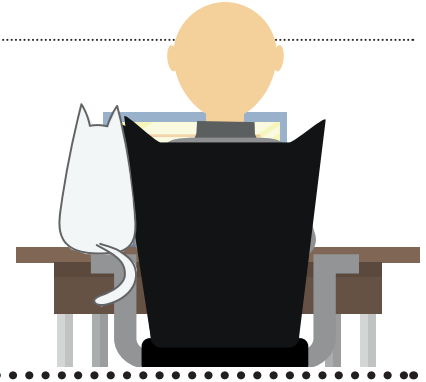


A directed-energy weapon could deter dawdling tourists, but your energy would be better spent throwing stuff. As reported by **Hilary Lamb**.

Dear Evil Engineer



QUESTION

Could I pick off tourists near my house with a microwave weapon?



Tourists tramp about disrupting my tranquility

Dear Evil Engineer, Five years ago, I hung up the white cat and retired to a pleasant village in the Cotswolds. Unfortunately, this village has been flung to unwanted prominence as the location used for filming a hit period drama series. Life has gone from perfect tranquillity to being disrupted daily by the arrival of half a dozen buses which dump tourists to trample about, posing for photos in front of our homes.

Always having struggled with confrontation, I'm looking for a way to get rid of tourists from outside my cottage without having to tell them to leave (putting out a sign and chaining a Nile crocodile outside my front door has only made my home more of a photo opportunity).

Ideally, I'd like to be able to shoot them from my bedroom window, but using microwave weapons rather than bullets, so as not to leave incriminating shrapnel in the bodies. Could you advise me as

to how to proceed?

*Yours,
A retired and retiring villain*

Dear villain, Directed-energy weapons that use electromagnetic waves (known as 'e-bombs') have been speculated about since Archimedes probably didn't focus sunlight on enemy ships during the Siege of Syracuse. High-power microwave (HPM) weapons – such as those depicted in 'Godzilla' – have a non-ionising effect on human targets, causing damage by heating the tissue just as a microwave oven does.

In 2001, the US Air Force revealed the Active Denial System (ADS): a microwave weapon intended for non-lethal use in crowd control. The ADS was recalled from field testing in Afghanistan in 2010, and just how well it performs under real-world conditions remains something of a mystery. According to a 2007 report in *Nature*, volunteers at an early press demonstration found exposure to the ADS produced a sensation of pleasant warmth

under those rainy conditions. Yet the idea of a microwave weapon has not gone away, particularly for anti-missile applications, and work continues on HPM systems in the US and elsewhere.

HPM weapons heat water and fat molecules in the target, causing microwave burns. On occasions on which it worked, the ADS inflicted incapacitating pain similar to the feeling of being on fire, causing the target to reflexively pull away. A non-lethal weapon, it uses high-frequency (95GHz) microwaves; the waves do not penetrate deeper than 0.4mm, limiting burns to the skin surface. A lethal microwave weapon would require lower-frequency waves capable of penetrating more deeply. For instance, 5.8GHz microwaves penetrate to 1.0mm and 2.45GHz microwaves penetrate to 1.7mm.

Modelling how electromagnetic energy is absorbed in human tissue is critical not only to ensure our wireless devices are safe (although mobile phones and other consumer devices use powers far, far below those discussed here) but also in medical research.

Microwave ablation – which involves passing a microwave antenna into the affected region, creating a small region of heat, and burning the surrounding dysfunctional tissue – is gaining traction as a minimally invasive procedure to treat lung and liver cancer. Absorption depends on factors including wave frequency and tissue type and is thoroughly complicated by complex interdependent antenna-tissue interactions.

Looking at very loose figures, ablation tends to involve applying microwaves at around 100W for up to 10 minutes of contact with the antenna. This is enough to heat the surrounding few centimetres of tissue to around 55°C (research on ADS exposure found first-degree burns start appearing at 51°C and second-degree burns at 58°C). Depositing comparable energy in a target, aiming at the brain through the eye, has the potential to be lethal. Certainly, it would be enough to stop an impromptu photoshoot in front of your cottage.

Of course, an HPM weapon is a different beast from a microwave ablation antenna. Most obviously – unless you are prepared to restrain your victim and wait a while – you'll need considerably higher power to deliver comparable energy in a timely matter.

A 100W microwave source run for 10 minutes (here we use the ballpark figures above) could deposit 60kJ of energy in the target's tissue. To achieve this in one second rather than 10 minutes would require a 60kW microwave source. Remember, this is the absolute minimum we would require, as efficiency is never 100 per cent, and you will need to be able to use your HPM weapon at a range of several metres. You'll also want as low a frequency as possible; 915MHz microwaves (centre of the 900MHz band) can penetrate to about 40mm.

You are in luck because you can buy an off-the-shelf 915MHz industrial microwave generator at 100kW. The ADS also runs at 100kW. It is power-hungry, but for a pulsed microwave – which would be preferable regardless for human targets – applied for one second at a time, it is not debilitatingly power hungry.

It would be remiss of me, however, not to remind you that there is a lot more potential for damage applying that energy in other ways. Imagine delivering that 60kJ to a projectile instead! For reference, minimum muzzle energies for big game hunting tend to be in the region of 2kJ. Directed-energy weapons are inherently lossy. Even lasers and masers (microwave lasers), which are not beholden to the inverse square law, are too lossy to form the basis of efficient weaponry – not that this has deterred ongoing research.

So, in conclusion – yes, you absolutely can use a microwave weapon to get the tourists away from your house. A lethal device would use a microwave source of at least 100kW generating pulsed microwaves with frequency no higher than 915MHz. However, the energy required to run the thing would be better spent in almost any other way.

*Yours,
The Evil Engineer*