Stop the Abuse of Application Efficiency

Term used in dramatic ways to describe irrigation events, system types

Freddie Lamm

Irrigation engineers and industry professionals often use the term application efficiency to describe the effectiveness of a particular irrigation event or system type. Yet, it is one of the most abused terms in irrigation. You, too, could be an abuser of application efficiency, or Ea. Now, before I start pointing fingers, let me confess – I abuse the term, too.

Several definitions of application efficiency appear in literature, but the one used here was reported in the 1990 ASAE monograph, Irrigation Efficiency and Uniformity, by members Dale F. Heermann, Wesley W. Wallender, and M.G. Bos. It is algebraically expressed as

$$E_a = V_{soil} / V_{field}$$

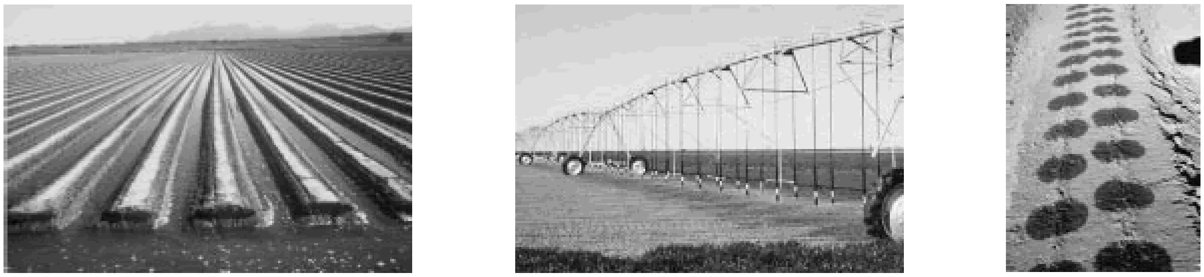
where Vsoil is equal to the volume of irrigation water needed for crop evapotranspiration to avoid undesirable water stress and Vfield is equal to the volume of water delivered to the field.

A 20th century perspective

Before we delve into the workings of the equation, let's look at the history of the term. As best as I can tell, it is a product of the 20th century. During my search, I initially couldn't find application efficiency, but I did find the terms "*duty of water*" and "*permissible waste*." The previous was defined by Sir R. (Robert) Hanbury Brown in his 1920 book, *Irrigation, Its Principles and Practice, as a Branch of Engineering,* as "the measure of the efficient irrigation work that water can perform, expressed in terms establishing the relation between the area of crop brought to maturity and the quantity of water used in its irrigation." Duty was usually expressed in terms of acre-foot/acre. "Gross duty" was the term applied to the irrigation amount diverted from the source to be used in irrigating an acre. It would include what we now call conveyance losses. "Net duty" represented the amount of water delivered to the field margin to irrigate an acre. It would include runoff, percolation and evaporation losses during the irrigation event.

Note from the definition, however, that the term "duty" was perceived as efficient, even though there was still much inefficiency built into it. "Permissible waste," a term I am sure would not be politically correct today, was defined as the fraction of water that was lost in conveyance, unequal in-field distribution, deep percolation and runoff. In the 1928 USDA Technical Bulletin No. 36, Samuel Fortier noted that even though "permissible waste" was still quite high, it was "*much less today than it was 20 years ago*." He went on to say there would always be a limit to improvements that would be governed by economics.

Orsen W. Israelsen does include the term application efficiency, Ea, in his 1932 book, *Irrigation Principles and Practices*. His definition differs from the equation listed above and would be more closely associated with the term water-storage efficiency. This term is the fraction of an irrigation amount stored in the remaining available crop-root zone following an irrigation event. Using the water-storage efficiency term is discouraged by Heermann because of the difficulty of determining the crop-root zone and because this efficiency can still be quite low while sufficient water is provided for crop production. Although application efficiency as defined by Israelsen does have a few technical differences with the Ea equation listed above, in many instances they can have the same value. Israelsen stated that Ea in some locales is probably as low as 20 percent and seldom greater than 75 percent. He concludes there is “undoubtedly great opportunity to increase Ea at costs well within economical limits.” I’m sure that such a statement can still be truthful in 2002.



