tuner is a misnomer! Properly, it should be referred to as an ASTU or Antenna System Tuning Unit.

An ASTU installed at the transmitter end of the feedline cannot and is not intended to correct the standing waves on the transmission line attached to the ASTU. The ASTU's function is to match the impedance at the end of the feedline to the coax line that feeds the modern transmitter or receiver. This is the case whether the feed line to the antenna is 50,70 or 600 ohm feedline.*

Upon matching there will be 100% transfer of power to the antenna minus a very low transmission line and tuner loss (Antenna Handbook, CQ Publications, Glanzer K7GCO, Page 73; Reflections, ARRL, Walt Maxwell, Page 16-8)

Modern transmitters and many commercial antennas are designed to match 50 ohm cable. Coaxial cable cannot withstand a high vswr near its maximum power rating . In addition a high vswr will often present a reactive impedance other than 50 ohms at the transmitter end of the coax (depending on the length). Pruning the coaxial cable length does not change the vswr, it will merely change the impedance reflected from the antenna and sometimes to a value that is easier for the transmitter to match. Low pass filters are designed for 50 ohm lines and their effectiveness is reduced by the presence of standing waves.

Reflected voltage and/or power due to a mismatch at the antenna creates standing waves on a line. The bulk of this reflected energy is by no means lost. It merely changes the impedance above or below the characteristic impedance of the line by an amount dependent upon the vswr value . For this reason playing with cable lengths is not a very good solution. Before carrying any further, for clarification we should lay down some definitions.

Radiation Resistance (Rr) The amount of energy radiated from or induced in an antenna can be directly related to a factor called radiation resistance. This is a fictitious resistance which, when substituted for the antenna will consume the same amount of power that is actually radiated.

Maximum power transfer theorem states: the maximum power will be absorbed by one network from another joined to it at two terminals if the impedance looking into the two networks at the junction are conjugate of each other.

The Conjugate Matching Theorem states: if a group of four terminal networks containing only pure reactances (or lossless lines), are arranged in tandem to connect a generator to its load then if at any junction there is a conjugate match of impedances then there is a conjugate match at all junctions of the network.

The term "conjugate match" identifies a condition where the impedances on opposite sides of a junction have identical resistive components, and reactive components that are equal in magnitude but opposite in sign. For an example, source Zc=50 + jX ohms feeds a load impedance of 50 - jX ohms .
Virtual: having the effect of but not taking the physical form of.

Conjugate: having the resistive component but possessed of the opposite reactive component.
Therefore when a conjugate match is accomplished at any junction in a system, all reactances in the system are canceled, including any reactance in the load (antenna) and this reactance cancellation establishes resonance in the entire system and the generator delivers its maximum available power to the load.

This means that a non resonant antenna as the load, is tuned to resonance by the conjugate match.
Reflections, ARRL, Walt Maxwell, Pages: 17-1, 17-2. Ref 1,2,3,4,5.

NOTE: only pure resistance can dissipate energy (convert to heat).The radiation resistance (virtual resistance) dissipates the energy by casting it off into space. When the antenna is longer than required to achieve resonance it becomes inductive and possessed of inductive reactance. Since this reactance cannot dissipate the energy it is reflected back to the source, ergo VSWR. Similarly when the antenna is too short to achieve resonance it becomes capacitive and possessed of capacitive reactance. Again since the capacitive reactance cannot dissipate the RFE it is reflected back to the source, ergo VSWR. Of course the amount of VSWR is determined by the amount of reactance present*. The current and voltage relationships in the reflected wave will behave similar to an open feedline when the antenna is too short and like a shorted feedline when the antenna is too long.

Amateur Antenna Tests, Howard W. Sams, Harry D. Hooton W6TYH, Page 54 Para. 3.3

OUR MODERN SOLID STATE TRANSCEIVER & VSWR

Solid state transmitters that reduce their output power in response to rising VSWR do so because of the presence of VSWR sensing and VSWR driven power reduction circuitry, not because solid state devices are used in their finals (AKA power foldback).

Why ? Because the output of the amplifier is fixed to 50 ohms. This is done for convenience sake, its also cheaper to manufacture. Lower ratings on components, no expensive variable capacitors and they can get more money from you later when they sell you an antenna tuner.

This feature is generally built into the RF amplifier section of amplifiers, transmitters and transceivers that use "bipolar junction transistors" as RF amplifiers. (B J T's).

B J T's require such protection if they cannot tolerate the collector voltage peaks that can occur in the presence of significant load mismatches. The B J T's used in today's gear usually require such protection.

The older vacuum tube output transmitters and transceivers did not suffer from this effect, not because tubes are more tolerant to VSWR (operate at higher voltages), but because the design of the output stage required operator adjustment! As a consequence output mismatches of anywhere from 3 to 1 and 5 to 1 and higher could be accommodated. For this reason most hams couldn't care less what the VSWR was.

We usually only resorted to an ASTU if we encountered TVI and an ASTU was the first step in cleaning up the problem.

In conclusion it is pointed out that the forgoing is applicable to HF operation only. At VHF and UHF, VSWR does present greater loss problems and since this is where the majority of the new hams start out today, all the mythology and baggage about VSWR acquired there is dragged to HF operation.