The three major irrigation types – surface, sprinkler and microirrigation – can all have high application efficiencies when properly designed and managed. (*From left to right, photos courtesy of USDA Water Conservation Laboratory, USDA Conservation and Production Laboratory, USDA Water Management Research Laboratory*)

About the equation

The application efficiency equation can be used for a single irrigation event or more as a term reflecting seasonal performance. The difference in how it is used can be quite dramatic. For example, the first irrigation event using furrow irrigation can have a very low application efficiency if the length of run is long, furrows are freshly corrugated, stream size is wrong or for several other reasons. However, subsequent irrigation events might have highly acceptable application efficiencies. Likewise, for sprinkler irrigation, one event might have a high application efficiency because the soil is extremely dry and is conducive to infiltration, whereas a similar event on wet soil might result in excessive runoff and thus a poor application efficiency.

If you are an irrigator, you probably don’t want to calculate your “*standard practice*” gross irrigation amount from the event with the worst application efficiency, but you could use that measured value of application efficiency if you were estimating what your net irrigation application was for that single worst event. Similarly, everyone in the business of selling irrigation systems would hate to sell on the basis of the application efficiency of that worst irrigation event, and would much rather pick the event where the application efficiency is high. A seasonal value of application efficiency has merit in some cases, but may be difficult to evaluate. The point is that we need to be particularly careful in how we use application efficiency with respect to time. In many of our attempts to model or predict irrigation performance, we assume the application efficiency is a fixed number for a system type when it is not.

From a mathematical perspective, it is easy to manipulate V_{field} so that E_a can be equal to 1 or 100 percent. *Any* irrigation system can be operated to achieve 100 percent E_a if V_{field} is low. Increasing E_a in this manner totally ignores the need for irrigation uniformity. For E_a to have practical meaning, V_{soil} needs to be considered to avoid undesirable water stress.

So what’s the point of looking at the math? Many people will use application efficiency as a relatively static term without realizing that it can be easily manipulated to obtain any desirable value. Efforts are being made to mandate certain levels of application efficiency through water laws and regulations. Irrigation should be used beneficially and wisely with minimal waste, but to raise the stature of such an easily manipulated term to such a high pedestal is wrong. If laws are needed, wouldn’t some measure of the derived benefit of the irrigation be more appropriate? In addition, obtaining a high benefit would economically demand efficient irrigation application.

Pesky numbers

I know you have a set of application efficiency numbers you like for particular systems and so do I. No, I am not going to tell you mine. Why should I? Chances are slim we would agree with each other. That's the point; there are lots of published numbers. If I dislike sprinkler irrigation one day, am I being responsible if I find all the numbers that show evaporation losses as tremendously lowering application efficiency for sprinkler irrigation? Those numbers are out there if you want them. Oh, you don't like surface irrigation? No problem; those low numbers are out there, too.

Well, what do I consider as the purpose of application efficiency? I would suggest that it should not be to compare irrigation system types. History implies the purpose of E_a was to help estimate the gross irrigation requirement once the net irrigation need was determined and vice versa. I think it was also to be used as a benchmark of the present condition to inspire us to make further improvements in irrigation.

Now before I close, let's put this all back in perspective. Yes, I am serious about my comments, but lighthearted in my approach. This is my opinion, it may not be yours. As professionals we should be able to agree to disagree. And finally, recognize that I am not equating the minor seriousness of misuse of an engineering term with the seriousness of the important and unfortunate types of abuse that deal with actions to us or to our relationships. I hope after reflecting on this we can all do our part in limiting the abuse of application efficiency.

Lamm's 5-step program

I was unable to find a 12- step program to overcoming application efficiency abuse. Still, I think we can borrow from those plans to set things right.

1. Recognize the abuse of E_a.
2. Recognize the limitations of E_a as it pertains to system comparisons.
3. Recognize that each measured or calculated E_a is different.
4. Help educate the community about the proper use of E_a.
5. Don't enable the abuse of E_a by others with your silence.

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